EVALUATION OF AFRICAN BERMUDAGRASS (*Cynodon transvaalensis*) AS A PUTTING SURFACE

By

DAVID ALAN GERKEN

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Kansas State University

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Thesis Approved:

Dennis L. Martin

Thesis Adviser

Brian A. Kahn

Charles M Taliaferro

Thomas C. Collins

Dean of the Graduate College

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INTRODUCTION

The golf course industry faces a dynamic new set of opportunities and challenges as the 20th century closes. The conservation and protection of environmental resources are major concerns of today's society. These issues have impacted and will continue to impact the golf course management industry. The quest to balance environmentally sound management strategies with maintenance of esthetically superior turf is a complex challenge facing the golf course industry.

The golf course industry has responded positively to these concerns. Turfgrass scientists in the United States are working diligently towards the development of products and management techniques that permit the maintenance of high quality turf with reduced environmental risks. Much of this research is funded partially or completely by the United States Golf Association.

Putting greens in particular are sensitive to an array of environmental balances. As the golf course superintendent tries to maintain a healthy turfgrass playing surface, players are demanding a harder, faster surface that has superior aesthetics. To create this situation, management of putting surfaces must be altered. Mowing, fertilizing, and watering are all changed in such a way to firm the playing surface. These changes, however, can be very damaging to the growth of turfgrass.

The selection of turfgrasses used as a putting surface is limited. Low mowing height, high density, and uniformity required for good putting quality currently restrict managers in the United States to only two genera of turfgrasses. Cultivars of bentgrass (*Agrositis* *spp.*), a cool-season (C-3) turfgrass and the warm-season (C-4) bermudagrass (*Cynodon spp.*) hybrids are adaptable to putting green conditions.

Creeping bentgrass is the turfgrass predominantly used on putting green surfaces throughout the United States (Turgeon, 1991). This cool-season turfgrass has been selected for tolerance to close mowing height, dark green color, fine texture, uniformity, aggressiveness, and density (Beard, 1973). All these traits make creeping bentgrass an ideal putting surface favored by the majority of the golfing public. Despite the fact that it is a cool-season turfgrass that is adapted best to the northern temperate zones, bentgrass is being demanded in southern areas such as Florida and Georgia. Moore (1985) suggested two primary factors that contribute towards this occurrence. First, the golfing public demands the golf course superintendent increase "ball speeds" and putting surface "trueness". Second, bermudagrass hybrids cut at low mowing heights have increased susceptibility to cold injury. Replacement of putting greens due to winter injury of the grass is very costly to clubs. Recently, Foy (1988) noted that an increased number of golf courses in Florida have tried to maintain creeping bentgrass as a perennial putting surface instead of the more adaptable bermudagrass hybrids. This has come about from an attitude on the part of golfers that bermudagrass cultivars are inferior to creeping bentgrass as a putting surface. Once again, the firmness, smoothness, and the increase in the "speed" of putting surfaces were suggested as the cause for this change.

As creeping bentgrass is incorporated into putting surfaces in the subtropical and tropical zones, the management level required to meet demands from the public intensifies significantly. The disease pressure placed on this cool-season turfgrass is enormous during summer months when temperature and humidity escalate. The severity of diseases such as those caused by *Pythium spp.* creates an increase in pesticide usage. Water management becomes a critical issue as well. During periods of intense heat, water use rates of creeping bentgrass increase. This puts added pressure on the turfgrass industry, especially in areas where water is considered a scarce resource.

Bermudagrass, in contrast, is a warm-season turfgrass that is suited for use on putting greens in the tropical and subtropical regions of the United States (Turgeon, 1991). It has been selected for its vigorous growth, high shoot density, fine texture, and ability to adapt to southern climates (Beard, 1973).

Two interspecific bermudagrass hybrids, Tifgreen and Tifdwarf (*Cynodon dactylon* x *C. transvaalensis*), were developed in the 1960's and have been used successfully on putting surfaces in the subtropical and tropical zones of the United States. Both were selected for their high shoot density, fine texture, and a dark green color (Beard, 1973).

The problem for the southern region superintendent and the turfgrass industry is to develop cultivars that combine the traits in demand. A high quality, fast putting surface that is fine textured, drought tolerant, and at the same time able to withstand climatic changes and disease pressures is required. In addition, fall color retention following frost or chilling temperatures must be addressed. In areas of the southern United States where the overseeding of putting greens is practiced, a bermudagrass that would provide late-season color retention could perhaps eliminate the need for overseeding.

Of the bermudagrasses available, *Cynodon transvaalensis* may possess the required traits for a putting surface. It is among the finest textured of the bermudagrass species, and it possess a relatively high shoot density. In addition, it has shortened internodes, and has the winter-hardiness to survive in Oklahoma (Harlan et al., 1970) and similar temperate climatic regions of the world.

In 1989, approximately 3300 progeny plants of *C. transvaalensis* were planted at the Oklahoma State University Turfgrass Research Station at Stillwater, Oklahoma. Evaluations of *C. transvaalensis* under putting green conditions were made for color, texture, rate of spread, and fall color retention. Further screenings were made and as a result, 500 progeny plants were evaluated under more intensive putting surface conditions in southern Florida.

This study evaluated six of those 3,300 genotypes under putting surface conditions at the Oklahoma State University Turfgrass Research Station in Stillwater, Oklahoma on a sand green.

At the time of this research the majority of the bermudagrass research for putting greens had been conducted with only Tifdwarf and Tifgreen. There was limited documentation found in the literature on *C. transvaalensis* performance and use as a putting surface. This led me to conclude that there was an opportunity for expansion of our knowledge for selecting improved genotypes of *C. transvaalensis* from which to propagate superior hybrids or use as a monoculture.

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CHAPTER I

REVIEW OF LITERATURE ON AFRICAN BERMUDAGRASS

(*Cynodon transvaalensis*)

ADAPTATION

Africa is generally considered to be a center of diversity for bermudagrass (*Cynodon spp.*), however, several species are found in parts of Asia (Harlan et al., 1970b). The geographical distribution of bermudagrass species was studied by Harlan et al. (1970b). They identified African bermudagrass (*Cynodon transvaalensis* Burtt-Davy) as indigenous to an area of South Africa called the Transvaal Valley. Likewise, de Wet and Harlan (1971) described this species as being dispersed throughout the southern and western portion of the Transvaal Valley. Some of the earlier bermudagrass accessions introduced into the United States were selected for turfgrass quality and have been grown successfully in many parts of the world (Hanson, 1972; Harlan et al., 1970b).

As of April 1993 there were a total of 24 *Cynodon transvaalensis* accessions listed by the Germplasm Resource Information Network (GRIN) as being maintained in the United States germplasm collections. Of the 24 accessions listed, the cultivars Uganda and Florida are most frequently mentioned in the literature. Other names used to describe African bermudagrass were Fine couchgrass, Floridagrass, Fuchs' Velvet lawn grass, Transvaal quick (grass), and Fine Bermuda (Chippindall, 1946).

Expansion of bermudagrass into the United States began as early as the mid 1700's when Gov. Henry Ellis introduced *Cynodon dactylon* to the southeastern region of the United States (Juska and Hanson, 1961). Since that period, bermudagrass has become the primary turfgrass across the southern region of the United States and parts of the transition zone (Hanson, 1972). However, certain species have been successfully grown in the northern limits of the transition zone between cool temperate and subtropical regions. The transition zone is an area approximately 322 km wide (North to South) spanning east to west across a central line of 37^0 north latitude of the United States (Turgeon, 1991).

Past research involving the use or breeding of African bermudagrass is limited. Primary emphasis of bermudagrass breeding research for turfgrass in the past was placed on the development of interspecific hybrids resulting from crossing *Cynodon dactylon* with *Cynodon transvaalensis*. Approximately eight turf bermudagrass cultivars have been developed by this method to date. The most widely used include Tifway, Tifgreen and Tifdwarf. Tifway and Tifgreen were developed by Dr. Glenn Burton at the Coastal Plain Experiment Station at Tifton, Georgia. Tifdwarf, a natural mutation of Tifgreen, was also tested and released by Dr. Burton.

Bermudagrass is the predominant grass used for golf greens in the southern region of the United States. Golf course superintendents surveyed in Florida reported 97 percent of the putting surface greens were bermudagrass (Anonymous, 1992). With rare exceptions, these putting greens would mostly be Tifdwarf.

Prior to the pioneering breeding efforts of Burton, there was no published work in the area of bermudagrass breeding research (Burton, 1947). Francis and Baird (1910) in a three part experiment studied cultivation, chemical composition, and digestibility of bermudagrass. They concluded that bermudagrass was a great asset to Oklahoma agriculture and exceeded many other grasses and forages in their tests. Additionally, they noted bermudagrass provided a superior turfgrass that was well adapted to Oklahoma.

African bermudagrass has been described as possessing the desirable characteristics to become a superior turfgrass. Although several selections have been named and distributed, none was officially released (Hanson, 1972). Hanson described one cultivar of African bermudagrass, Uganda, as having textural qualities and a low growth habit lending itself to use as an acceptable putting and tennis court surface. Cultivars Transvaalensis and Florida are two additional African bermudagrasses described by Juska and Hanson (1961) as being used extensively throughout South Africa on lawns, putting surfaces, and bowling greens. Younger (1955) noted that African bermudagrass in trials at the UCLA Turfgrass Research Station in California exhibited superior turfgrass quality. *Cynodon transvaalensis* has been described by Hanson (1972) as providing an excellent turfgrass for lawns, tennis courts, and putting greens. In addition African Bermudagrass has been found on low maintenance putting greens in southwest Oklahoma which is considered as being within the transition zone (D.L. Martin, personal communication).

Juska and Hanson (1961) tested several accessions along with other species and hybrid crosses of *Cynodon spp.* at Beltsville, MD. They showed that Uganda and Florida had excellent winter hardiness, but were inferior in turfgrass quality when comparisons were made with interspecific hybrid bermudagrasses.

A conclusion that can be drawn from this review of the literature is that wide variation among the *Cynodon* species (including *C. transvaalensis* introductions) exists, and that these grasses may lend themselves to the further improvement of bermudagrass in the transition zone.

BIOLOGY

Of the *Cynodon spp.*, African bermudagrass is the finest textured (Beard, 1973). Morphological characteristics of African bermudagrass have been described as leaf blades being very fine, 1.5 mm wide, and having a yellowish green color (Juska and Hanson, 1961; Hanson, 1972; Younger et al., 1972; Mahdi, 1955; de Wet and Harlan, 1971; Harlan et al., 1970a and 1970b). *Cynodon transvaalensis* reproduces vegetatively by stolons and rhizomes (Juska and Hanson, 1961; Younger et al., 1972; Harlan et al., 1970a). de Wet and Harlan (1971) characterized African bermudagrass as being morphologically uniform. *C. transvaalensis* plants generally possess spikes numbering between 1-3 with 2 being the most common (Harlan et al., 1970a; Hurcombe, 1947; Juska and Hanson, 1961). Hanson (1972) also described this species as a low growing turfgrass.

Juska and Hanson (1961) described the genus *Cynodon* as being divided into two groups. The separation was based on spike numbers and their arrangement in relation to the central axis of the plant. *C. transvaalensis* was placed in the second group and further subdivided on vernation and absence or presence of rhizomes.

Harlan et al. (1970c) when reclassifying the genus *Cynodon* identified the species *transvaalensis* as a diploid (2n=2x=18).

CULTURE

The limited interest in the use of African bermudagrass may be explained by the fact that early cultivars expressed several undesirable morphological characteristics and cultural limitations (C.M. Taliaferro, personal communication). One limitation of earlier cultivars of *C. transvaalensis* was their tendency to exhibit a lighter green or more yellowish appearance than other bermudagrasses (Mahdi, 1955; Younger et al., 1972; Harlan et al., 1970a). It is also a characteristic of African bermudagrasses to turn a purplish color as temperatures drop below the optimum for growth during fall months. This characteristic has been a disadvantage for the African bermudagrasses and is viewed as being undesirable (Mahdi, 1955; Harlan et al., 1970a; Hanson, 1972). Without extensive management, African bermudagrass may develop a grainy appearance (Mahdi, 1955). However, Mahdi (1955) noted that with a top dressing program this may be prevented.

Golf memberships have also historically demanded faster putting speeds. Typically a bermudagrass putting surface will tend to have slower stimpmeter readings than creeping bentgrass. Morphological differences between the two species may have an influence on ball speed. Bermudagrass shoots have a more upright growth habit with leaves being more vertical, while bentgrass tends to assume a more prostrate growth habit with leaves more horizontal. This variable can also be influenced by many cultural and environmental factors. Mowing height, fertilizer, and irrigation are a few management practices that can be adjusted to achieve higher "ball speeds". "Ball speed" or "putting speed" are terms used to describe the distance which a golf ball travels over the most level portion of a putting surface. Emphasis on "ball speeds" varies among golfers. All too often, members desire faster "putting speeds" and fail to realize the detrimental effects this may place on the putting surface due to the stress of intense management practices.

PEST SUSCEPTIBILITY

Younger (1972) suggested that, to a limited extent, African bermudagrass is susceptible to insects and diseases but gave no specific information on pests or the severity of injury that might be expected.

Both common and hybrid bermudagrasses are susceptible to root knot nematodes (Riffle, 1964). Rifle reported *Meloidogyne* nematodes infecting African bermudagrass in Albuquerque, NM. No reports as to damage from other environmental factors have been found.

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CHAPTER II

EVALUATION OF AFRICAN BERMUDAGRASS (*Cynodon transvaalensis*) UNDER FIELD PUTTING GREEN CONDITIONS

ABSTRACT

The putting surface characteristics of six experimental African bermudagrass genotypes and 'Uganda' African bermudagrass (*Cynodon transvaalensis*) and 'Tifgreen' bermudagrass (*Cynodon dactylon x C. transvaalensis*) mowed at 0.3 and 0.5 cm heights were evaluated over two growing seasons at Stillwater, Oklahoma. The performance characteristics that were assessed were establishment rate, clipping yield, and spring green-up as well as visual color, quality, density rating, and "distance of ball roll" as measured with a USGA Stimpmeter. Root mass, shoot density, and leaf blade angles were also assessed. Experimental African bermudagrasses generally equaled or exceeded Tifgreen and Uganda for turf quality, shoot density, and early spring green-up. Tifgreen established faster and had darker green color than any of the African bermudagrasses. Tifgreen was significantly more prostrate when comparisons of leaf blade angles were made with the African bermudagrasses. Regrowth following the 1991-92 winter indicated all African bermudagrasses in the study had significantly greater winter-hardiness than Tifgreen.

INTRODUCTION

African bermudagrasses (*Cynodon transvaalensis*) are fine textured and have been used as putting surfaces in southern Africa (Juska and Hanson, 1961). Although African bermudagrass may possess qualities that would be acceptable as a putting surface, the author has found little documentation about *C. transvaalensis* adaptation and performance. To the authors knowledge, there has been no formal research involving the use of African bermudagrass as a putting surface. The possibility exists to breed improved plants for putting surfaces throughout the subtropical and tropical regions of the United States as well as within the transition zone between temperate and subtropical regions. In addition, African bermudagrass breeding projects may lead towards the improvement of bermudagrass hybrids that are widely used in the subtropical and tropical regions of the United States and throughout the transition zone.

The objectives of this research were to:

i). Identify genotypes of *C. transvaalensis* with superior putting surface quality and

ii). Evaluate differences among *C. transvaalensis* genotypes when compared to Tifgreen (*C. dactylon* x *C. transvaalensis*) and Uganda (*C. transvaalensis*).

MATERIALS AND METHODS

African bermudagrass performance was evaluated on a research putting green at the Oklahoma State University Turfgrass Research Center at Stillwater. Soil consisted of a 90-10% washed concrete sand-rice hulls mix.

On 17 October 1990 six African bermudagrass (*Cynodon transvaalensis* Burtt-Davy) genotypes were selected from a population of approximately 3300 genotypes in a preliminary screening nursery. Plugs of each genotype were removed from the field and taken into the greenhouse where populations were increased in 25 cm^2 containers. Two additional bermudagrass cultivars, Tifgreen (*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy) and Uganda (*Cynodon transvaalensis* Burtt-Davy) were increased in the same manner.

The field site was prepared in April 1991. Existing creeping bentgrass (*Agrostis palustris*) was removed. An additional 5 m^3 of washed masonry sand was added to the 30 m x 12 m area, tilled 20 - 25 cm deep, and leveled. Methyl bromide was applied at a rate of 488 kg ha^{-1} under a polyethylene cover for 48 hr for weed control. Initial soil test analysis by the Oklahoma State University Soil Testing Laboratory showed the soil to contain approximately 34 kg ha^{-1} P and 48 kg ha^{-1} K. Soil pH was 7.6. Soil pH was adjusted to 6.5 with the addition of 537 kg S ha^{-1}. Phosphorous and potassium deficiencies were corrected by the addition of potassium sulfate at the rate of 121 kg ha^{-1} and triple super phosphate at a rate of 34 kg ha^{-1}.

On 26 April 1991 10 cm^2 plugs were taken from the greenhouse and planted on 0.3 m centers in 3.0 x 3.7 m plots that were replicated four times. As the genotypes began to cover plots, mowing height was gradually reduced from approximately 6 cm to final treatment cutting heights. Initially, plots were separated by spraying a small band of glyphosate around treatment borders. Once plots were established, genotypes were allowed to grow together. On 1 September 1991 replications were divided in half and randomly assigned mowing heights of 0.3 cm and 0.5 cm. Thus, the smallest experimental unit (hereafter called a data unit) was 1.5 x 3.7 m. Plots were maintained with a Jacobson reel mower throughout both seasons of growth.

Periodic soil tests were taken in order to maintain optimum nutrient levels of phosphorous and potassium. Based on soil test results, corrections were made in fertilizing schedules to correct any deficiencies which may have occurred.

Plots were fertilized on 17 May 1991 at a rate of 98 kg N ha^{-1} and 70 kg K ha^{-1}. On 6 June through 1 August 1991 plots were fertilized at a rate of 49 kg N ha^{-1} and 35 kg K ha^{-1} every two weeks. An additional 49 kg K ha^{-1} and 89 kg P ha^{-1} was added on 23 September 1991. Applications of 49 kg N ha^{-1} and 35 kg K ha^{-1} were made on 9 May, 23 May, 8 June, and 22 June 1992. Beginning on 8 July 1992 and ending 14 September 1992 plots were fertilized with 180 kg N ha^{-1}, 5 kg P ha^{-1}, 9 kg K ha^{-1} every two weeks. On 14 July 1992, 49 kg K ha^{-1} and 53 kg P ha^{-1} were added.

Plots were irrigated to prevent visual drought stress. A light topdressing program using mason sand was implemented to level and firm-up plots on an as-needed basis during both seasons. The following variables were measured on the bermudagrass in the research area during this study:

Establishment Rate

Two methods were employed to estimate the rate of establishment by the genotypes. The first method utilized a randomly-placed grid. The grid was a 1.2 m by 1.2 m square frame. Eight points were randomly selected on each side of the frame and connected by string to create 64 intersects within the square frame. The grid was placed at random over plots and the number of intersections coming in contact with bermudagrass were counted weekly from 24 May 1991 to 28 June 1991, when all plots had 100% cover as measured by this method. The second method involved weekly estimates of the percentage of the plots covered with turf during the period of 14 May 1991 until all plots had reached 100 percent coverage on 20 July 1991.

Clipping Yield

Clippings were collected from a 2.5 m x 0.5 m strip of each data unit. Dry mass was determined after drying clippings at 38^0 C for a minimum of 48 hours. Clipping samples were taken in 1991 on 12 September, 26 September, 3 October, and 10 October. A total of eight samples were taken in 1992 beginning on 11 June and continuing at approximately two week intervals.

Leaf Blade Angle

Three 1.9 cm diameter plugs were taken from each data unit. Five shoots containing a minimum of four leaves were selected from each plug for leaf blade angle measurement. The angle of orientation of the leaf from the vertical axis was recorded for each plant. An average leaf blade angle of the first four emerging leaves on plants from each data unit was calculated for analysis. Samples were taken during the weeks of 20 July 1992 and 21 September 1992.

Root Mass Distribution

Samples for estimating root mass distribution were collected on 23 October 1991, and 1 June, 31 July and 10 October 1992. Three 1.9 cm diameter x 15 cm deep plugs were taken from each data unit. After removal of the thatch layer, plugs were cut in two in order to determine root mass in the 0 - 7.5 cm and 7.5 - 15 cm depth range. Roots were separated from soil by washing samples in a Vortex Root Washer (Gillison's Variety Fabrication Inc., Benzonia, MI). Root dry mass was obtained following a minimum 48 h oven drying period at 38^0 C.

Shoot Density

Three 1.9 cm diameter plugs were removed from each data unit on 23 October 1991, 1 June 1992, and 31 July 1992. Total shoot numbers were determined by counting individual shoots of each plug and pooling shoot counts across sample plugs.

Spring Green-up

In 1992, two visual evaluations were made per week estimating the percentage of the plot with green cover. Sampling began on 5 May 1992 and continued until plots had 100 percent green cover. During the spring of 1993, three ratings were performed per week beginning 2 April and continuing until plots had 100 percent green-up. Twelve visual samples of the estimation of the percent green-up were made in 1992 and seven in 1993.

USGA Stimpmeter Readings

The distance that a golf ball would roll was measured using a United States Golf Association Stimpmeter. Although this measurement is often referred to as "ball speed", the Stimpmeter reading is actually a measure of the distance a golf ball will travel from a given point and not the speed at which the ball rolls. Distances were measured for three golf ball rolls in one direction and then for three corresponding rolls in the opposite direction. An average of the six rolls was used in the analysis. Samples were taken weekly during the two growing seasons. Sampling began on 13 September 1991 and 27 May 1992 and ended 18 October 1991 and 9 October 1992, respectively.

Visual Ratings

Density, color and overall turfgrass quality were visually assessed on a scale of 1 - 9 (Murray, 1983). A color rating of 1 equaled straw yellow appearance and 9 equaled dark green. For density and quality a rating of 1 equaled poor and 9 equaled excellent. Visual ratings were taken weekly during the two growing seasons.

Winter Hardiness

Winter hardiness was visually assessed by estimating the percentage of regrowth of plants within each plot. Winter hardiness evaluations in the spring of 1992 and 1993 began after genotype selections had reached 100% green-up.

Thatch

An O.J. Noer Soil Profile Sampler (Smiley and Craven, 1970) was used to collect three profile samples from each data unit to a depth of 12 cm.

Analysis of Data

The experimental design was a randomized complete block with a split block arrangement of treatments (Steel and Torrie, 1980). Main plots were bermudagrass genotypes. Subplots consisted of the two mowing heights which extended the entire length of each replication. Sub-sub plots were sampling dates. In the case of leaf blade angle and root mass, leaf blade position and depth were considered a sub-sub-sub plot respectively.

An analysis of variance was conducted using SAS Proc Anova (SAS Institute, 1985). Fisher's Protected LSD Test was used to separate means when effects were determined significant at the $P \leq 0.05$ level.

RESULTS AND DISCUSSION

Rate of Establishment

The analyses of variance (ANOVAs) for ground cover as measured by two sampling methods are shown in Table 1. Although two methods were employed to determine establishment rates, there was no intent of comparing methodology in this study. Highly significant genotype, sampling date and sampling date * genotype interactions were present in ANOVA's conducted on data collected using the two assessment methods. Percent of ground covered with turfgrass increased with increasing time after planting, regardless of the method of assessment used. As a result of a significant genotype * time interaction for both the randomized grid method and the visual estimates of percent area covered with grass, Fishers LSD test was employed to separate genotype means within sampling dates.

For the randomized grid method, Tifgreen ranked numerically the highest in percentage of stolons coming in contact with grid intersects on four of the six sampling dates (Table 2). Genotype Ctr-2747 ranked numerically the lowest in percentage of ground cover on four of these sampling dates. On the first and last two sampling dates there were no significant differences among the cultivars. Overall, Tifgreen and Ctr-2747 had the fastest and slowest rates of establishment respectively, with Uganda intermediate in its rate of establishment.

Trends of visual ratings for ground cover were much the same as when the randomized grid method was employed (Table 3). Tifgreen and Uganda were the first cultivars to attain 100 percent plot coverage. Tifgreen had numerically the greatest or equal to the greatest percentage ground cover on 8 of 10 sampling dates. During the first two sampling dates no statistical differences were present among genotypes. For the last four sampling dates there was no significant difference among Tifgreen and the other cultivars with the exception of Ctr-2747. Ctr-2747 had the lowest percentage of ground cover on 8 of the 10 sampling dates with significantly lower percentage cover than any other turfgrass on last 4 sampling dates.

Although Ctr-2747 had numerically the slowest rate of establishment, this genotype expressed a dark color and appeared to be the highest quality turfgrass throughout the establishment period although no data was taken on this characteristic during establishment.

Data collection for the randomized grid method began 10 days after visual estimates were started due to adjustments made to the grid. There was additionally a difference in the time at which the two methods assessed the turf plots as having reached 100 percent coverage. The randomly placed grid method reached 100 percent coverage 5 wk prior to the visual method of estimating establishment. This effect was believed to be due to the fact that numerous stolons actively growing over plots came in contact with 100 percent of the intersects before the turf canopy became enclosed by leaf blades. In order for a visual estimate to be considered 100 percent establishment, the turf canopy must be entirely enclosed.

Clipping Yield

The ANOVA's for clipping yield data collected in 1991 and 1992 are shown in Table 4. Although data were not analyzed over years, weekly mean clipping yields harvested from bermudagrass in 1992 were greater than those collected in 1991 for each genotype. This result is not unexpected as 1991 was an establishment period for the grasses, whereas they were mature turf in 1992.

In 1991, significant mowing height (MH), time (T), T * MH and genotype (G) * T effects were present (Table 4). In 1991, genotype effects were not significant. When mean clipping yields for genotypes pooled over mowing heights (Table 5) were analyzed within sampling dates using the LSD test, there was no significant difference among the genotypes for the first three of the four sampling dates. On the last sampling date in 1991 Uganda had a significantly higher yield than any other bermudagrass. Also, on the last sampling date in 1991 Tifgreen numerically ranked higher than any of the remaining African bermudagrasses.

In 1992, significant genotype (G), time (T), T * mowing height (MH), G * T and G * T * MH effects were present. During the 1992 season, Ctr-2747 had numerically the highest clipping yields on 6 and 5 of the 8 sampling dates for mowing heights of 0.3 cm and 0.5 cm, respectively (Table 6). Clipping yields of Ctr-2747 taken at the 0.3 cm mowing height were significantly the highest compared to other African bermudagrasses, Uganda, and Tifgreen on 6 August 1992 and 23 August 1992. Uganda also had a large amount of clippings at both heights. Tifgreen numerically yielded the least amount of clippings on 6 and 3 of the sampling dates for mowing heights 0.3 cm and 0.5 cm, respectively. Tifgreen yielded significantly lower amounts of clippings as compared to Uganda and African bermudagrasses on two sampling dates mowed at 0.3 cm and one sample date mowed at 0.5 cm. These results would be expected due to winter injury of Tifgreen plots, especially at the 0.3 cm height of cut. At the 0.5 cm mowing height, Ctr-2387 significantly had the lowest yields on 11 June 1992 and ranked numerically lower than any of the other bermudagrasses on 3 sampling dates.

The fact that Ctr-2747 yielded a high amount of clippings is consistent with the analysis of both shoot counts and visual density ratings where the Ctr-2747 genotype typically ranked highest among genotypes tested.

Leaf Blade Angle

The analysis of variance for data on angle of orientation (AO) of bermudagrass leaf blades from the vertical axis is shown in Table 7. A larger AO indicates a more horizontally oriented leaf blade. Highly significant genotype, sampling date and leaf position effects were present as well as leaf position * genotype and leaf position * time effects. Mean AO of leaves pooled over genotypes were separated within sampling dates using the LSD Test (Fig. 1). The AO of leaf blades were significantly different from each other for all leaf positions on date 1. The AO of the first and second leaf positions both had significantly greater vertical angles than the third and fourth positions at the $P \leq 0.05$ level for both dates. This would be expected because as leaves mature, the angle from the central axis becomes more prostrate. On the first sampling date, the AO of leaf position three was significantly more vertical than leaf position four. However, on the second date there were no significant differences in the AO of either of the last two leaf positions. The AO of leaves became more prostrate over time as illustrated in the differences between sampling date one and two. Leaf one was significantly more prostrate on Tifgreen than any of the other bermudagrasses in the study (Table 8). The AO of the first leaf position for Tifgreen was 57.1^0 and AO became more prostrate as older leaves were examined. Mowing heights had no effect on leaf blade AO.

The AO could be useful in describing morphological features of a genotype for possible use in cultivar identification. It also may be important when trying to characterize genotypes for future work that would examine the correlation between AO and tolerance to scalping.

Root Mass

The ANOVA's for root mass data collected from eight bermudagrasses during 1991 and 1992 are shown in Table 9. The main effect of mowing height was not significant in either of the two growing seasons sampled.

In 1991, only a significant depth effect was present. Mean root mass in 1991 for the upper root zone was 0.116 g and was significantly greater than the mean root mass at 7.5 - 15 cm depth (0.044 g).

In 1992, significant genotype, time, depth, D * G, D * MH and D * T effects were present. Root mass was greater in the upper root zone (0 - 7.5 cm) than in the lower root zone (7.5 - 15 cm) for each genotype tested on all sampling dates (Table 10). When comparisons of African bermudagrasses were made to Uganda and Tifgreen, significant differences were present on the first and last dates sampled at the 0 - 7.5 cm depth. Significant differences were only present on 10 October 1992 for root mass in the 7.5 - 15 cm root zone. On 1 June 1992 Ctr-1415 and Ctr-1397 numerically had the greatest root mass in the upper zone and were significantly higher in root mass than Tifgreen. On the last sampling date, five of the six African bermudagrasses had significantly greater root masses in the 0 - 7.5 cm zone than Uganda and Tifgreen.

Root mass is particularly important to turfgrass management and survival characteristics of the plant. Root mass of plants directly affects the amount of nutrient and moisture uptake.

Shoot Density

The number of shoots per unit area is a direct measure of turfgrass density. Shoot density samples were taken once in 1991 and twice in 1992. In both years, no mowing height effect was present (Table 11). A significant genotype effect was present in 1991.

In 1991, Ctr-696 had a mean density of 15.2 shoots cm^{-2} and was numerically the highest of all the genotype treatments (Table 12). Tifgreen had the least number of shoots with 5.4 shoots cm^{-2} in 1991.

In 1992, the genotype * time interaction was significant at the 0.05 level and shoot count means were separated by sampling dates. Five of the *Cynodon transvaalensis* genotypes had a greater number of shoots than Tifgreen on both sampling dates in 1992. On 31 July 1992 Tifgreen had the least number of shoots per unit area when comparisons were made to Uganda and other African bermudagrasses.

In nearly all instances, shoot counts were greater for all grasses on both sampling dates in 1992 than in the previous year. This would be expected as plots became more dense as the turfgrasses matured. Winter injury of Tifgreen plots may have had an effect on shoot count density during sampling in 1992, but it was apparent that throughout the study Tifgreen was more coarse and open than all of the *C. transvaalensis* genotypes.

Spring Green-Up Ratings

Aesthetics of turfgrass are a vital consideration to all facets of the industry. In the Florida region, where bermudagrass is widely used as a putting surface, the spring green-up transition period where turfgrasses begin to regenerate new growth is critical. It would be very desirable for bermudagrass putting surfaces to green-up early during this spring transition.

The analysis of variance for visual estimates of the percentage green-up during 1992 and 1993 is presented in Table 13. As significant mowing heights, genotypes, time, genotype * time and genotype * time * mowing height effects were present, mean percentage green-up by genotype were separated with the LSD test within MH by sampling dates in 1992. In 1993, block, genotype, time, and genotype * time effects were present.

Green-up ratings in 1992 began 2 March and extended through 16 April. In most instances during the spring of 1992 plots mowed at the 0.5 cm height of cut exhibited faster green-up percentages than the 0.3 cm height turfgrass (Table 14). Ctr-696 greened-up relatively quickly at each mowing height. However Ctr-2387 was first to reach 100 % green-up at the 0.3 cm mowing height. Overall Tifgreen was the slowest of all the bermudagrasses to green-up in 1992. Tifgreen ranked numerically the lowest on each sample date. This was due primarily to severe winter injury to the plots mowed at the 0.3 cm height requiring re-establishment of grass via lateral spread.

Ratings in 1993 began on 30 March and extended through 23 April. Plots observed 1 wk prior to the beginning of 1993 green-up ratings had not recovered enough to warrant rating. During the week of 22 March 1993 plots had greened up dramatically. As significant genotype, time and genotype * time interactions were present in 1993, mean green-up ratings for genotypes were analyzed by sampling date. Ctr-2747 ranked numerically the highest on 4 of the 7 sample dates, however, it often was not significantly different than other African bermudagrass selections (Table 15). On all sampling dates in 1993, Tifgreen had a significantly lower percentage green-up than any of the African bermudagrass selections.

These findings agree with Juska and Hanson (1961), as P.I. 213391 'Florida' had a higher spring-recovery rating than Tifgreen in their work.

USGA Stimpmeter Readings

The ANOVAs for USGA stimpmeter data collected for 8 bermudagrasses during 1991 and 1992 are shown in Table 16. Turf mowed at a height of 0.3 cm provided significantly larger stimpmeter readings during both 1991 and 1992 (data not shown). Overall stimpmeter readings were greater in 1991 when compared with 1992 season. Plots established in 1991 may have had a harder putting surface and were not as dense as the same plots in 1992. This may have led to less resistance and thus, faster ball speeds. The ANOVA procedure showed a highly significant genotype and genotype * time interaction in 1991 and again in 1992. Mean stimpmeter readings for each genotype were separated using the LSD Test for each sampling date. Tifgreen had numerically the greatest mean distance of ball roll on four of the six sampling dates in 1991 when compared to Uganda and other African bermudagrasses (Table 17). Uganda numerically had the lowest stimpmeter readings on all six sampling dates in 1991. Uganda had significantly the lowest ball speed readings on four of the six dates in 1991 when comparisons were made to Tifgreen and other African bermudagrasses. Genotypes Ctr-2387 and Tifgreen had consistently high numeric stimpmeter readings in 1992 (Table 18). On the last 3 sample dates, Uganda had lower stimpmeter readings than any of the experimental African bermudagrasses and Tifgreen. On the remaining sampling dates Uganda or Ctr-2747 tended to have the slowest stimpmeter readings over sampling dates in 1992.

It may have been possible to increase stimpmeter rates with certain management and cultural practices such as verticutting, changing nutrient regime and watering. However, additional cultural practices such as verticutting were avoided in order to reduce the possibility of mechanically mixing the different genotypes.

Visual Density

The ANOVAs for visual density appear in Table 19. There were no significant block, genotype or genotype * time * mowing height effects in 1991. No block effects were present in 1992.

In 1991, a genotype * time interaction was significant at the 0.001 probability level for visual density ratings. Mowing heights were pooled, and in 1991 mean visual density ratings were analyzed by sampling dates. Significant differences in density among genotypes were present on only 3 of the 7 sampling dates in 1991 (Table 20). Ctr-2747 numerically ranked the most dense turf on 4 of the 7 rating dates. On the dates where significant differences were present, all African bermudagrass genotypes and Uganda had a visual density rating above an acceptable density rating of six.

In 1992, genotype * time * mowing height effect was significant at the 0.01 level and genotype means were separated by mowing heights for each date sampled. The 1992 analysis of data again revealed that Ctr-2747 had a relatively dense turf canopy. On the 24 sampling dates, Ctr-2747 had the highest numeric ranking on 20 and 21 dates for plots mowed at the 0.3 cm and 0.5 cm height respectively (Table 21). Rankings for Ctr-2747 were significantly higher than those of the other tested bermudagrasses for 4 dates at the 0.3 cm height and 5 dates for the 0.5 cm height of cut.

During the winter of 1991, Tifgreen experienced severe winter injury at the 0.3 cm height of cut and this had a dramatic impact on visual density ratings. Visual density for Tifgreen mowed at 0.3 cm was significantly lower than any other genotype on 15 of the 24 dates while ranking numerically lowest on 19 of those dates when comparisons were made with Uganda and other African bermudagrasses. Tifgreen plots mowed at 0.5 cm had significantly lower visual density on 8 sampling dates and numerically ranked the least dense on 16 of the 24 sampling dates compared to Uganda and African bermudagrasses. Tifgreen plots at the Oklahoma Turfgrass Research Center in Stillwater appeared very coarse. Individual shoots were not as dense and plants appeared more open than the African bermudagrasses.

Visual Color Ratings

Aesthetics dictate in many ways the management systems of the golf course. Turfgrass color may be the single most important factor that determines aesthetic appearance.

The ANOVA's for turfgrass visual color ratings are presented in Table 22. No significant genotype * mowing height or genotype * time * mowing height interactions were present in 1991. During 1992 there were no significant block and genotype * time * mowing height effects. In both years a significant mowing height effect was present. Color ratings were significantly greater for turf mowed at 0.5 cm than for those mowed at 0.3 cm. Plots mowed at 0.5 cm height of cut had a mean rating of 7.0 and 7.1 in 1991 and 1992, respectively. Plots mowed at the 0.3 cm height rated an average of 6.4 and 6.7 during 1991 and 1992 respectively.

Genotype * time interactions were significant for visual color ratings during 1991 and 1992. Tifgreen possessed numerically the highest mean color rating of all genotypes for 3 of the 7 sampling dates in 1991 (Table 23). These differences were however statistically different only on 13 September when compared with the African bermudagrasses and Uganda. Uganda numerically ranked the lowest in color ratings on 6 of the 7 dates. On 5 of 7 dates in 1991, Uganda had mean color ratings below an acceptable rating of 6. Uganda had significantly lower color ratings than any other genotypes in the test through 4 October. Other genotypes in the study were inconsistent in their rankings throughout sampling dates.

Throughout 1992, Tifgreen had relatively high color ratings (Table 24). When comparisons of Tifgreen with Uganda and African bermudagrasses were made, differences were statistically significant on 11 of 24 dates. Ratings for Uganda were significantly lower than other African bermudagrass treatments on 16 of the 24 sample dates in 1992. Uganda had significantly lower color ratings than Tifgreen on all 24 sampling dates in 1992.

Results of this study are consistent with tests conducted at the Alabama Agricultural Experiment Station, Auburn, where bermudagrasses managed as lawns and golf greens were rated for turfgrass color (Juska and Hanson 1961). In an overall comparison of means when managed as a turfgrass lawn, Tifgreen rated 10 where 10 is the darkest green color and Uganda rated 3. In 1962 evaluations at the same location, Tifgreen rated a darker green than either Uganda or the variety Florida. Color evaluations conducted at the Arizona Agricultural Experiment Station at Tucson in 1960 and 1961 showed much the same when bermudagrass was managed as general-purpose turf (Juska and Hanson 1961). Tifgreen was a darker color in both spring and fall evaluations. However, evaluation of bermudagrass varieties at Middle Rio Grande Substation, Los Lunas, NM and Norfolk VA during 1958 - '61 found African bermudagrass selections darker green than Tifgreen (Juska and Hanson 1961).

African bermudagrass genotypes in this research usually had better color than earlier genotypes such as Uganda. This research suggests that improvement of color in *Cynodon transvaalensis* may be possible since a great deal of variation appears to be present in the species.

Turfgrass Quality

Turfgrass quality combines together factors relating to color, texture, density, uniformity, growth habit and smoothness (Turgeon, 1991).

The 1991 and 1992 ANOVA's for turfgrass quality revealed significant genotype * time interaction (Table 25). As plots matured in 1991, turfgrass quality increased. On the last sample date in 1991, 1 November, overall quality was the highest with an average rating of 7.7 when genotype treatments were pooled over mowing heights. During the 1992 growing season algae growth was prevalent on plots during the spring and early summer which reduced the quality of genotype treatments. Scalping was also a problem which impacted quality, especially at the 0.5 cm mowing height. Scalping was believed to occur due to unevenness of turfgrass mat and growth habit when cut at 0.5 cm. This may be attributed to the graininess (growth habit) of Uganda and the other African bermudagrasses. In addition, African bermudagrasses at this height assumed a softer, spongy appearance which could have contributed to scalping.

During the 1991 growing season Ctr-2747 ranked numerically the highest on four of the seven sampling dates (Table 26). These differences however were significant only on 27 September 1991. The African bermudagrass selection, Ctr-2387 was among the lowest ranking genotypes and was significantly the lowest on the last sampling date.

In 1992, Ctr-2747 again ranked numerically the highest quality on 22 out of the 24 sampling dates and was significantly the most superior turfgrass on 7 of those dates (Table 27). Tifgreen numerically ranked the poorest quality 17 of the 24 dates sampled and was significantly lowest in visual quality on 8 dates sampled.

These data are inconsistent with data of Juska and Hanson (1961) who evaluated Tifgreen, Uganda, and P.I.213391 (Florida). They showed Tifgreen to have significantly superior quality to both Uganda and Florida. It must be noted that their trial was managed as a lawn and not as a high maintenance putting surface. Plots managed at the Oklahoma

Research Station were maintained at substantially lower mowing heights. In addition, bermudagrasses in Oklahoma were frequently topdressed with mason sand in order to maintain a level surface. Changes in mowing height, topdressing procedures, and fertility are a few of the maintenance practices that varied between studies and may have had an effect on the different observations among the two studies.

Winter Hardiness

No winter injury occurred to any of the African bermudagrass selections during both years. In 1991, Tifgreen experienced a mean of 69% winter injury to plots mowed at the 0.3 cm height and 10% damage on plots mowed at 0.5 cm. There were no noticeable signs of winter damage to Tifgreen in the spring of 1993. Both winters were considered mild. During the 1991 - 1992 winter the region received very little snow cover compared to the following winter season. It is most likely that the winter injury experienced in 1991 was a result of a severe drop in daily air temperatures beginning on 29 October 1991 and continuing through 11 November 1991. Daily air temperatures for the 1991, 1992 and 1993 winter seasons are listed in Appendix B.

Thatch

An attempt was made to measure accumulation of thatch in this study. Several samples were taken from various plots. There was no noticeable thatch layer in any of the samples taken. Additionally, there was no clear distinction among the layers in the soil profile due to frequent topdressing. As a result no measurements of thatch could be taken. Measurements of thatch in African bermudagrass plots may only be possible after several years of plot maintenance.

Observations on Insect and Disease Damage

There was very little incidence of insect or disease injury to the bermudagrasses in either of the two years of this study. The test was adjacent to creeping bentgrass plots. Statistical comparisons between the two turfgrass putting surfaces could not be made, but apparent differences in insect and disease problems were noted. High levels of infestation of black cutworms (*Agrotis ipsilon* Hufnagel) were observed on creeping bentgrass plots in both years. When numbers of cutworms and damage caused by cutworms were observed, there was considerably less incidence on any of the bermudagrass plots. Black cutworm numbers were determined by counting individual larva rising to the surface following insecticide application on 12 September 1992. There were no statistical differences among bermudagrass genotypes. A gradient of decreasing numbers of cutworms with distance of the bermudagrass plots from bentgrass was present.

Observations on incidence of Dollar Spot caused by the fungus *Sclerotinia homoeocarpa* were made during the 1991 and 1992 growing seasons. There was a heavy incidence of dollar spot observed on creeping bentgrass cultivars. The dollar spot fungi had injurious effects on bentgrass cultivars, however no signs of damage occurred to any bermudagrass selections and only traces of mycelium were observed on bermudagrass genotypes.

In the spring of 1992 and 1993, there were signs of what was presumed to be Spring Dead Spot disease caused by *Ophiosphaerella herpotricha*. Damage was not uniform enough to merit evaluation. Damaged areas recovered quickly. Currently, all bermudagrass cultivar species are believed to be susceptible to Spring Dead Spot disease with some differences present in tolerance and recuperative capacity (N. Tisserat, personal communications). Spring Dead Spot disease is known to be a serious problem on Tifgreen putting greens in southern Oklahoma (D.L. Martin, personal communications).

Seed Head Production

Beginning on approximately 11 July 1991 during the establishment period, Tifgreen began producing a large number of seed heads. This pattern continued through August 1991. During 1991 there were no seedheads produced on any of the African bermudagrasses.

In 1992, all African bermudagrass genotypes except Ctr-2747 began producing seed heads by 30 April 1992. On 30 April 1992 seedheads were more predominant on plots mowed at 0.5 cm height. Throughout the 1992 season, African bermudagrass Ctr-2747 had an estimated seed head production of only 25% at any one time. Tifgreen began producing seedheads on 6 July 1992. Seedheads were noticeable through 13 July 1992 for most African bermudagrasses. After this date the number of seedheads declined substantially. On 20 August 1992 Ctr-2387 began producing seedheads. Within 2 d, plots were completely covered with seedheads for a duration of approximately 2 wk. It is unclear as to why Ctr-2387 began seedhead production at this time.

SUMMARY

Tifgreen and Uganda were the first cultivars to attain 100% ground cover as assessed by a visual method. When the angle of orientation of leaf blades to the vertical axis of the shoot was measured, Tifgreen was found to have a more prostrate growth habit. Overall bermudagrass root mass was greater at 0 - 7.5 cm depth than at 7.5 - 15 cm depth. No clear trends existed among genotypes for root mass distribution. Additionally, Tifgreen had the slowest spring green-up rates in both years. When analyzing readings taken from a USGA Stimpmeter, there was no overall difference for ball speed between Ctr-2387 and Tifgreen in both years. African bermudagrass genotype Ctr-2747 had a more dense turfgrass canopy than Tifgreen, as supported by shoots per unit area and visual density ratings. In both years Tifgreen was rated darker green in color than either Uganda or any of the selected *C. transvaalensis* genotypes. African bermudagrass genotypes Ctr-2747 and Ctr-2864 generally had greater visual quality in both the 1991 and 1992 growing seasons than did Tifgreen hybrid bermudagrass. Following the first winter after establishment, Tifgreen mowed at 0.3 cm height was less winterhardy than either Uganda or *C. transvaalensis* genotypes.

Results of this research indicate morphological variation exists among *C. transvaalensis* genotypes. Due to this variation, screening of many different progeny plants may lead to the development of improved cultivars for use on golf course putting greens.

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Table 1. Analysis of variance for ground cover using a visual estimate of plot cover and a grid method for cover of bermudagrass during 1991.

	Visual Ratings		Grid Method	
Source	df	Mean Squares	df	Mean Squares
		%		%
Block	3	462.1 NS	3	194.2 NS
Genotype (G)	7	1074.1 **	7	760.7 **
Error a	21	294.5	21	154.7
Time (T)	9	42428.4 ***	4	13975.8 ***
G * T	63	105.2 ***	28	73.5 ***
Error b	216	43.6	96	29.0

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.

Table 2. Mean percent ground cover of bermudagrass on a weekly basis using a randomly placed grid in 1991†.

	Percent Ground Coverage					
Genotype	24 May	31 May	6 Jun	16 Jun	21 Jun	28 Jun
	%					
696	19.5	44.9 a	73.1 a	96.1 a	95.3	100.0
1397	16.0	44.1 ab	63.7 abc	94.9 ab	92.1	100.0
1415	20.3	28.9 bcd	54.0 abc	93.8 ab	96.9	100.0
2387	14.8	23.1 cd	43.0 cd	80.5 b	87.1	100.0
2747	13.3	21.1 d	30.9 d	50.4 c	77.0	100.0
2864	13.3	27.3 cd	45.7 bcd	85.6 ab	95.7	100.0
Tifgreen	25.4	49.2 a	67.6 ab	98.4 a	98.8	100.0
Uganda	14.1	37.9 abc	59.8 abc	94.9 ab	98.0	100.0
$LSD_{(0.05)}$	NS	15.8	24.2	15.2	NS	NS

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 3. Mean percent ground cover of bermudagrass on a weekly basis in 1991 using a visual method†.

Genotype	Percent Ground Cover									
	14 May	24 May	30 May	7 Jun	14 Jun	21 Jun	29 Jun	6 Jul	13 Jul	20 Jul
	%									
696	9.3	22.5	30.0 a	40.0 a	77.5 a	83.8 ab	97.0 a	99.5 a	100.0 a	100.0 a
1397	11.3	25.0	38.8 ab	41.3 a	68.8 ab	76.3 abc	65.8 a	98.8 a	100.0 a	100.0 a
1415	8.0	17.5	21.3 cd	36.3 a	60.0 abc	76.3 abc	95.8 a	99.5 a	100.0 a	100.0 a
2387	6.0	18.8	21.3 cd	35.0 ab	52.5 bc	62.5 cd	91.3 a	97.8 a	99.0 a	100.0 a
2747	8.0	15.0	20.0 d	25.0 b	41.3 c	50.0 d	74.5 b	86.3 b	93.3 b	98.3 b
2864	8.0	15.0	22.5 bcd	32.5 ab	55.0 bc	65.0 bcd	92.0 a	98.5 a	99.5 a	100.0 a
Tifgreen	11.3	20.0	27.5 abc	42.5 a	80.0 a	89.5 a	99.5 a	100.0 a	100.0 a	100.0 a
Uganda	8.0	13.8	23.8 abcd	40.0 a	71.3 ab	81.3 abc	97.8 a	100.0 a	100.0 a	100.0 a
$LSD_{(0.05)}$	NS	NS	6.8	10.3	21.8	21.1	12.6	5.3	6.7	1.2

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 4. Analysis of variance for clipping yield of bermudagrasses in 1991 and 1992.

	Clipping Yields			
	1991		1992	
Source	df	Mean Squares	df	Mean Squares
		g		g
Block (Blk)	3	3.1 NS	3	29.2 NS
Mowing Height (MH)	1	11.6 *	1	2.1 NS
Error a	3	0.6	3	8.6
Genotype (G)	7	3.6 NS	7	77.2 ***
Error b	21	1.5	21	3.2
G * MH	7	0.6 NS	7	5.9 NS
Error c	21	0.5	21	3.3
Time (T)	3	37.6 ***	7	423.4 ***
T * MH	3	5.4 ***	7	11.8 ***
G * T	21	0.6 *	49	3.9 ***
G * T * MH	21	0.2 NS	49	3.1 *
Error d	144	0.4	336	2.1

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.

Table 5. Mean clipping yields collected from bermudagrass during 1991†.

Genotype	Clipping Yield			
	12 Sept	26 Sept	3 Oct	10 Oct
	kg ha^{-1}			
696	18.7	5.5	6.61	6.5 cd
1397	18.6	7.3	7.4	7.1 c
1415	22.8	9.9	8.2	7.6 bc
2387	16.1	6.2	6.0	4.1 de
2747	21.8	9.1	9.4	4.6 de
2864	11.9	5.4	5.4	3.2 e
Tifgreen	14.5	7.6	10.5	9.7 b
Uganda	22.2	10.1	10.9	13.0 a
$LSD_{(0.05)}$	NS	NS	NS	2.5

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 6. Means for clipping yields for bermudagrass during 1992†.

Genotype	11 Jun MH 1‡	11 Jun MH 2	25 Jun MH 1	25 Jun MH 2	9 Jul MH 1	9 Jul MH 2	23 Jul MH 1	23 Jul MH 2
	Clipping Yield (kg ha^{-1})							
696	56.21 dc	57.06 bc	43.49 bc	36.35 bc	55.36 ab	45.85 bc	54.45 ab	58.14 abcd
1397	68.48 ab	68.33 abc	49.95 b	40.73 abc	61.85 ab	47.90 b	52.30 abc	61.72 ab
1415	67.55 ab	60.78 bc	51.82 b	43.80 abc	59.81 ab	44.00 bc	60.25 ab	48.60 cd
2387	50.33 de	43.55 d	36.21 cd	31.77 c	49.80 b	46.40 bc	47.66 bc	45.93 d
2747	73.25 a	69.57 ab	64.68 a	50.89 a	68.29 a	52.75 b	64.89 a	68.10 a
2864	62.57 abc	56.51 c	45.64 bc	40.61 abc	49.17 b	33.82 c	51.06 abc	59.10 abc
Tifgreen	40.37 e	58.96 bc	31.03 d	42.68 abc	30.72 c	51.19 b	36.65 c	54.97 bcd
Uganda	59.34 bcd	76.93 a	54.18 ab	45.07 ab	63.82 ab	71.82 a	55.69 ab	64.00 ab
$LSD_{(0.05)}$	10.87	12.56	11.65	11.49	18.17	12.66	15.91	12.55

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 6. (Continued)†

	Clipping Yield							
	6 Aug		23 Aug		17 Sept		1 Oct	
Genotype	MH 1‡	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
	kg ha^{-1}							
696	64.06 c	67.17 b	74.38 cd	60.74 de	48.27 b	58.16 ab	19.42 bc	8.73 d
1397	72.33 bc	71.25 ab	79.40 bc	73.20 cd	45.93 b	68.74 a	19.25 bc	14.51 bc
1415	73.30 bc	72.97 ab	77.21 c	74.30 bcd	42.72 b	55.11 ab	19.38 bc	13.36 bc
2387	64.69 c	66.45 b	72.97cd	78.63 bc	35.11 b	49.00 b	13.36 c	10.29 cd
2747	94.12 a	79.82 a	111.76 a	92.77 a	47.03 b	68.90 a	25.69 ab	17.77 b
2864	72.29 bc	74.87 ab	74.37 cd	75.38 bc	47.32 b	60.21 ab	19.90 bc	13.43 bc
Tifgreen	44.30 d	56.42 c	58.80 d	52.91 e	51.56 b	48.04 b	19.40 bc	11.38 cd
Uganda	78.00 b	78.00 a	94.58 b	87.13 ab	71.96 a	59.53 ab	30.40 a	23.85 a
$LSD_{(0.05)}$	12.25	9.48	16.31	13.82	17.54	15.41	7.10	4.61

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 7. Analysis of variance for the angle of orientation of the first four leaf blades of a bermudagrass shoot during 1992.

Source	df	Leaf Blade Angle Mean Squares
		degrees
Block (Blk)	3	120.3 NS
Mowing Height (MH)	1	1342.8 NS
Error a	3	137.3
Genotype (G)	7	1393.2 ***
Error b	21	102.1
G * MH	7	129.7 NS
Error c	21	123.6
Time (T)	1	3351.6 ***
T * MH	1	198.3 NS
T*G	7	28.1 NS
T *G* MH	7	97.5 NS
Error d	48	92.5
Leaf Position (LP)	3	31241.5 ***
LP*G	21	113.0 *
LP*MH	3	41.1 NS
LP*T	3	350.4 **
LP*G*MH	21	58.0 NS
LP*T*G	21	88.9 NS
LP*T*MH	3	20.6 NS
LP*T*G*MH	21	72.2 NS
Error e	288	64.7

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.

Table 8. Mean angle of orientation for the first four leaf positions for bermudagrass during 1992†.

Genotype	Leaf Blade Angle‡ First Leaf Position	Second Leaf Position	Third Leaf Position	Fourth Leaf Position
696	47.8 bc	68.7 ab	74.8 ab	72.6 bc
1397	48.7 bc	65.8 bcd	71.7 bc	68.9 cd
1415	45.3 c	66.2 bcd	71.6 bc	68.5 cd
2387	47.7 bc	64.4 cde	73.8 ab	73.9 b
2747	47.7 bc	63.3 de	72.2 bc	71.8 bc
2864	46.3 bc	62.0 e	70.5 bc	65.5 d
Tifgreen	57.1 a	71.7 a	79.7 a	80.4 a
Uganda	50.7 b	67.2 bc	68.4 c	71.8 bc
$LSD_{(0.05)}$	4.8	3.2	5.0	4.3

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test

‡ Angle of orientation of the leaf blade from the vertical axis in degrees.

Table 9. Analysis of variance for root mass distribution of bermudagrasses in 1991 and 1992.

	Root Mass			
	1991†		1992	
Source	df	Mean Squares	df	Mean Squares
		g		g
Block (Blk)	3	0.003 NS	3	0.010 NS
Mowing Height (MH)	1	0.001 NS	1	0.124 NS
Error a	3	0.001	3	0.046
Genotype (G)	7	0.001 NS	7	0.059 ***
Error b	21	0.001	21	0.006
G * MH	7	0.002 NS	7	0.011 NS
Error c	21	0.001	21	0.012
Time (T)	--	--	2	0.511 ***
T * MH	--	--	2	0.011 NS
G * T	--	--	14	0.015 NS
G * T * MH	--	--	14	0.010 NS
Error d	--	--	96	0.011
Depth (D)	1	0.163 ***	1	14.586 ***
D*G	7	0.001 NS	7	0.052 ***
D*MH	1	0.001 NS	1	0.062 *
D*T	--	--	2	0.460 ***
D*T*MH	--	--	2	0.015 NS
D*T*G	--	--	14	0.014 NS
D*G*MH	7	0.002 NS	7	0.009 NS
D*T*G*MH	--	--	14	0.008 NS
Error e	48	0.001	144	0.010

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.
† Sampling was conducted on only one date in 1991.

Table 10. Mean root mass at two depths for bermudagrass during 1992†.

	Root Mass					
	1 June		31 July		10 October	
	cm		cm		cm	
Genotype	0 - 7.5	7.5 - 15	0 - 7.5	7.5 - 15	0 - 7.5	7.5 - 15
	g					
696	0.311 abc	0.037	0.497	0.042	0.629 a	0.043 bc
1397	0.374 ab	0.054	0.531	0.034	0.607 a	0.057 ab
1415	0.411 a	0.047	0.518	0.057	0.631 a	0.050 b
2387	0.325 abc	0.049	0.495	0.030	0.472 ab	0.029 c
2747	0.251 c	0.048	0.420	0.045	0.643 a	0.070 a
2864	0.272 bc	0.048	0.423	0.048	0.599 a	0.059 ab
Tifgreen	0.227 c	0.042	0.467	0.049	0.400 b	0.057 ab
Uganda	0.257 bc	0.028	0.308	0.040	0.394 b	0.048 b
$LSD_{(0.05)}$	0.120	NS	NS	NS	0.117	0.019

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 11. Analysis of variance for bermudagrass shoot counts during 1991 and 1992.

	Shoot Counts			
	1991		1992	
Source	df	Mean Squares	df	Mean Squares
		shoots cm^{-2}		shoots cm^{-2}
Block (Blk)	3	811.0 NS	3	1390.8 NS
Mowing Height (MH)	1	203.0 NS	1	2186.3 NS
Error a	3	583.4	3	1900.2
Genotype (G)	7	4944.6 ***	7	12596.9 ***
Error b	21	191.5	21	1047.3
G * MH	7	144.6 NS	7	943.8 NS
Error c	21	113.3	21	1208.3
Time (T)		--	1	149262.8 ***
T * MH		--	1	476.6 NS
G * T		--	7	3702.1 **
G * T * MH		--	7	2267.4 NS
Error d		--	48	1207.2

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.

Table 12. Mean number of shoots per unit area for bermudagrass during 1991 and 1992†.

Genotype	Shoot Count		
	1991	1992	
	23 Oct	1 Jun	31 Jul
	shoots cm^{-2}		
696	15.2 a	13.3 bc	26.2 a
1397	12.9 bc	14.7 ab	21.4 c
1415	13.2 bc	15.0 ab	23.3 abc
2387	11.9 bc	19.4 a	21.0 c
2747	13.6 ab	15.2 ab	24.9 ab
2864	13.1 bc	15.4 ab	25.8 a
Tifgreen	5.4 d	8.2 c	13.0 d
Uganda	11.6 c	13.0 bc	22.3 bc
$LSD_{(0.05)}$	1.7	5.4	3.1

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 13. Analysis of variance for visual estimate of percent green-up for bermudagrass during the spring of 1992 and 1993.

	Spring Green-up Rating			
	1992		1993	
Source	df	Mean Squares	df	Mean Squares
		%		%
Block	3	393.6 NS	3	1315.9 *
Mowing Height (MH)	1	9102.5 **	1	207.6 NS
Error a	3	182.9	3	128.6
Genotype (G)	7	4591.5 ***	7	11274.5 ***
Error b	21	557.2	21	588.9
G * MH	7	63.2 NS	7	101.5 NS
Error c	21	52.3	21	61.7
Time (T)	11	38160.3 ***	6	13792.5 ***
T * MH	11	152.3 ***	6	43.8 NS
G * T	77	307.6 ***	42	406.6 ***
G * T * MH	77	59.4 **	42	19.2 NS
Error d	528	38.8	288	54.4

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.

Table 14. Mean visual percentage green-up for bermudagrass at two mowing heights (MH) during 1992†.

	Green-up Ratings							
	2 Mar		5 Mar		9 Mar		12 Mar	
Genotype	MH 1‡	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
	%							
696	3.7	6.8	7.0	10.6 a	10.0	15.0 a	10.0 a	15.0 a
1397	1.3	4.3	4.4	8.1 a	6.1	9.3 a	6.1 ab	9.3 a
1415	2.3	5.0	5.5	8.8 a	6.9	11.3 a	6.9 a	11.3 a
2387	1.5	5.0	4.3	9.4 a	6.9	11.3 a	6.9 a	11.3 a
2747	1.8	7.5	5.0	8.6 a	6.8	12.5 a	6.8 a	12.5 a
2864	1.0	3.5	3.5	10.0 a	4.3	10.0 a	4.3 ab	10.0 a
Tifgreen	0.0	0.0	1.3	1.3 b	0.5	2.3 b	0.5 b	2.3 b
Uganda	0.5	3.5	1.5	5.6 ab	4.3	8.8 ab	4.3 ab	8.8 ab
$LSD_{(0.05)}$	NS	NS	NS	5.5	NS	6.6	6.2	6.6

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 14. (Continued)†

Genotype	Green-up Ratings							
	16 Mar		18 Mar		23 Mar		26 Mar	
	MH 1‡	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
	%							
696	18.1	25.0	22.5 a	32.5 a	25.0 a	37.5 a	25.0 a	37.5 a
1397	10.0	15.0	18.8 ab	25.0 a	17.5 a	33.8 a	17.5 a	33.8 a
1415	10.6	17.5	18.8 ab	28.8 a	18.8 a	31.2 a	18.8 a	31.3 a
2387	11.9	22.5	15.0 ab	28.8 a	18.8 a	27.5 a	18.8 a	27.5 a
2747	12.5	21.3	15.0 ab	26.3 a	25.0 a	33.8 a	25.0 a	33.8 a
2864	7.5	20.0	12.5 b	27.5 a	15.0 a	25.0 a	15.0 a	25.0 a
Tifgreen	0.5	7.5	0.5 c	5.0 b	1.3 b	7.5 b	1.3 b	7.5 b
Uganda	6.3	12.5	11.3 b	22.5 a	12.5 ab	26.3 a	12.5 ab	26.3 a
$LSD_{(0.05)}$	NS	NS	9.6	10.0	13.0	17.2	13.0	17.2

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 14. (Continued)†

Genotype	Green-up Ratings 6 Apr MH 1‡	6 Apr MH 2	8 Apr MH 1	8 Apr MH 2	13 Apr MH 1	13 Apr MH 2	16 Apr MH 1	16 Apr MH 2
	%							
696	13.8 ab	16.3	32.5 a	41.3 a	53.8 ab	63.8 a	98.8 a	100.0 a
1397	15.0 ab	18.8	35.0 a	42.5 a	55.0 ab	63.8 a	97.5 ab	77.5 a
1415	17.5 ab	22.5	35.0 a	37.5 a	52.5 ab	58.8 a	97.5 ab	100.0 a
2387	12.5 b	16.3	33.8 a	36.3 a	60.0 a	63.8 a	100.0 a	100.0 a
2747	21.3 a	21.3	35.0 a	37.5 a	57.5 a	61.3 a	95.0 ab	100.0 a
2864	12.5 b	16.3	26.3 a	33.8 a	51.3 ab	60.0 a	95.0 ab	100.0 a
Tifgreen	2.5 c	13.8	4.8 b	18.8 b	12.3 b	36.3 b	16.3 c	51.2 b
Uganda	10.6 b	16.3	25.0 a	36.3 a	42.5 c	57.5 a	86.3 b	100.0 a
$LSD_{(0.05)}$	8.1	NS	12.2	12.5	14.2	12.1	11.5	24.6

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 15. Mean visual green-up ratings for bermudagrass during 1993†.

Genotype	Green-up Ratings						
	30 Mar	2 Apr	5 Apr	7 Apr	12 Apr	20 Apr	23 Apr
	%						
696	71.9 a	68.1 ab	63.8 bc	70.6 ab	77.5 bc	100.0 a	100.0 a
1397	73.1 a	68.4 ab	62.5 c	66.9 b	75.6 c	100.0 a	100.0 a
1415	71.9 a	72.1 ab	67.5 abc	72.5 ab	75.6 c	100.0 a	100.0 a
2387	67.5 a	64.4 b	61.3 c	73.8 ab	73.8 c	100.0 a	100.0 a
2747	81.9 a	82.8 a	82.5 a	77.5 ab	89.4 a	100.0 a	100.0 a
2864	76.3 a	65.6 b	71.9 abc	77.5 ab	75.6 c	100.0 a	100.0 a
Tifgreen	23.4 b	29.0 c	23.4 d	15.9 c	50.6 d	61.9 b	94.4 b
Uganda	80.6 a	75.0 ab	80.6 ab	83.8 a	84.4 ab	100.0 a	100.0 a
$LSD_{(0.05)}$	15.3	15.9	17.2	14.1	8.4	8.6	2.7

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 16. Analysis of variance for USGA stimpmeter readings on bermudagrass during 1991 and 1992.

	Stimpmeter Readings			
	1991		1992	
Source	df	Mean Squares	df	Mean Squares
		cm		cm
Block (Blk)	3	1775.7 NS	3	2968.8 NS
Mowing Height(MH)	1	589984.0 **	1	1713417.9 ***
Error a	3	7280.3	3	2261.3
Genotype(G)	7	40867.9 ***	7	40407.4 ***
Error b	21	4411.1	21	4357.5
G * MH	7	1018.1 NS	7	1100.6 NS
Error c	21	1509.4	21	1762.9
Time(T)	5	68990.5 ***	14	52454.6 ***
T * MH	5	21487.3 ***	14	2296.1 ***
G * T	35	1491.7 ***	98	1169.7 ***
G * T * MH	35	452.0 NS	98	373.0 NS
Error d	240	479.2	672	422.8

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.

Table 17. Weekly means for USGA stimpmeter readings for bermudagrass during 1991†.

Genotype	USGA Stimpmeter Readings					
	13 Sept	20 Sept	27 Sept	4 Oct	11 Oct	18 Oct
	cm					
696	213.3 bc	229.0 bc	262.7 ab	245.6 bc	249.0 bc	241.6 c
1397	215.0 b	226.7 c	248.9 bc	240.5 c	244.2 bc	247.1 bc
1415	212.7 bc	227.3 c	249.1 bc	237.7 c	238.0 cd	242.2 c
2387	222.1 ab	239.5 ab	258.2 abc	256.7 ab	266.3 a	261.2 a
2747	220.9 ab	224.3 c	246.4 c	239.1 c	249.1 bc	250.1 abc
2864	221.8 ab	245.1 a	265.8 a	260.5 a	259.0 ab	256.7 ab
Tifgreen	229.0 a	249.9 a	272.3 a	263.4 a	251.0 abc	244.3 bc
Uganda	202.2 c	206.3 d	222.0 d	219.1 d	225.0 d	222.1 d
$LSD_{(0.05)}$	11.6	11.1	16.3	14.0	16.8	13.9

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 18. Means for USGA Stimpmeter readings for bermudagrass during 1992†.

	USGA Stimpmeter Readings							
Genotype	27 May	10 Jun	24 Jun	8 Jul	14 Jul	22 Jul	29 Jul	12 Aug
	cm							
696	196.3 bc	217.2 b	207.7 a	215.4 ab	214.4 a	200.6 ab	207.5 abc	205.5
1397	191.2 bcd	212.6 b	195.4 bc	209.0abc	212.0 ab	194.3 abc	202.0 bc	198.8
1415	194.1 bcd	213.3 b	201.2 ab	205.8 bc	208.4 ab	193.9 abc	203.3 abc	200.5
2387	208.1 a	231.0 a	207.0 a	218.2 ab	217.1 a	202.6 a	209.0 ab	203.0
2747	187.0 cd	208.5 b	193.6 bc	196.8 c	203.2 b	187.7 c	197.8 cd	196.6
2864	201.3 ab	212.0 b	196.6 ab	215.6 ab	213.5 a	200.7 ab	205.8 abc	197.4
Tifgreen	199.7 ab	231.5 a	196.6 bc	219.8 a	210.0 ab	199.6 abc	211.9 a	200.7
Uganda	185.7 d	207.2 b	187.9 c	199.1 c	209.1 ab	190.3 bc	190.9 d	195.9
$LSD_{(0.05)}$	10.4	13.4	9.2	13.9	10.1	12.1	9.7	NS

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 18. (Continued)†

Genotype	USGA Stimpmeter Readings						
	21 Aug	28 Aug	10 Sept	17 Sept	25 Sept	30 Sept	9 Oct
	cm						
696	198.0 abc	198.0 bc	189.5 bcd	198.5 ab	202.5 bc	212.0 bc	237.4 bcd
1397	193.4 cde	192.6 c	190.5 bc	190.3 bc	199.5 c	204.9 bc	238.5 bc
1415	191.9 cde	194.1 c	189.0 bcd	193.1 bc	201.1 c	209.2 bc	240.0 bc
2387	209.0 a	208.8 ab	193.4 b	203.5 a	217.8 a	230.0 a	257.8 a
2747	184.7 de	192.1 c	179.0 d	188.3 c	197.9 c	203.4 c	227.7 d
2864	195.8 bcd	200.3 bc	186.6 bcd	193.3 bc	199.1 c	215.4 b	230.1 cd
Tifgreen	205.6 ab	217.7 a	217.8 a	204.6 a	213.1 ab	230.8 a	246.8 b
Uganda	184.4 e	193.4 c	180.3 cd	185.9 c	183.7 d	190.9 d	214.5 e
$LSD_{(0.05)}$	11.2	11.7	11.1	10.1	11.6	10.7	10.4

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.

Table 19. Analysis of variance for visual density ratings of bermudagrass during 1991 and 1992.

	Visual Density Ratings†			
	1991		1992	
Source	df	Mean Squares	df	Mean Squares
Block (Blk)	3	0.3 NS	3	16.9 NS
Mowing Height (MH)	1	62.3 ***	1	479.3 **
Error a	3	0.1	3	6.4
Genotype (G)	7	5.7 NS	7	123.4 ***
Error b	21	2.5	21	4.9
G * MH	7	0.2 *	7	16.7 ***
Error c	21	0.1	21	2.8
Time (T)	6	23.0 ***	23	10.9 ***
T * MH	6	3.0 ***	23	6.1 ***
G * T	42	1.4 ***	161	1.7 ***
G * T * MH	42	0.1 NS	161	0.7 **
Error d	288	0.3	1104	0.47

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.
† Scale is based on a rating of 1 - 9 (1=straw, 6=acceptable, and 9=dark green).

Table 20. Mean visual estimates of turfgrass density for bermudagrass during 1991†.

	Visual Density Rating‡						
Genotype	13 Sept	20 Sept	27 Sept	4 Oct	11 Oct	18 Oct	1 Nov
696	6.5	6.0 d	6.0	6.5 d	7.1	7.8	8.8 a
1397	6.4	6.3 cd	6.3	6.5 d	6.8	7.5	8.5 a
1415	7.0	6.5 cd	6.5	6.9 cd	6.8	7.5	8.6 a
2387	6.8	6.0 d	6.1	6.8 d	6.5	7.5	7.0 b
2747	7.1	8.0 a	7.5	8.0 a	7.1	7.8	8.1 a
2864	6.8	7.3 ab	7.3	7.4 bc	7.5	7.8	8.1 a
Tifgreen	5.8	7.0 bc	7.0	6.6 d	7.0	7.6	7.9 ab
Uganda	6.5	6.3 cd	6.4	7.5 ab	7.3	8.1	8.3 a
$LSD_{(0.05)}$	NS	1.0	NS	0.5	NS	NS	0.9

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = very thin, 6 = acceptable, 9 = very dense).

Table 21. Weekly means for visual estimate of turfgrass density for bermudagrass at two mowing heights (MH) during 1992†.

	Visual Density Rating‡							
	30 Apr		11 May		18 May		25 May	
Genotype	MH 1§	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
696	4.3 b	6.0 abc	6.5 ab	8.3 a	6.5 ab	8.3 a	6.5 ab	8.0 abc
1397	4.3 b	5.5 bc	6.0 ab	7.8 a	6.8 ab	8.0 ab	6.3 ab	8.0 abc
1415	5.5 ab	6.3 abc	6.5 ab	7.5 ab	7.0 ab	8.0 ab	6.5 ab	8.3 ab
2387	6.8 a	6.5 ab	6.3 ab	7.5 ab	6.8 ab	8.0 ab	6.5 ab	7.0 c
2747	5.0 ab	5.3 c	7.3 a	8.3 a	7.3 a	8.3 a	7.3 a	8.5 a
2864	5.3 ab	6.8 a	6.3 ab	7.8 a	6.5 ab	8.0 ab	6.5 ab	8.0 abc
Tifgreen	4.0 b	6.0 abc	2.5 c	6.5 b	2.3 c	7.0 b	2.3 c	7.3 bc
Uganda	5.0 ab	6.3 abc	5.3 b	7.3 ab	5.5 b	7.8 ab	5.3 b	7.3 bc
$LSD_{(0.05)}$	2.4	1.2	1.8	1.1	1.6	1.0	1.6	1.0

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = very thin, 6 = acceptable, 9 = very dense).
§ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 21. (Continued)†

	Visual Density Ratings‡							
	31 May		8 Jun		18 Jun		22 Jun	
Genotype	MH 1§	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
696	6.8 a	7.8 abc	5.3 bc	7.3 bc	6.0 bc	7.0 c	6.0 abc	7.0 b
1397	6.5 a	8.0 ab	6.3 ab	7.3 bc	5.8 c	7.8 ab	6.5 ab	7.3 b
1415	6.8 a	7.8 abc	6.5 ab	7.5 b	6.3 bc	7.8 ab	6.5 ab	7.0 b
2387	6.3 ab	7.5 abc	5.5 bc	7.0 bc	5.3 cd	7.5 b	5.8 bc	7.3 b
2747	7.0 a	8.3 a	7.0 a	8.3 a	7.5 a	8.0 a	7.3 a	8.0 a
2864	7.0 a	7.5 abc	6.0 ab	7.3 bc	7.0 ab	8.0 a	7.0 ab	7.3 b
Tifgreen	2.5 c	7.0 c	2.5 d	6.8 c	2.5 e	6.0 d	3.0 d	6.0 c
Uganda	5.3 b	7.3 bc	4.5 c	7.0 cb	4.5 d	7.0 c	5.0 c	7.0 b
$LSD_{(0.05)}$	1.5	0.8	1.4	0.6	1.2	0.5	1.3	0.4

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = very thin, 6 = acceptable, 9 = very dense).
§ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 21. (Continued)†

	Visual Density Ratings‡							
	29 Jun		6 Jul		13 Jul		20 Jul	
Genotype	MH 1§	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
696	5.5 bcd	6.8 bc	5.8 bc	6.8 c	5.8 c	7.0 d	6.0 bc	7.3 de
1397	6.5 ab	7.0 abc	5.5 bc	7.0 bc	6.0 bc	7.5 dcd	6.3 bc	7.5 cd
1415	6.0 abc	7.3 ab	5.8 bc	7.5 ab	6.5 bc	7.5 cd	6.5 bc	7.5 cd
2387	5.0 cd	7.3 ab	5.5 bc	7.5 ab	6.0 bc	8.0 bc	5.3 c	8.0 bc
2747	7.0 a	7.8 a	7.3 a	8.0 a	8.8 a	8.8 a	8.8 a	9.0 a
2864	6.3 abc	7.8 a	6.8 ab	8.0 a	7.5 ab	8.5 ab	7.8 ab	8.5 ab
Tifgreen	2.5 e	6.3 c	2.8 d	6.8 c	3.3 d	7.0 d	3.3 d	7.3 de
Uganda	4.3 d	6.5 bc	5.0 c	7.0 bc	5.3 c	7.5 cd	5.0 cd	6.8 e
$LSD_{(0.05)}$	1.4	0.8	1.3	0.6	1.5	0.8	1.9	0.7

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = very thin, 6 = acceptable, 9 = very dense).
§ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 21. (Continued)†

	Visual Density Ratings‡							
	27 Jul		10 Aug		17 Aug		24 Aug	
Genotype	MH 1§	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
696	6.3 b	7.3 b	6.8 c	7.5 de	6.3 c	7.0 c	7.0 b	6.8 bc
1397	6.5 b	7.3 b	6.8 c	7.8 cde	6.0 c	7.0 c	6.8 b	6.8 bc
1415	6.8 b	7.0 b	7.5 bc	8.3 bc	6.8 c	8.0 b	6.5 bc	7.0 bc
2387	6.3 b	7.0 b	7.3 bc	8.0 cd	6.0 c	7.0 c	5.3 d	6.3 c
2747	8.3 a	8.3 a	9.0 a	8.8 ab	9.0 a	9.0 a	8.5 a	8.8 a
2864	8.0 a	8.0 a	8.3 ab	9.0 a	7.8 b	8.5 ab	7.0 b	7.5 b
Tifgreen	5.0 c	6.0 c	4.3 d	6.0 f	4.5 d	6.0 d	5.8 cd	5.3 d
Uganda	6.8 b	7.0 b	6.8 c	7.3 e	6.5 c	7.3 c	6.5 bc	6.5 c
$LSD_{(0.05)}$	0.8	0.5	1.1	0.7	0.9	0.6	0.7	0.8

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = very thin, 6 = acceptable, 9 = very dense).
§ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 21. (Continued)†

	Visual Density Rating‡							
	31 Aug		9 Sept		14 Sept		21 Sept	
Genotype	MH 1§	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
696	6.3 b	6.8 b	5.3 bc	6.0 c	5.3 bc	6.0 c	5.5	6.5 c
1397	6.0 b	7.0 b	5.3 bc	6.3 c	5.3 bc	6.3 c	6.0	6.3 bc
1415	6.3 b	7.0 b	5.3 bc	6.8 b	5.3 bc	6.8 b	7.0	7.3 abc
2387	5.8 b	7.0 b	4.8 c	6.0 c	4.8 c	6.0 c	5.8	6.3 bc
2747	8.3 a	8.3 a	7.3 a	7.8 a	7.3 a	7.8 a	7.0	7.8 a
2864	7.5 a	7.8 a	6.0 b	7.0 b	6.0 b	7.0 b	7.0	7.0 abc
Tifgreen	4.0 c	5.5 c	5.0 bc	6.3 c	5.0 bc	6.3 c	5.5	6.5 abc
Uganda	6.3 b	7.0 b	6.0 c	7.0 b	6.0 b	7.0 b	6.8	7.5 ab
$LSD_{(0.05)}$	0.9	0.5	1.2	0.5	1.2	0.5	NS	1.2

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = very thin, 6 = acceptable, 9 = very dense).
§ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 21. (Continued)†

	Visual Density Rating‡							
	28 Sept		5 Oct		12 Oct		19 Oct	
Genotype	MH 1§	MH 2	MH 1	MH 2	MH 1	MH 2	MH 1	MH 2
696	5.5	6.0 c	6.5 c	7.3 c	6.0 cd	6.5 cd	6.0 bc	6.3 c
1397	6.0	6.3 bc	7.8 abc	7.8 bc	6.5 abc	6.8 bc	7.0 ab	6.3 c
1415	7.0	7.3 abc	7.5 abc	7.5 bc	6.3 bcd	6.8 bc	7.0 ab	7.0 b
2387	5.8	6.3 c	6.5 c	7.0 c	6.0 cd	6.5 cd	6.0 ab	6.3 c
2747	7.0	7.8 a	8.8 a	8.8 a	7.3 a	7.5 a	8.0 a	8.0 a
2864	7.0	7.0 abc	8.0 ab	8.3 ab	7.3 a	7.8 a	7.8 a	7.5 ab
Tifgreen	5.5	6.5 abc	5.0. d	6.0 d	5.5 d	6.0 d	5.3 c	6.0 c
Uganda	6.8	7.5 ab	7.3 bc	7.8 bc	7.0 ab	7.3 ab	7.0 ab	7.3 b
$LSD_{(0.05)}$	NS	1.2	1.3	0.8	0.9	0.7	1.2	0.7

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = very thin, 6 = acceptable, 9 = very dense).
§ Mowing height (MH) was 0.3 cm for MH 1 and 0.5 cm for MH 2.

Table 22. Analysis of variance for visual color ratings of bermudagrass during 1991 and 1992.

	Visual Color Ratings †			
	1991		1992	
Source	df	Mean Squares	df	Mean Squares
Block (Blk)	3	0.7 **	3	0.8 NS
Mowing Height (MH)	1	39.5 ***	1	37.8 **
Error a	3	0.1	3	0.4
Genotype (G)	7	29.7 ***	7	119.7 ***
Error b	21	0.6	21	1.4
G * MH	7	0.1 NS	7	0.8 ***
Error c	21	0.1	21	0.1
Time (T)	6	13.6 ***	23	28.4 ***
T * MH	6	4.3 ***	23	3.4 ***
G * T	42	2.5 ***	161	2.3 ***
G * T * MH	42	0.1 NS	161	0.1 NS
Error d	288	0.2	1104	0.3

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.

† Ratings were based on a scale of of 1 - 9 where 1=straw color, 6=acceptable, and 9=dark green.

Table 23. Mean visual color ratings for bermudagrass during 1991.†

Genotype	Visual Color Rating‡						
	13 Sept	20 Sept	27 Sept	4 Oct	11 Oct	18 Oct	1 Nov
696	5.8 c	6.1 b	6.0 c	7.5 abc	7.4 a	7.3 ab	7.8 a
1397	6.3 bc	6.5 b	6.5 b	7.8 ab	6.3 b	7.5 a	8.0 a
1415	6.5 b	6.5 b	6.5 b	7.3 bc	6.5 b	7.5 a	8.0 a
2387	6.5 b	6.3 b	6.4 bc	7.0 bc	6.0 bc	6.5 bc	7.8 a
2747	6.5 b	7.6 a	7.3 a	7.3 bc	6.0 bc	6.3 c	6.8 b
2864	6.5 b	7.5 a	7.3 a	6.8 c	5.3 cd	6.0 c	6.8 b
Tifgreen	7.8 a	7.5 a	7.5 a	8.3 a	7.4 a	7.5 a	8.0 a
Uganda	4.5 d	4.3 c	4.0 d	5.5 d	5.0 d	6.0 c	6.5 b
$LSD_{(0.05)}$	0.6	0.5	0.5	0.8	0.8	0.9	0.6

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 =straw, 6 = acceptable, 9 = dark green).

Table 24. Mean visual color ratings for bermudagrass during 1992†.

	Visual Color Ratings‡					
Genotype	30 Apr	11 May	18 May	25 May	31 May	8 Jun
696	5.8 b	7.5 bc	7.0 c	6.3 c	6.5 d	8.0 c
1397	6.6 ab	7.9 ab	7.8 b	7.4 b	7.6 bc	9.0 a
1415	5.6 b	7.8 bc	8.0 b	7.4 b	7.8 b	9.0 a
2387	6.1 b	7.0 c	7.8 b	7.4 b	7.1 c	8.5 b
2747	5.6 b	7.4 bc	7.5 bc	7.5 b	7.8 b	8.3 bc
2864	5.5 b	7.1 bc	7.0 c	7.5 b	7.3 bc	8.0 c
Tifgreen	8.0 a	8.6 a	8.6 a	8.6 a	8.6 a	9.0 a
Uganda	5.5 b	7.5 bc	7.0 c	6.6 c	6.1 d	7.3 d
$LSD_{(0.05)}$	1.5	0.9	0.5	0.7	0.6	0.5

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = straw, 6 = acceptable, 9 = dark green).

Table 24. (Continued)†

	Visual Color Ratings‡					
Genotype	18 Jun	22 Jun	29 Jun	6 Jul	13 Jul	20 Jul
696	6.9 c	7.1 bc	7.4 ab	8.3 a	7.6 bc	7.1 bc
1397	7.3 bc	7.3 bc	7.4 ab	8.5 a	8.0 ab	7.8 a
1415	7.3 bc	7.1 bc	7.1 ab	8.5 a	8.3 a	7.6 ab
2387	7.0 bc	7.5 b	6.4 c	7.5 b	8.0 ab	6.9 cd
2747	7.6 ab	7.1 bc	7.0 bc	7.5 b	7.8 ab	6.5 d
2864	7.5 bc	6.8 c	7.0 bc	7.3 b	7.5 bc	6.6 cd
Tifgreen	8.3 a	8.4 a	7.8 a	7.5 b	7.1 c	6.6 cd
Uganda	5.8 d	5.6 d	4.9 d	5.5 c	5.6 d	4.5 e
$LSD_{(0.05)}$	0.7	0.7	0.6	0.4	0.6	0.5

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = straw, 6 = acceptable, 9 = dark green).

Table 24. (Continued)†

Genotype	Visual Color Ratings‡					
	27 Jul	10 Aug	17 Aug	24 Aug	31 Aug	9 Sept
696	7.5 abc	7.3 ab	7.3 cd	6.1 bc	6.1 c	6.0 bc
1397	7.9 a	7.5 a	8.0 ab	7.0 a	7.3 b	6.4 b
1415	7.8 ab	7.4 ab	8.3 a	6.3 abc	7.3 b	6.4 b
2387	7.6 abc	6.6 b	6.5 e	4.8 d	6.4 c	5.5 c
2747	7.3 bc	6.8 ab	6.8 de	5.9 c	6.5 c	6.3 bc
2864	7.1 c	6.8 ab	6.8 de	5.6 c	6.6 c	6.0 bc
Tifgreen	7.3 bc	7.5 a	7.5 bc	6.8 ab	7.9 a	7.8 a
Uganda	5.8 d	5.0 c	4.8 f	4.0 d	4.6 d	4.4 d
$LSD_{(0.05)}$	0.6	0.8	0.7	0.8	0.6	0.8

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = straw, 6 = acceptable, 9 = dark green).

Table 24. (Continued)†

Genotype	Visual Color Ratings‡ 14 Sept	21 Sept	28 Sept	5 Oct	12 Oct	19 Oct
696	6.0 bc	7.0 c	7.0 c	7.8 ab	6.8 bc	6.8 ab
1397	6.4 b	8.0 b	8.0 b	7.3 bc	7.0 b	7.0 a
1415	6.4 b	8.0 b	8.0 b	7.0 c	7.0 b	6.5 ab
2387	5.5 c	7.3 c	7.3 c	7.0 c	6.0 cd	5.9 b
2747	6.3 bc	6.8 cd	6.8 cd	6.0 d	6.3 bc	4.9 c
2864	6.0 bc	6.3 d	6.3 d	6.3 d	6.0 cd	3.4 d
Tifgreen	7.8 a	8.9 a	8.9 a	8.0 a	8.0 a	6.0 b
Uganda	4.4 d	4.0 e	4.0 e	5.3 e	5.3 d	3.1 d
$LSD_{(0.05)}$	0.8	0.7	0.7	0.5	0.9	0.9

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = straw, 6 = acceptable, 9 = dark green).

Table 25. Analysis of variance for visual quality ratings of bermudagrass during 1991 and 1992.

	Visual Quality Ratings †			
	1991		1992	
Source	df	Mean Squares	df	Mean Squares
Block (Blk)	3	3.1 **	3	16.9 NS
Mowing Height (MH)	1	79.7 ***	1	346.0 **
Error a	3	0.1	3	5.2
Genotype (G)	7	8.6 **	7	116.4 ***
Error b	21	1.7	21	9.3
G * MH	7	0.2 NS	7	24.6 ***
Error c	21	0.1	21	3.5
Time (T)	6	10.8 ***	23	18.1 ***
T * MH	6	3.6 ***	23	8.4 ***
G * T	42	1.6 ***	161	2.3 ***
G * T * MH	42	0.1 NS	161	0.5 NS
Error d	288	0.2	1104	0.4

*, **, *** Significant at the $P \leq 0.05$, 0.01, and 0.001 probability levels respectively.
† Scale is based on a rating of 1 - 9 (1=poor, 6=acceptable, 9=excellent).

Table 26. Mean visual quality ratings for bermudagrass during 1991†.

Genotype	13 Sept	20 Sept	27 Sept	4 Oct	11 Oct	18 Oct	1 Nov
	Visual Quality Rating‡						
696	6.8 abc	6.5 bc	5.8 de	6.3 c	7.0 ab	7.0 bc	7.8 a
1397	6.5 bcd	6.5 bc	6.4 bcd	6.3 c	7.0 ab	7.3 bc	7.9 a
1415	7.4 ab	7.5 a	6.1 cde	6.6 c	6.5 bc	7.3 bc	7.8 a
2387	6.9 abc	7.0 ab	5.5 e	6.3 c	6.3 c	6.9 c	7.0 b
2747	7.6 a	7.8 a	7.8 a	8.0 a	6.6 bc	7.6 ab	7.6 a
2864	7.3 abc	7.3 ab	7.0 b	7.6 ab	7.3 a	8.0 a	7.9 a
Tifgreen	5.8 d	5.8 c	6.5 bc	6.4 c	6.6 bc	6.9 c	7.9 a
Uganda	6.4 cd	6.0 c	6.3 cd	7.4 b	7.5 a	6.9 c	7.8 a
$LSD_{(0.05)}$	0.9	0.9	0.7	0.6	0.6	0.7	0.4

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 = poor, 6 = acceptable, 9 = excellent).

Table 27. Mean visual quality ratings for bermudagrass during 1992†.

	Visual Quality Ratings‡					
Genotype	30 Apr	11 May	18 May	25 May	31 May	8 Jun
696	7.4 ab	5.1	7.1 ab	5.9 cd	6.4 c	5.4 bc
1397	6.9 ab	5.5	7.6 a	6.8 abc	6.9 abc	6.1 b
1415	7.3 ab	5.3	7.4 ab	7.1 ab	7.1 ab	6.0 b
2387	7.3 ab	5.0	6.8 ab	6.1 bcd	6.8 bc	5.4 bc
2747	7.6 a	5.1	7.8 a	7.3 a	7.5 a	7.0 a
2864	6.9 ab	4.9	6.4 b	6.5 abcd	6.9 abc	5.4 cb
Tifgreen	4.0 c	3.6	4.6 c	4.6 e	4.6 e	4.3 d
Uganda	6.1 b	4.5	6.4 b	5.6 de	5.5 d	5.1 c
$LSD_{(0.05)}$	1.3	NS	1.1	1.0	0.7	0.8

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 ($1 \leq$ poor, 6 = acceptable, 9 = excellent).

Table 27. (Continued)†

Genotype	Visual Quality Rating‡					
	18 Jun	22 Jun	29 Jun	6 Jul	13 Jul	20 Jul
696	5.1 de	5.4 bc	5.1 cd	6.4 cd	6.4 cd	5.5 cb
1397	6.0 bcd	5.8 b	5.9 bc	6.5 bc	7.0 bc	6.1 bd
1415	6.3 bc	6.1 ab	5.9 bc	6.5 bc	7.4 bc	6.5 b
2387	6.0 bcd	6.1 ab	6.5 cd	6.5 bc	6.9 c	5.0 bc
2747	7.4 a	7.1 a	7.0 a	7.8 a	8.9 a	7.9 a
2864	6.4 ab	6.4 ab	6.6 ab	7.4 ab	8.0 ab	6.5 b
Tifgreen	4.3 e	4.6 c	4.6 d	4.4 e	5.0 e	4.4 d
Uganda	5.3 cde	5.4 bc	4.9 d	5.5 d	5.8 de	5.4 cd
$LSD_{(0.05)}$	1.0	1.1	1.0	0.9	1.1	1.0

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 ($1 \leq$ poor, 6 = acceptable, 9 = excellent).

Table 27. (Continued)†

Genotype	Visual Quality Ratings‡					
	27 Jul	10 Aug	17 Aug	24 Aug	31 Aug	9 Sept
696	6.3 cd	6.8 c	6.6 b	6.5 b	5.9 cd	4.5 c
1397	6.6 bcd	7.0 c	6.8 b	7.0 b	5.9 cd	5.6 abc
1415	6.8 bc	7.4 c	7.3 b	6.9 b	6.3 c	5.9 ab
2387	6.5 bcd	7.3 c	6.6 b	4.5 d	5.4 de	5.1 bc
2747	8.0 a	9.0 a	8.4 a	8.0 a	7.8 a	6.8 a
2864	7.1 b	8.1 b	8.3 a	7.1 b	6.9 b	6.0 ab
Tifgreen	4.9 e	4.8 d	4.1 c	4.8 cd	5.1 e	6.4 a
Uganda	6.0 d	6.8 c	6.4 b	5.5 c	6.0 c	6.1 ab
$LSD_{(0.05)}$	0.7	0.7	0.9	0.8	0.5	1.2

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 ($1 \leq$ poor, 6 = acceptable, 9 = excellent).

Table 27. (Continued)†

Genotype	Visual Quality Ratings‡					
	14 Sept	21 Sept	28 Sept	5 Oct	12 Oct	19 Oct
696	4.5 c	5.3 d	5.3 d	6.5 cd	6.0 d	6.2 bc
1397	5.6 abc	6.6 bc	6.6 bc	6.9 bc	6.8 bc	6.5 bc
1415	5.9 ab	6.8 bc	6.8 bc	7.4 ab	6.9 b	6.6 b
2387	5.1 bc	5.9 cd	5.9 cd	6.5 cd	6.1 cd	5.8 c
2747	6.8 a	8.3 a	8.3 a	8.1 a	7.8 a	7.6 a
2864	6.0 ab	7.5 ab	7.5 ab	6.9 cb	7.9 a	6.1 bc
Tifgreen	6.4 a	6.1 cd	6.1 cd	5.8 d	6.5 bcd	5.9 bc
Uganda	6.1 ab	6.8 bc	6.8 bc	6.9 bc	6.8 bc	6.6 b
$LSD_{(0.05)}$	1.2	1.0	1.0	0.8	0.7	0.8

† Means within columns followed by the same letter are not significantly different at the $P \leq 0.05$ level using the LSD test.
‡ Ratings are based on a scale of 1 - 9 (1 ≤ poor, 6 = acceptable, 9 = excellent).

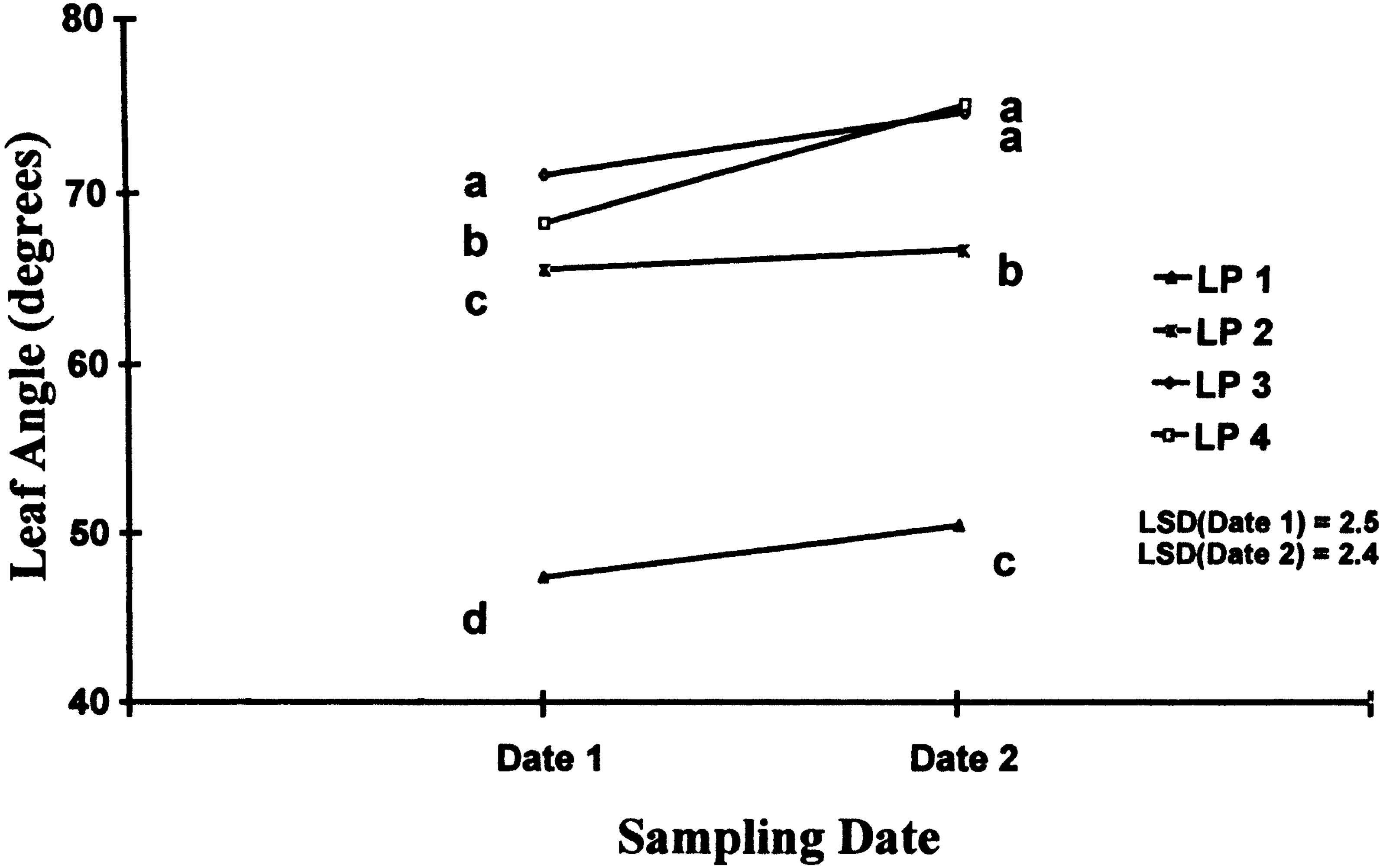

Figure 1. Means of the angle of orientation for each leaf positon (LP) of African bermudagrass on two sampling dates. Means with the same letter within sampling dates are not significantly different at the $P \leq 0.05$ level using the LSD Test.

CHAPTER III

TOLERANCE OF AFRICAN BERMUDAGRASS (*Cynodon dactylon*) TO SEVERAL POSTEMERGENT HERBICIDES

ABSTRACT

The intrusion of unwanted weed species is a persistent problem in managing golf course putting greens. Many herbicides may have phytotoxic effects on putting green turf. A greenhouse study was conducted to determine phytotoxic effects of postemergent herbicides on six experimental African bermudagrass (*Cynodon transvaalensis*) genotypes, Uganda African bermudagrass, Tifgreen hybrid bermudagrass (*Cynodon dactylon x C. transvaalensis*) and Tifdwarf hybrid bermudagrass (*Cynodon dactylon x C. transvaalensis*). Materials and rates included metsulfuron methyl at 0.01 kg ha^{-1}; dithiopyr at 0.57 kg ha^{-1}; dicamba at 0.11 kg ha^{-1}; MCPP at 0.56 kg ha^{-1}; MSMA at 1.14 and 2.29 kg ha^{-1}; Pronamide at 0.56 kg ha^{-1}; 2,4-D at 1.06 kg ha^{-1}; and the combination of 2,4-D, dicamba and MCPP at 0.17, 0.17 and 1.14 kg ha^{-1}, respectively. Grasses were evaluated visually 3 times a week for a period of 2 weeks for signs of phytotoxcity. The experiment was conducted two times. No visual phytotoxicity to any bermudagrass was seen during either study. Results of this experiment indicate no ultra sensitivity of African bermudagrass to commonly used post-emergent herbicides. Nomenclature: Metsulfuron Methyl, Methyl 2-[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-amino]carbonyl]amino]; Dithiopyr, 3,5-pyridinedicarbothioic acid, 2-(difluoromethyl)-4-(2-methylpropyl)-6-

(trifluoromethyl)-S, S-dimethyl ester; Dicamba, Dimethylamine salt of dicamba (3,6-dichloro-o-anisic acid); MCPP, Dimethylamine salt of 2-(2-methyl-4-chlorophenoxy) propionic acid; 2, 4-D, Dimethylamine salt of 2, 4-Dichlorophenoxyacetic acid; MSMA, Monosodium Acid Methanearsonate; Pronamide, 5-dichloro-N-(1, 1-dimethyl-2-propynyl)-benzamide; and a combination of 2, 4-D, Dimethylamine salt of 2, 4-Dichlorophenoxyacetic acid, Dicamba, Dimethylamine salt of Dicamba (3,6-dichloro-o-anisic acid) and MCPP, Potassium salt of 2-(2-methyl-4-chlorophenoxy) propionic acid.

INTRODUCTION

Broadleaf and grassy weeds are a persistent problem on golf course putting greens. Control of weed species is commonly accomplished through use of pre- and postemergent herbicides.

The majority of the putting greens in the southern region of the United States are composed of interspecific hybrid bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) (Anonymous, 1992). The primary use of *Cynodon transvaalensis* in the United States has been for the breeding of these interspecific hybrid bermudagrasses. African bermudagrass as a monoculture has been used primarily in South Africa. It has been used successfully on putting greens, tennis courts and bowling greens (Hanson, 1972). The use of *C. transvaalensis* by itself has been very limited in the United States. African bermudagrass has been used as a putting surface on a lower maintenance golf course in southwestern Oklahoma (D.L. Martin, personal communication).

Documented research on African bermudagrass of any kind has been limited in the past. Yang and Bingham (1984) showed *C. transvaalensis* to be less sensitive to the postemergent chemical metribuzine than other *Cynodon spp* in their trials. The bulk of research accomplished thus far has been with the use of interspecific hybrid bermudagrasses, Tifway, Tifgreen and Tifdwarf. These cultivars are commonly used in the southern regions (subtropical and tropical) of the United States on golf course putting greens.

Putting quality of turfgrass and aesthetics are especially important on golf courses. Superintendents must be aware of phytotoxic effects of herbicides which can result in reduction in quality or discoloration of turfgrass.

Postemergent herbicides have been shown to be phytotoxic to interspecific hybrid bermudagrasses. Johnson (1983) reported injury to Tifway, Tifgreen, and Tifdwarf mowed between 3 - 4 cm following fall applications of 2,4-D + mecoprop + dicamba at triple normal use rates (3.3 + 1.8 + 0.3 kg ha^{-1}). Johnson (1980b and 1982) also concluded when 2,4-D + mecoprop + dicamba was applied at rates of 1.1 + 0.6 + 0.1 and 1.2 + 0.6 + 0.1 kg ha^{-1} respectively during winter months, this postemergent herbicide had adverse effects on the re-growth and quality of common bermudagrass fairways during spring re-growth. Johnson (1984) suggested that the use of dicamba applied at rates of 1.2 and 2.4 kg ha^{-1} may have had a greater effect on the delay of spring re-growth of interspecific hybrid bermudagrasses at a mowing height of 7.5 cm than 2,4-D (2.4 and 4.8 kg ha^{-1}). This hypothesis would be consistent with an earlier report by Johnson (1973) where applications of MSMA + 2,4-D at 2.24 + 0.28 kg ha^{-1} were shown to have no phytotoxic effects during the establishment of Tifway bermudagrass. When applied alone, MSMA (2.2 kg ha^{-1}) had slight to no effects on the quality of bermudagrass fairways (McCarty et al., 1991; Johnson, 1977b). McCarty et al (1991) also reported slight to no effects of MSMA (2.2 kg ha^{-1}) on bermudagrass putting green quality when mowed at 0.5 cm height - of - cut. Murdoch and Ikeda (1974), however, observed phytotoxicity from MSMA (2.24 kg ha^{-1}) on Tifgreen but not on common bermudagrass. The preemergent herbicide pronamide, also having postemergent activity, has been shown to have no adverse effect on regrowth of common bermudagrass fairways during spring when applied at rates of either 1.6 or 0.8 kg ha^{-1} (Johnson, 1975 and Johnson, 1977a).

Applications of postemergent herbicides on bermudagrass putting surfaces have been shown to cause discoloration and reduction in density of the turfgrass (Higgins et al., 1987). McCarty (1991) reported combinations of MSMA and Diclofop injured both Tifgreen and Tifdwarf turfgrasses mowed at 1.9 cm. However, no adverse effects were found 14 days after postemergent treatment. Johnson (1980a) reported similar results when a combination of MSMA (2.24 kg ha^{-1}), methazole (0.14 kg ha^{-1}), and metribuzin (0.14 kg ha^{-1}) was applied to a Tifdwarf putting green mowed at 0.6 cm. However, injury to turfgrass was less severe on plots that were treated with MSMA alone. Injury to

Tifdwarf putting greens following application of dithiopyr has also been reported (J.F. Moore, personal communication). However, it was not determined that dithiopyr was the main cause of this injury. Moore (personal communication) suggested that there may have been an antagonistic effect occurring as a result of turfgrass putting surface undergoing water stress or from stress caused by use of plant growth regulators.

Overseeding is a common practice used in the southern region where bermudagrass is used for putting surfaces. During the fall and extending through early spring when temperatures drop and daylength shortens, bermudagrass dormancy occurs. Throughout this period, bermudagrass assumes a yellowish appearance which is unacceptable to golfers. Bermudagrass putting greens are typically overseeded with perennial ryegrass (*Lolium perenne* L.). Weed management strategies become more complex as superintendents must manage two metabolically different turfgrasses. Herbicides must be used cautiously to prevent injury to existing cool-season species as well as the underlying bermudagrass. This is especially true during the transition period when cool-season species are being removed form the green and regrowth of bermudagrass is being encouraged. The use of postemergent herbicides has been shown to reduce quality of bermudagrass overseeded with perennial ryegrass during the spring transition when grasses were mowed at 6 and 5.6 mm height - of - cut (Johnson, 1988 and Johnson, 1990).

The objective of this experiment was to evaluate several postemergent herbicides/rates for phytotoxic effects on African bermudagrass (*C. transvaalensis*) genotypes and two interspecific hybrids, Tifgreen (*Cynodon dactylon x C. transvaalensis* 'Tifgreen') and Tifdwarf (*Cynodon dactylon x C. transvaalensis* 'Tifdwarf').

MATERIALS AND METHODS

In the fall of 1992 nine bermudagrass (*Cynodon spp.*) selections were removed from field plots and maintained in a greenhouse until application of treatments. Tifgreen (*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy 'Tifgreen') and seven African bermudagrass (*C. transvaalensis* Burtt-Davy) genotypes, Ctr-696; Ctr-1397; Ctr-1415; Ctr-2387; Ctr-2747; Ctr-2864 and Uganda were removed from a sand-based research putting green at the Oklahoma State University Turfgrass Research Center in Stillwater, Oklahoma. Sprigs of Tifdwarf (*Cynodon dactylon* (L.) Pers. x *C. transvaalensis* Burtt-Davy) were additionally taken from the Oklahoma State University World Collection nursery at Stillwater and allowed to fill to 100% coverage of pots. Tifdwarf and Tifgreen were included in this study as most putting surfaces in the southern region of the United States are composed of these cultivars. Plugs from field plots were sampled with a 10 cm diameter cup cutter and placed in 13 cm diameter pots with the remaining portion filled with washed masonry sand.

The greenhouse environmental control system was set for a 28/22 ^{0}C (day/night) regime with daylight supplemented by HID 1000 W Phillips HPI-T (North America Phillips Lighting, Summerset, NJ) sodium lamps timed to provide a 12 hr photoperiod.

Pots were fertilized at a rate of 24 kg N ha^{-1}, 5 kg P ha^{-1}, and 20 kg K ha^{-1} every 2 wk. Prior to application of treatments, pots showed excess amounts of algae. Fertilizer was changed to 150 mg N kg^{-1} of 5 - 4.8 - 21.6 solution and treated every 2 wk. Plants were irrigated as needed to prevent drought stress. Turf was clipped at a 1 to 1.5 cm height - of - cut.

A completely randomized experimental design was used (Steel and Torrie, 1980). Nine post-emergent herbicide treatments were applied to each bermudagrass genotype and replicated three times (Table 29). Three pots were used for each bermudagrass genotype where one pot equated to one replication. A conventional spray chamber was utilized for the purpose of applying chemical treatments. A 9515 even flat fan stainless steel tip was used at a working pressure of 117.3 kp with a carrier rate of 814 liters ha^{-1}. The spray tip traveled at a speed of 0.92 m s^{-1}. There was a distance of 36 cm from the end of the spray tip to the top of the table surface. This provided a 64 cm spray pattern width. Chemical treatments were applied on 18 December 1992 with the entire experiment repeated on 10 February 1993.

Grasses were evaluated visually 3 times per week for a period of 2 weeks for signs of phytotoxcity. The phytotoxic response of bermudagrasses to chemical treatments was rated on a 1 - 10 scale, where 1 equaled brown turfgrass and 10 equaled no phytotoxicity.

RESULTS AND DISCUSSION

No phytotoxicity was observed on any bermudagrass during either experiment due to chemical treatments. This study was an attempt to screen herbicides for phytotoxicity to African bermudagrass selections and hybrid bermudagrasses at labeled rates. Bermudagrass selections grown in the greenhouse could not be mowed at the same mowing heights as putting green field plots. A shorter mowing height could possibly affect the susceptibility of turfgrasses to herbicide injury.

Grasses were also grown in a modified environment where temperatures and light were kept in the optimum range. It is therefore necessary to conduct further field research in the area of screening of both pre- and postemergent herbicides for use on African bermudagrass.

The results of this research do indicate that no ultra-sensitivity to commonly used herbicides was present in the bermudagrasses screened in this research.

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Table 28. Chemical treatments and rates applied to bermudagrass in a greenhouse experiment.

Product Name	Common Name of Active Ingredient	Chemical Name of Acitve Ingredient	Rate of Formulated Product (kg ha^{-1})
1. DMC Weed Control	Metsulfuron Methyl	Methyl 2-[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-amino]carbonyl]amino]	0.01
2. Dimension	Dithiopyr	3,5-pyridinedicarbothioic acid, 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-S, S-dimethyl ester	0.57
3. Banvel	Dicamba	Dimethylamine salt of dicamba (3,6-dichloro-o-anisic acid)	0.11
4. Weedestroy MCPP-4 Amine	MCPP	Dimethylamine salt of 2-(2-methyl-4-chlorophenoxy) propionic acid	0.56
5. Trimec Bengrass Formula	2, 4-D	Dimethylamine salt of 2, 4-Dichlorophenoxyacetic acid	0.17
	Dicamba	Dimethylamine salt of Dicamba (3,6-dichloro-o-anisic acid)	0.17
	MCPP	Potassium salt of 2-(2-methyl-4-chlorophenoxy) propionic acid	1.14
6. Weedar 64A brand	2, 4-D	Dimethylamine salt of 2, 4-Dichlorophenoxyacetic acid	1.06
7. Daconate 6	MSMA	Monosodium Acid Methanearsonate	1.14
8. Daconate 6	MSMA	Monosodium Acid Methanearsonate	2.29
9. Kerb 50-W	Pronamide	5-dichloro-N-(1, 1-dimethyl-2-propynyl)-benzamide	0.56
10. Control			

APPENDICES

APPENDIX A

PESTICIDE RATES AND APPLICATION DATES USED IN MANAGING BERMUDAGRASS PUTTING GREENS IN 1991 AND 1992.

Product Name	Common Name of Active Ingredient	Chemical Name of Active Ingredient	Rate of Formulated Product (kg ha^{-1})	Application Dates
D z n diazanon-4E	diazinon	O,O-Diethyl O-(2-isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate	4.57 4.57 4.57 2.28	6 Jun 1991 15 Jul 1991 13 Aug 1991 11 Sept 1991
Triumph 4-E	isazofos	0-(4-chloro-1-[methlethyl]-1H-1,2,4-riazol-3-yl) 0.0-diethyl phosphorothioate	2.28 2.28 2.28 1.52	14 Apr 1992 23 Jun 1992 21 July 1992 13 Aug 1992
Javelin WG		*Bacillus thuringiensis* var Kurstaki	1.12	27 Jul 1991 2 Jul 1992
Dithane F-45	mancozeb	zinc ion coordination product of manganese ethylenebisdithiocarbamate	14.64	25 Apr 1992 18 May 1992 24 May 1992
Scotts Goose & Crabgrass Contol	bensulide	[S-0,0-Diisopyopyl phosphorodithioate) ester of n-(2-mercaptoethyl) benzenesulfanamide] [2-tert-Butyl-4-(2,4-dichloro-5-isopropoxyphenyl)- 2-1,3,4-oxadiazolin-5-one]	128.00	19 Jun 1991

APPENDIX B

MAXIMUM AND MINIMUM TEMPERATURES†

Date	September 1991 Max.	September 1991 Min.	October 1991 Max.	October 1991 Min.	November 1991 Max.	November 1991 Min.	December 1991 Max.	December 1991 Min.
1	31††	21	27	11	2	-3	6	-2
2	26	22	28	12	4	-7	1	-2
3	30	22	31	17	-3	-9	2	-6
4	31	21	31	18	3	-6	6	-6
5	29	17	24	4	10	-4	12	-4
6	29	19	21	5	11	-3	13	-2
7	26	23	19	6	14	-5	19	18
8	31	21	27	7	-2	-10	20	17
9	33	21	28	12	6	-1	16	6
10	33	22	30	11	14	-1	19	0
11	33	22	27	11	13	3	18	7
12	33	21	33	11	4	-2	17	11
13	33	21	36	11	17	-1	13	0
14	31	22	29	14	20	9	9	-1
15	28	24	23	8	16	13	13	-2
16	29	20	22	8	17	8	4	-2
17	26	20	27	9	17	9	12	1
18	27	12	31	16	19	9	12	-2
19	14	5	28	4	23	7	7	-1
20	18	7	18	7	12	4	3	0
21	19	13	21	9	14	-2	6	4
22	21	16	27	11	20	3	4	4
23	23	9	29	17	12	0	11	7
24	22	9	31	19	8	-2	10	-2
25	21	5	29	8	11	-1	11	-4
26	27	6	17	9	9	-2	11	4
27	26	11	22	16	16	3	9	5
28	26	13	24	16	17	16	12	4
29	27	12	23	1	24	18	7	4
30	26	12	8	1	23	1	11	6
31			6	0			13	8

† Ambient air temperatures collected at the Oklahoma State University Agronomy Research Satation, Stillwater, Oklahoma.

†† Maximum and minimum temperatures expressed as degree celsius, °C

APPENDIX B (Continued)

MAXIMUM AND MINIMUM TEMPERATURES†

	January 1992		February 1992		March 1992		April 1992	
Date	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	10††	7	20	1	23	6	17	-1
2	11	3	23	2	26	13	11	-4
3	9	-3	19	5	24	14	12	-2
4	16	2	17	7	23	13	21	0
5	14	11	11	-2	19	10	29	6
6	14	7	8	-2	22	7	26	8
7	10	6	13	-4	27	13	18	4
8	17	2	12	-3	22	17	22	6
9	8	-4	8	-2	26	4	27	10
10	8	-4	13	1	16	-5	31	16
11	12	-1	13	3	6	-7	27	16
12	15	6	10	3	16	-2	27	9
13	13	-1	4	1	11	-1	14	12
14	3	-6	9	1	23	5	26	12
15	11	-8	22	3	21	3	29	18
16	-5	-11	15	2	19	7	26	17
17	7	-7	18	4	24	11	26	13
18	10	-8	16	4	22	10	21	14
19	8	-9	21	-2	17	2	21	12
20	9	-4	15	1	12	-2	17	11
21	14	-3	21	7	18	3	14	3
22	13	0	23	8	22	1	21	4
23	9	-2	16	7	9	-6	29	9
24	9	-6	21	10	14	1	26	14
25	17	3	7	-1	17	2	23	7
26	17	-3	7	-4	17	2	22	6
27	11	-2	16	-2	23	5	22	3
28	9	3	17	4	19	7	21	6
29	13	-2	25	1	19	11	17	10
30	14	-1			17	7	24	11
31	16	-2			12	-2		

† Ambient air temperatures collected at the Oklahoma State University Agronomy Research Satation, Stillwater, Oklahoma.

†† Maximum and minimum temperatures expressed as degree celsius, ^{0}C

APPENDIX B (Continued)

MAXIMUM AND MINIMUM TEMPERATURES†

Date	September 1992 Max.	September 1992 Min.	October 1992 Max.	October 1992 Min.	November 1992 Max.	November 1992 Min.	December 1992 Max.	December 1992 Min.
1	25††	18	26	8	2	-3	11	-6
2	27	17	27	11	4	-7	14	-4
3	28	17	27	7	-3	-9	11	0
4	31	17	27	8	3	-6	17	0
5	29	22	28	10	10	-4	4	-1
6	32	18	29	10	11	-3	-1	-3
7	30	21	27	11	14	-5	7	-4
8	33	19	25	5	-2	-10	6	-6
9	29	18	18	1	6	-1	6	-2
10	33	16	26	9	14	-1	7	0
11	26	11	23	5	13	3	13	-2
12	27	11	27	9	4	-2	14	7
13	28	14	28	9	17	-1	17	8
14	31	22	32	17	20	9	11	6
15	32	21	29	8	16	13	12	-1
16	31	20	21	6	17	8	4	-4
17	31	19	16	3	17	9	4	-4
18	32	19	16	4	19	9	4	-2
19	26	13	21	6	23	7	14	6
20	21	13	22	9	12	4	5	-2
21	33	21	28	11	14	-2	5	-2
22	29	16	28	16	20	3	12	-3
23	26	8	27	12	12	-5	16	-5
24	24	7	29	15	8	-2	13	-9
25	25	8	26	8	11	-1	8	-4
26	25	17	27	14	9	-2	10	-7
27	25	9	22	4	16	3	13	-7
28	27	9	23	6	17	16	15	7
29	26	6	27	11	24	18	16	12
30	24	7	13	7	23	1	23	17
31			53	49				

† Ambient air temperatures collected at the Oklahoma State University Agronomy Research Satation, Stillwater, Oklahoma.

†† Maximum and minimum temperatures expressed as degree celsius, °C

APPENDIX B (Continued)

MAXIMUM AND MINIMUM TEMPERATURES†

	January 1993		February 1993		March 1993		April 1993	
Date	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	-1††	-9	19	-2	7	6	12	4
2	-1	-1	18	-3	8	5	8	-3
3	8	-2	16	2	8	2	15	11
4	16	0	14	6	9	2	15	7
5	4	-7	14	5	10	-1	8	6
6	6	-4	8	-1	13	-7	11	4
7	6	-1	16	-2	16	0	17	7
8	9	0	20	-1	21	2	23	6
9	4	1	21	4	24	4	12	3
10	4	2	17	6	20	3	24	6
11	-1	-4	12	4	29	2	27	7
12	5	-2	8	-1	9	-2	26	15
13	6	-9	7	-2	6	-4	30	9
14	-1	-9	12	-3	3	-6	20	6
15	0	-10	8	-2	17	-1	20	4
16	7	-1	2	-11	13	7	14	3
17	9	-1	-4	-10	21	-2	21	7
18	7	-4	-7	-15	9	-1	15	7
19	-2	-4	1	-12	9	-1	27	9
20	1	-4	13	0	9	7	24	6
21	3	0	26	3	12	4	17	1
22	11	-3	10	-2	17	6	18	3
23	16	4	8	-3	11	-2	25	11
24	13	-4	4	-4	18	2	23	14
25	8	-6	2	-2	22	2	26	11
26	12	-6	3	-8	15	-1	26	7
27	17	-3	3	-5	20	2	26	10
28	21	-2	5	0	23	13		
29	18	-7			27	16		
30	4	-4			24	13		
31	12	1			22	8		

† Ambient air temperatures collected at the Oklahoma State University Agronomy Research Satation, Stillwater, Oklahoma.

†† Maximum and minimum temperatures expressed as degree celsius, °C

VITA

David Alan Gerken

Candidate for the Degree of

Master of Science

Thesis: EVALUATION OF AFRICAN BERMUDAGRASS (*Cynodon transvaalensis*) AS A PUTTING SURFACE

Major Field: Horticulture

Biographical:

Personal Data: Born in Paola, Kansas, January 27, 1961, the son of Ted and Frances Gerken.

Education: Graduated from Paola High School, Paola, Kansas, in May, 1979; received Associate of Arts Degree in Agriculture from Allen County Community College at Iola, Kansas in May, 1981; recieved Bachelor of Science Degree in Vocational Education from Kansas State University at Manhattan, Kansas in December, 1983; completed requirements for the Master of Science degree at Oklahoma State University in December 1994.

Professional Experience: Research Assistant, Department of Horticulture and Landscape Architecture, Oklahoma State University, August, 1990 to December 1994

Professional Associations: Weed Science Society of America; Gamma Sigma Delta Honor Society of Agriculture; Golf Course Superintendents Association of America.