ANNUAL PROGRESS REPORT

CONCERNING

BREEDING AND EVALUATION OF SEEDED COLD-TOLERANT BERMUDAGRASS VARIETIES

AND

BERMUDAGRASS VARIETIES FOR GOLF COURSE PUTTING GREENS

FOR THE PERIOD

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EXECUTIVE SUMMARY

Objectives of the Oklahoma State University bermudagrass breeding program are to develop: (1) seed-propagated, cold-tolerant, fine-textured varieties for the U.S. transition zone; and (2) improved vegetatively-propagated varieties for golf course putting greens, with emphasis on adaptation to southern coastal states.

Two bermudagrass, *Cynodon dactylon*, broad-base genetic populations have been developed using phenotypic recurrent selection. One population, $C_{3fer\text{-}2tex}$, was developed from cold tolerant germplasm subjected to three and two cycles of selection, respectively, for increased fertility (seed set) and finer texture. The second population, C_{1ct} , was more recently developed from germplasm with high seed yield potential but moderate cold tolerance. Selection was practiced within the population for increased cold tolerance and fine texture. Synthetic varieties derived from selected parental plants from $C_{3fer\text{-}2tex}$ have demonstrated good cold tolerance and turf quality in comparison to control varieties. Additional cyclic selection was completed within each of the broad base populations in 1993.

Evaluation of more than 3,000 African bermudagrass, *C. transvaalensis*, progeny plants has demonstrated extensive variability for many characteristics. Wide variation exists for important turf performance traits such as response to high or low temperatures, low mowing tolerance, texture, and sod density. Variation also exists for color. The wide phenotypic variability is indicative of substantial genetic diversity within the species. Hybrid populations have been developed to study the magnitudes of genetic variances and heritabilities of selected traits. African selections have demonstrated finer texture, greater sod density, and greater cold tolerance than Tifgreen or Tifdwarf. The African bermudagrasses tend to have lighter green color, greater tendency to thatch, and greater susceptibility to scalping than conventional varieties.

Morphologically or cytologically variant Tifdwarf plants were found among R_0 progeny. Morphological variants are either more or less dwarfed than Tifdwarf. Cytological variants have chromosome numbers of $2n=45$ or $2n=54$.

Alterations in protein synthesis associated with cold acclimation (CA) was studied in Midiron and Tifgreen turf bermudagrasses.. Acidic (pIs of ca. 5 to 6) proteins of ca. 34 kD were diminished in crowns of both varieties following CA. Both varieties synthesized cold-regulated (COR) proteins of several size ranges, including ca. 14 to 15 kD, 20 to 28 kD, 32 to 37 kD, and 45 to 55 kD, in association with CA. Midiron crowns synthesized low molecular weight (MW) (ca. 20 to 28 kD) basic (pIs of ca. 7 to 9) COR proteins in greater numbers and amounts, and intermediate MW (ca. 32 to 37 kD) acidic (pIs of ca. 4 to 6) COR proteins in greater amounts than Tifgreen crowns.

I. INTRODUCTION

The turf bermudagrass breeding program was initiated in 1986 under the joint sponsorship of the United States Golf Association and the Oklahoma Agricultural Experiment Station. The initial broad objective was to develop fine-textured, winter hardy, seed-propagated varieties for the U.S. transition zone. The program was expanded in 1990 to include the development of superior vegetatively-propagated varieties for use on putting greens in the southern U.S. where bentgrass is poorly adapted.

Important ongoing activities supporting the breeding effort include the development/improvement/use of techniques to measure physiological and morphological parameters related to environmental stresses; the procurement, evaluation, and use of new turf bermudagrass germplasm in the breeding effort; use of tissue culture in generating genetic variation and screening for desirable traits at the cellular level; and evaluation of bermudagrass varieties and breeding lines for turf performance.

This report summarizes activities and progress for the period 1 November 1992 through October 31 1993.

II. RESEARCH PROGRESS

Breeding Seed-Propagated Varieties. Several experimental seeded varieties are being evaluated for seed production potential and turf quality. The experimental varieties were developed from one of two broad base populations designated as $C_{3fer\text{-}2tex}$ and C_{1ct}. $C_{3fer\text{-}2tex}$ is a cold-tolerant population subjected to three and two cycles of phenotypic recurrent selection for fertility (% seed set) and finer plant texture. C_{1ct} was developed from germplasm having moderate cold tolerance but high fertility and seed yield potential. The population was developed by initially selecting for seed yield and turf quality among spaced plants growing at Yuma, Arizona followed by screening the derived population for cold tolerance.

A field trial of OSU experimental seeded bermudagrass as well as commercially available and industry experimental seeded bermudagrasses was established on 20-23 July 1992. Sources of the materials are shown in Table 1. During the establishment phase in 1992 and 1993 the trial was maintained with a 1.5 inch cutting height, 5 lbs of N 1000 ft^{-2} yr^{-1} and irrigation to prevent wilting. Spring green-up ratings, percentage winter-kill, visual quality, visual color and seed head production ratings were collected from the trial in 1993.

Preliminary spring green-up ratings of 18 seeded bermudagrasses are shown in

Table 2. Spring green-up ratings reflect i) the inherent tendency of a genotype to begin regrowth following winter and ii) survival through the winter period. The 20 July seeding date in 1992 was much later than recommended in the Stillwater, OK area; heavy spring rains prevented earlier establishment. Bermudagrasses were not as mature as normally recommended for entering their first winter, thus a great degree of winter-kill was suffered by certain genotypes (Table 3). As these bermudagrasses were not fully mature upon entering the winter of 1992-1993 both green-up ratings and winter-kill ratings may not reflect the performance of these grasses when allowed to enter winter in a more mature condition. Winter-kill varied from approximately 3 to 80% of the plot area dependent upon the genotype. The highest levels of winter-kill were exhibited by "Seed from U-3", Poco Verde, Arizona Common, and Cheyenne bermudagrass. The least winter-kill was observed on a seeded selection of African bermudagrass, BERPC 89-3, Sundevil, BERPC 91-6 and Ft. Reno. The appearance of BERPC 89-3 and Arizona Common plots is shown in Fig. 1. Additional spring green-up and winter-kill information will be collected in spring of 1994.

Visual quality of these same 18 bermudagrasses mowed at 1.5 inches are shown in Table 4. For comparison sake it is important to note that Sonesta (NMS-3) provided the highest overall visual quality of any commercially available seeded common bermudagrass during the 1986-1991 National Bermudagrass evaluation. Visual quality of the genotypes varied by the date on which they were rated. Cutting height treatments of 3/8, 1/2 and 1.5 inches were imposed on the 18 genotypes in late 1993. These heights represent heights frequently used for bermudagrass tees, fairways and roughs. Preliminary data from a single rating date (Table 5) indicates that no statistical differences were present among the genotypes of seeded bermudagrasses at the 3/8 and 1/2 inch cutting height for visual quality. At 1.5 inches, Poco Verde provided statistically better quality than "Seed from U-3" with all other bermudagrasses ranking in between these two grasses. Additional evaluation for quality at various cutting heights will continue in 1994.

Preliminary visual color ratings of these bermudagrasses when cut at a 1.5 inch height are shown in Table 6. Color ratings of bermudagrasses typically are highly variable from one portion of the growing season to another. Ratings were highly variable in this study, however, OSU selection Ft. Reno 111-1 and the commercial variety Sundevil consistently provided the highest color ratings. Color rating evaluations will be continued on these bermudagrasses in 1994.

Preliminary seed head ratings are shown for 18 seeded bermudagrasses maintained at a 1.5 inch cutting height in Table 7. Seed head expression is usually considered undesirable from an aesthetic and playability standpoint, however, adequate seed production is necessary for commercialization of a seeded type bermudagrass. Seedhead expression also is seasonably variable. Seedhead expression was highly variable among the genotypes on a single sampling date in 1993. DSM 250, Primavera and Sonesta had the greatest seedhead expression in our preliminary data whereas C2, Guymon, BERPC 89-3 and African bermudagrass exhibited the fewest number of inflorescence expressed.

On 17-19 August 1993 a field study of 26 bermudagrasses was established for evaluation of Tolerance to the disease Spring Dead Spot (Table 8). All entrees in the trial are seed propagated except for Midlawn, Midfield and Tifton 10. These vegetatively propagated materials were included for standards, with Midlawn and Midfield having a known high degree of tolerance to Spring Dead Spot Disease (SDS). Plots were not inoculated in 1993 with the casual organism of SDS disease as the disease is rarely seen on newly established bermudagrass and because damage due to winter-kill on first-year bermudagrass would confound ratings for SDS tolerance.

The cold hardy breeding population $C_{3fer\text{-}2tex}$ underwent an additional cycle of greenhouse selection for fine texture during winter 1992-93. Selected plants were planted in a field polycross in summer 1993 to produce $C_{3fer\text{-}3tex}$ seed. Individual plants from the $C_{3fer\text{-}2tex}$ population selected over the past 2-3 years are being evaluated for turf quality, seed production, and parental combining ability in order to identify superior plants to use as parents of narrow base synthetic varieties. Establishment year seed yields and seed germination for 29 selections are given in Table 9. Seed yields of the entries ranged from 1 to 239 lbs pure seed/acre. Plants with low seed yields were generally slower spreading types that did not produce seedheads. First year seed yields are not good indicators of seed yield potential because of the strong effect of rate-of-stand establishment on seedhead production and seed set. Seed were harvested from the plots in summer 1993 and will be processed during the 93-94 winter.

Seed of eight experimental bermudagrasses (BERPC 91-1, BERPC 91-2, BERPC 91-3, BERPC 91-4, BERPC 91-10, BERPC 91-12, BERPC 91-14, and BERPC 91-15) was sent to Dr. Bob Carrow 5/14/93. Dr. Carrow will extensively evaluate these materials.

Several african bermudagrass, *C. transvaalensis,* plants were selected from breeding nurseries in 1992 on the basis of potential superior seed yield. We will evaluate these and pursue the potential of developing seed-propagated varieties.

Breeding Vegetatively-Propagated Varieties. M.S. Candidate David Gerken completed 2.5 years research on African bermudagrass in spring of 1993. This work compared putting surface characteristics of 6 OSU experimental African bermudagrass with Tifgreen hybrid bermudagrass and Uganda African bermudagrass. Data from this research have been presented in previous research reports. An overall summary of our findings follows.

Tifgreen established slightly faster than any of the African bermudagrasses. Additionally, those African bermudagrasses having superior putting green characteristics were the slowest genotypes to establish. This should not however be a concern if any genotypes are commercialized, as sprigging rates can simply be increased to increase rate of putting green establishment. In research comparison trials, all of our plots are plugged to avoid contamination between plots as large numbers of genotypes are included in each screening.

No differences in clipping yields were present among Tifgreen or any of the African bermudagrasses in their first year as a putting surface, however, as the plots matured in 1992 differences were present among the grasses. African bermudagrass Ctr 2747 which had the highest shoot and visual density also rated highest in production of clippings. Tifgreen, which was the least dense of any of the grasses, had the least amount of clippings produced on mature plots. As African bermudagrasses were previously reported to have problems with thatch production, we attempted to measure thatch production in this study. We were unsuccessful in measuring thatch production, as the topdressing that we applied in order to simulate actual putting green conditions prevented us from being able to separate a thatch layer from the soil mix. Thatch production potential of these grasses will need further evaluation in the future.

Mowing the grasses at 3/16 or 1/8 inch produced no significant differences in root mass distribution during this study in either the 0-8 or 8-15 cm depth. Tifgreen and Uganda typically had the lowest root mass density in the upper 15 cm of soil as compared to any of the other grasses tested when plots were mature. Although several OSU experimental African bermudagrasses were inconsistent in their ranking for root mass distribution from date to date, Ctr2747 usually ranked highest in root mass density. High root mass density is believed to be a very desirable characteristic. No significant differences in density were found in grasses mowed at 3/16 or 1/8 inch cutting heights in either of the two growing seasons in this study. Tifgreen consistently had fewer shoots per unit area than any African bermudagrass. Uganda African bermudagrass usually had fewer shoots per unit than most OSU experimental African bermudagrasses.

All African bermudagrasses reached complete green-up more rapidly than Tifgreen bermudagrass during the springs of 1992 and 1993. No African bermudagrasses suffered winter-kill during the 2.5 years of our research, however, Tifgreen suffered 69% and 10% winter-kill at the 1/8 and 3/16 inch heights-of-cut during the winter of 1991/1992.

Tifgreen usually provided a darker greener putting surface than African bermudagrass during both growing seasons of our work. Uganda African bermudagrass typically was lighter green than any OSU experimental African bermudagrass during our research. Progress appears to have been made in improving the color of African bermudagrass over the earlier released genotypes such as Uganda. It is important to note that the six OSU genotypes used in this study were selected at random from a pool of 3,300 genotypes. It is very probable that additional dramatic improvement in color can be made through continued selection pressure for this trait.

Visual quality of turf combines the overall integrated effect of several characteristics such as uniformity, color, density, smoothness, and growth habit. Tifgreen provided lower visual quality ratings than most African bermudagrasses during the 1991 and 1992 growing seasons. OSU experimental selection Ctr 2747 typically ranked the highest in overall quality during this research. Uganda African bermudagrass usually ranked lowest of all the African bermudagrasses evaluated.

Tifgreen bermudagrass provided a faster putting surface than any African bermudagrass during our study as measured with a U.S.G.A. stimp meter. This is not surprising though as Tifgreen had the lowest clipping yield and also the lowest shoot density of any of the grasses tested. It appears there is a trade off between density of the turf and ball speed, with the more dense the putting surface the slower the "ball speed" of the green.

All grasses tested in the putting green evaluation showed signs of Spring Dead Spot Disease in the spring of 1992 and 1993. All grasses recovered satisfactorily. As the plots were not uniformly affected, no judgments could be made on genotypic differences to tolerance to the disease was possible.

Although no research was performed on susceptibility of African bermudagrasses to insect invasion, we observed Pennlinks and Penncross creeping bentgrasses located on the borders of our plots to be more heavily infested with black cutworms, *Agrotis ipsilon*, in the 1991, 1992 and 1993 growing seasons than any of the African bermudagrasses or Tifgreen.

Of the 6 OSU experimental African bermudagrasses intensively evaluated over 2.5 years, Ctr2747 provided the most superior putting surface characteristics. This grass warrants further intensive evaluation for possible commercial release as a putting surface in selected geographical regions.

Research was conducted in the fall of 1992 and winter of 1993 in the greenhouse to determine the phytotoxic response of six OSU experimental African bermudagrasses, Uganda, and Tifgreen to several post-emergent herbicide treatments/rates (Table 10) commonly used on bermudagrass putting greens. Two duplicate studies were conducted. No phytotoxicity was found on any of the grasses utilized in this study under greenhouse conditions at commonly used rates. No 2 and 3x rates were screened, which would represent double overlap application or miscalculation. Field screening for pesticide sensitivity should take place when superior genotypes are nearing commercial release. Environmental conditions in the field may produce somewhat different results than seen under greenhouse conditions. Our data indicates that no ultra sensitivity to commonly used post-emergent herbicides exists in the African bermudagrass genotypes evaluated to date.

In May of 1993, thirteen of the OSU experimental bermudagrasses demonstrating desirable putting surface characteristics as well as Uganda African bermudagrass, Tifgreen and Tifdwarf hybrid bermudagrasses were plugged to a 90/10 sand/sphagnum peat moss research green at Stillwater, OK. Establishment rates are show in Table 10. A spraying system accident occurred in September of 1993 forcing the current study to be terminated. Preliminary data from grasses established by plugging establishment again showed OSU experimental African bermudagrasses selected for improved putting surface characteristics to establish more slowly than Uganda African bermudagrass and Tifgreen bermudagrass. OSU experimental African bermudagrasses in general established at equal or greater rates than Tifdwarf bermudagrass.

A 1,200 ft^2 putting green was established in May on the 9 hole Comanche Golf Course at Comanche Oklahoma to observe the performance of OSU experimental African bermudagrass Ctr2747 under play conditions. Play began on the green in September of 1993. Observation on the performance of the putting surface will continue in the future. A July 93 planting of Ctr 2747 was made on a tennis court belonging to Mr. Rick Nelson, owner of Mingo Tree and Turf, Tulsa, OK (Fig. 2). This will provide additional information on performance of the genotype.

Plantings of African bermudagrasses selected from golf course screening nurseries were made in 1992 on the Palm Beach (Fig. 3), Emerald Dunes, and Imperial courses in Florida and the Champions course in Houston. Observational data from the Emerald Dunes and Imperial sites indicated outstanding quality performance for some selections relative to Tifdwarf. The best selections at both sites were 1111, 2352, 2570, and 3048. The 1111 selection was from the screening nursery at the Palm Beach CC, while the other three came from the screening nursery on the High Ridge CC. The African selections maintained better color and did not go offcolor in response to cold spells. However, in early spring Tifdwarf was rated as having better quality than the best of the African selections at Emerald Dunes. According to John Foy, USGA Agronomist, the African selections had greater thatch accumulation than Tifdwarf at all locations. Also, seedhead production on the African selections detracted from quality for a brief period of time. Summer performance of the African bermuda's in the Emerald Dunes and Imperial tests was inferior to that of Tifdwarf due primarily to thatch accumulation. No management practices to control thatching had been employed on any of the experiments. Mr. Foy and Chip Fowkes, Emerald Dunes Superintendent, expressed the opinion that the African bermudagrasses would likely require different management than hybrids such as Tifdwarf, and that the early spring decline in quality of the African selections could have been minimized or negated by management.

Dr. Ronnie Duncan, Georgia Experiment Station, Griffin, GA., has identified individual African bermudagrass plants with superior performance under low pH. One such plant, OKC 90-16, has done well under both low and optimal pH levels.

African bermudagrass selections 1111, 2352, 2570, 3048, and 2747 (Dave Gerken's best selection) along with Tifdwarf, Tifgreen, and Uganda were planted in replicated tests in 1993 on golf courses at the following locations: San Dimas, CA, Las Vegas, NV, and Pinehurst NC. These same varieties are also included in tests conducted by Dr. Monica Elliott at the Ft. Lauderdale REC and Dr. Charles Peacock, North Carolina State Univ. Raleigh NC.

Two hundred F_1 progeny plants were field planted in spring 1992 and an additional 600 progeny plants were field planted in spring 1993. These represent intra- and inter-specific crosses between C. transvaalensis and C. dactylon. Selections will be made from these nurseries on the basis of turf appearance and cold tolerance and advanced to intensive evaluation under turf maintenance conditions. Additional crosses were made in spring 1993 between selected parents.

Cold-hardiness and Cytogenetic Research

We previously reported on controlled-environment procedures to evaluate and select bermudagrass genotypes for cold hardiness. LT_{50} values of six genotypes were in accordance with expectations based on previous reports and field experience. However, Tifway was significantly hardier than expected. Therefore, we retested Tifway, along with an authentic sample of Tifway from another source and several other grasses (Coastal, Tifton 85, Tifton 44 and Tifgreen). Mean LT_{50} values (of three experiments) are reported in Table 11. The sample previously evaluated as Tifway was, once again, very hardy with an LT_{50} of -10.7°C. An authentic sample of Tifway, however, had an LT_{50} of -7.6°C. Tifton 85 was the least hardy of the genotypes examined with an LT_{50} of -5.3°C. Tifton 44, Coastal, Tifgreen, and authentic Tifway were not significantly different in hardiness ($P=0.05$). Apparently, a genotype other than Tifway was sampled for the 1992 report and we regret any confusion. Closer examination of the erroneously identified plant confirmed that it is morphologically different from Tifway. It may be one of the Kansas State University strains. Data from the initial experiment comparing Tifgreen, Tifton 10, Midfield, Vamont, Midlawn, and Midiron were recently published in HortScience 28(9):955. A copy of the publication is appended.

Dr. Mark Gatschet recently completed a doctoral study of alterations in protein synthesis associated with cold acclimation in bermudagrass. Midiron and Tifgreen bermudagrasses were grown under cold-acclimating [8/2 °C (day/night) cycles with a 10 hour photoperiod] or non-acclimating (28/24 °C) conditions in controlled environment chambers for 26 days. Freezing stress in 1 °C decrements was applied to cold-acclimated and non-acclimated plants. Regrowth of plants of each treatment combination (non-acclimated Midiron, cold-acclimated Midiron, non-acclimated Tifgreen, cold-acclimated Tifgreen) eight weeks after freezing was evaluated to estimate lethal temperatures for 50% of plants (LT_{50} 's). Proteins synthesized by crowns isolated from other unfrozen plants were in vivo radiolabeled with ^{35}S-Methionine and ^{35}S-Cysteine. Isolated proteins were separated using sodium dodecyl sulfate (SDS) and two-dimensional (2D) polyacrylamide gel electrophoresis (PAGE). Gels were silver stained and used for fluorography. Midiron plants tolerated freezing to lower temperatures than Tifgreen, both without and after cold acclimation (CA). After CA, LT_{50} values decreased from -6.5 to -11.3 °C for Midiron plants, and from -3.6 to -8.5 °C for Tifgreen plants. Analysis of silver-stained gels revealed that, in association with CA, acidic (pI's of ca. 5 to 6) proteins of ca. 34 kD were diminished in crowns of both cultivars. Densitometry of fluorographs revealed that, in association with CA, crowns of both cultivars synthesized cold-regulated (COR) proteins of several size ranges, including ca. 14 to 15 kD, 20 to 28 kD, 32 to 37 kD, and 45 to 55 kD. Midiron crowns synthesized low molecular weight (MW) (ca. 20 to 28 kD) basic (pI's of ca. 7 to 9) COR proteins in greater numbers and amounts, and intermediate MW (ca 32 to 37 kD) acidic (pIs of ca. 4 to 6) COR proteins in greater amounts than Tifgreen crowns. The manuscript "Cold acclimation and Alterations in Protein Synthesis in Bermudagrass Crowns" by Gatschet et al. is scheduled for publication soonn in the Journal of the American Society of Horticultural Science.

Several somaclonal variant Tifdwarf bermudagrass plants have been obtained from golf courses or through tissue culture. Two somaclonal variants from tissue culture are dramatically different having much wider leaves and stouter stems. Chromosome number determinations indicate these plants to have ca 2n=45 chromosomes. Some of the somaclonal variant plants are dramatically more dwarfed than the original Tifdwarf (Fig. 4). These are being increased and will be evaluated in comparison to Tifdwarf.

III. RESEARCH PLANNED

<u>Seed Propagated Bermudagrasses</u>: Evaluation of experimental synthetic varieties has been broadened and intensified to determine their potential for release as quickly as possible. Two seeded experimental varieties, one moderately cold tolerant, the other very cold tolerant, were entered in the 1993 National Bermudagrass Test. Other experimental synthetic varieties are being field tested at OSU. Field testing of 18 seeded bermudagrasses will continue in 1994 by new M.S. Candidate Richard Austin. Treatments include nitrogen at 3 and 5 lbs N

1000 ft^{-2} yr^{-1} and cutting heights of 3/8, 1/2 and 1.5 inches. Data to be collected include percentage winter-kill, spring green-up, visual quality, visual color, shoot density, seedhead expression and recovery rate from divoting. In the fall of 1994, 23 seeded bermudagrasses and 3 vegetatively propagated bermudagrasses will be inoculated with *Ophiosphaerella herpotricha*, one of the causal agents of Spring Dead Spot Disease. Evaluation for resistance or tolerance to the disease will begin in the spring of 1995. Dr. Ned Tisserat of Kansas State University is serving as a cooperator in this effort. This trial will be maintained under a 1/2 inch cutting height, 5 lbs N 1000 ft^{-2} yr^{-1} and irrigation to prevent wilting.

It is our intention to increase propagating material of parental lines or synthetic varieties and to effect their release as quickly as possible if their performance is satisfactory. Commercial seed companies are assisting in evaluating seed production and turf quality.

The following breeding activities are to be continued: (1) greenhouse phenotypic recurrent selection for textural refinement, (2) selection for earlier and more prolific seed head production in cold-tolerant populations, (3) testing of plants selected from broad base populations for combining ability, and (4) selection for increased cold-tolerance in populations derived from common bermudagrass.

Vegetatively Propagated Bermudagrasses:

Five African bermudagrass selections from initial Florida screening trials (Ctr 1111, 2352, 2570, 3048) plus Ctr 2747 are in replicated tests in California, Nevada, Texas, North Carolina, and Florida. These tests will be monitored closely in 1994 to determine the performance of these varieties. These selections plus more recent ones will be planted in a replicated test for intensive evaluation at Stillwater, OK. The test will be conducted under putting green maintenance conditions.

Approximately 800 F_1 plants from C. transvaalensis x C. transvaalensis or C. transvaalensis x C. dactylon were field planted in 1992 and 1993. Selections will be made from these nurseries on the basis of cold tolerance and turf appearance. Selected plants will then be evaluated under turf maintenance conditions.

Thirty-two randomly selected C. transvaalensis plants were intercrossed during the past two springs using a mating design producing full and half sib progeny. This population will enable evaluation of the magnitude of genetic variation within the species for characters of interest and will permit estimation of genetic parameters such as heritabilities.

Table 1. Sources of seeded bermudagrasses evaluated in 1992-1993 field trial[1].

Genotype	Source	Genotype	Source
African bermuda	OSU	Ft. Reno	OSU
Arizona Common	Many	Guymon	Johnston Seed Co.
BERPC 91-2	OSU	J-912	Jacklin Seed Co.
BERPC 91-6	OSU	Poco Verde	Farmers Marketing
BERPC 89-3	OSU	Primavera	Farmers Marketing
BERPC 91-1	OSU	Sonesta	O.M. Scotts
C2	Finelawn Research	Sundevil	Medalist America
Cheyenne	Pennington Seed	Tropica	Turf Merchants
DSM 250	Desert Sun Marketing	Seed From U-3	Many

[1] All genotypes were established from seed except DSM 250 which was established vegetatively.

Table 2. Spring Green-up ratings for seeded bermudagrasses in 1993.

Cultivar	2 April	9 April	16 April	22 April	6 May
African Bermuda	2.67A	4.33A	5.33A	4.67B	7.00ABC
BERPC 89-3	2.33AB	4.33A	5.67A	6.33A	7.33AB
Ft. Reno	2.00BC	3.67AB	5.33A	4.00BC	6.00BCD
Sundevil	2.00BC	3.67AB	5.00A	5.67A	7.67A
BERPC 91-6	1.67CD	3.00BC	3.67B	3.00DE	5.67CDE
Guymon	1.67CD	3.33B	3.67B	3.67CD	5.33DE
C[2]	1.33DE	2.00D	2.00C	2.33EF	3.00FGH
Cheyenne	1.33DE	2.00D	2.00C	2.00F	2.67GH
Sonesta	1.33DE	2.00D	2.00C	2.00F	3.00FGH
BERPC 91-2	1.00E	2.33CD	2.33C	2.33EF	4.33EF
Arizona Common	1.00E	2.00D	2.00C	2.00F	2.67GH
BERPC 91-1	1.00E	2.00D	2.33C	2.33EF	3.33FGH
Primavera	1.00E	2.00D	2.33C	2.33EF	3.33FGH
Poco Verde	1.00E	2.00D	2.00C	2.00F	2.33GH
J-912	1.00E	2.00D	2.33C	2.33EF	3.67FG
Tropica	1.00E	2.00D	2.00C	2.00F	2.67GH
Seed From U-3	1.00E	2.00D	2.00C	2.00F	2.00H
$LSD_{(0.05)}$	0.62	0.96	0.92	0.97	1.51

[1]Green-up is rated on a 1-9 scale where 9 = complete green-up and 1 = straw colored
[2]All means, including the LSD value were rounded

Table 3. Percentage Winterkill of seeded bermudagrass in 1993.

Cultivar	Percentage Winterkilled
DSM 250	26.67CDE
Primavera	43.33ABCD
Sonesta	38.33BCDE
J-912	26.67CDE
BERPC 91-6	10.00DE
BERPC 91-1	45.00ABCD
Tropica	51.67ABC
Seed From U3	80.00A
Cheyenne	61.67ABC
BERPC 91-2	36.67BCDE
Ft. Reno	13.33DE
Poco Verde	76.67A
Arizona Common	68.33AB
Sundevil	3.33E
C2	51.67ABC
Guymon	36.67BCDE
BERPC 89-3	3.33E
African Bermuda	3.33E
$LSD_{(0.05)}$	36.83

Table 4. Visual quality ratings of seeded bermudagrasses in 1993.

Cultivar	28 June	19 July	20 August	1 September
BERPC 91-2	7.67A	6.67BC	7.67AB	6.67AB
BERPC 89-3	7.33AB	6.67BC	7.33ABC	7.00AB
African Bermuda	7.00ABC	8.00A	8.00A	7.00AB
Sundevil	7.00ABC	7.00B	7.67AB	6.33AB
C2	7.00ABC	6.33BC	6.67CD	6.33AB
Ft. Reno	7.00ABC	6.67BC	7.33ABC	7.00AB
DSM 250	6.67BCD	6.00C	7.00BCD	7.00AB
BERPC 91-1	6.67BCD	6.67BC	7.00BCD	7.00AB
BERPC 91-6	6.67BCD	6.33BC	6.33D	7.00AB
J-912	6.67BCD	6.00C	7.33ABC	7.33AB
Primavera	6.67BCD	6.00C	7.00BCD	7.33AB
Cheyenne	6.67BCD	6.33BC	7.00BCD	6.67AB
Guymon	6.33CD	6.33BC	6.67CD	7.33AB
Arizona Common	6.00D	6.33BC	7.00BCD	7.00AB
Poco Verde	6.00D	6.00C	7.00BCD	7.67A
Sonesta	6.00D	6.00C	6.33D	7.00AB
Tropica	6.00D	6.00C	7.33ABC	7.00AB
Seed From U3	6.00D	6.00C	6.67CD	6.00B
$LSD_{(0.05)}$	0.78	0.69	0.86	1.37

[1]Visual quality is rated on a 1-9 scale where 1 = poorest quality and 9 is the highest possible quality.

Table 5. Visual quality rating of bermudagrasses at 3 cutting height in 1993.

Cultivar	⅜ inch	½ inch	1½ inch
African Bermuda	6.67	6.00	7.00AB
Sonesta	6.33	6.67	7.00AB
J-912	6.33	6.67	7.33AB
Sundevil	6.33	6.67	6.33AB
Arizona Common	6.00	6.67	7.00AB
Poco Verde	6.00	7.00	7.67A
BERPC 89-3	6.00	6.67	7.00AB
BERPC 91-6	6.00	6.67	7.00AB
Tropica	6.00	6.67	7.00AB
Ft. Reno	6.00	6.67	7.00AB
Guymon	6.00	6.67	7.33AB
BERPC 91-1	6.00	6.33	7.00AB
Primavera	6.00	7.00	7.33AB
Seed From U3	6.00	6.00	6.00B
BERPC 91-2	5.67	6.00	6.67AB
C2	5.67	6.67	6.33AB
DSM 250	5.67	6.67	7.00AB
Cheyenne	5.67	6.33	6.67AB
LSD $_{(0.05)}$	N.S.	N.S.	1.37

[1]Visual quality is rated on a 1-9 scale where 1 = poorest quality and 9 is the highest possible quality.
[2]Ratings were taken on 1 September 1993.

Table 6. Color ratings of seeded bermudagrasses on 2 dates in 1993.

Cultivar	16 July	20 August
DSM 250	6.00C	7.67BCD
Primavera	6.33BC	7.33CD
Sonesta	6.33BC	7.33CD
J-912	6.33BC	7.67BCD
BERPC 91-6	6.00C	7.67BCD
BERPC 91-1	6.00C	7.00D
Tropica	6.67ABC	7.00D
Seed From U3	6.33BC	7.33CD
Cheyenne	6.33BC	7.00D
BERPC 91-2	6.33BC	8.00BC
Ft. Reno	7.33A	8.33AB
Poco Verde	6.33BC	7.00D
Arizona Common	6.00C	7.67BCD
Sundevil	7.00AB	9.00A
C2	6.67ABC	7.67BCD
Guymon	6.33BC	7.67BCD
BERPC 89-3	7.00AB	8.00BC
African Bermuda	6.67ABC	7.67BCD
$LSD_{(0.05)}$	0.90	0.98

[1]Color was rated on a 1-9 scale where 1 = straw colored and 9 = dark green.

Table 7. Seedhead ratings for seeded bermudagrasses on 15 July 1993.

Cultivar	Rating
DSM 250	7.67A
Primavera	7.00A
Sonesta	6.67AB
J-912	6.33ABC
BERPC 91-6	6.33ABC
BERPC 91-1	5.33BCD
Tropica	5.00CDE
Seed From U3	5.00CDE
Cheyenne	5.00CDE
BERPC 91-2	4.67DE
Ft. Reno	4.33DEF
Poco Verde	4.00DEFG
Arizona Common	4.00DEFG
Sundevil	4.00DEFG
C2	3.67EFG
Guymon	3.00FGH
BERPC 89-3	2.67GH
African Bermuda	2.0H
$LSD_{(0.05)}$	1.35

[1]Seedheads were rated on a 1-9 scale where 1 = no seedheads and 9 = complete coverage.

Table 8. Entries in Bermudagrass Spring Dead Spot Tolerance Study.

Genotype	Source	Genotype	Source
91173	Internat. Seeds	Cheyenne	Jacklin Seed Co.
91180	Internat. Seeds	Ft. Reno	OSU
African bermudagrass	OSU	Guymon	Johnston Seed Co.
Arizona Common	Many	J-912	Jacklin Seed Co.
BERPC 91-2	OSU	Poco Verde	Farmers Marketing
BERPC 91-6	OSU	Primavera	Farmers Marketing
BERPC 89-3	OSU	Sonesta	O.M. Scotts
BERPC 91-3	OSU	Sundevil	Medalist America
BERPC 91-4	OSU	Tropica	Turf Merchants
BERPC 91-1	OSU	NuMex Sahara	Farmers Marketing
BERPC 91-12	OSU	Tifton 10	GA Ag Exp Station
BERPC 91-13	OSU	Midlawn	KSU/OSU
C2	Finelawn Research	Midfield	KSU/OSU

All entrees are seed propagated except for Tifton 10, Midlawn and Midfield bermudagrasses

Table 9. Seed yield and seed germination of turf type bermudagrass, Agronomy Research Station, 7100 Series, Stillwater, OK. 1992

Entry No.	Strain	Seed Yield	Germination	Hard Seed	Total Germination
		Lbs/acre	%		
1	1-1-5	118.52	81	1	82
2	1-3-7	82.54	92	1	93
3	1-5-10	111.73	87	4	91
4	1-9-4	70.51	78	1	79
5	1-12-8	150.05	75	2	77
6	1-12-9	181.42	63	6	69
7	1-18-7	14.16	72	3	75
8	1-18-10	72.81	83	0	83
9	1-19-10	122.09	62	5	67
10	1-22-10	1.13	66	2	68
11	1-23-3	10.63	56	7	63
12	1-23-7	136.14	57	4	61
13	2-1-8	44.76	86	2	88
14	2-3-11	82.27	93	1	94
15	2-4-5	64.64	81	3	84
16	2-4-8	84.58	83	5	88
17	2-5-9	121.79	73	5	78
18	2-5-11	4.04	63	3	66
19	2-6-5	93.60	75	3	78
20	2-10-8	86.03	84	0	84
21	2-10-10	41.71	77	4	81
22	2-11-7	238.80	76	3	79
23	2-11-11	37.84	69	9	78
24	2-12-6	17.44	60	3	63
25	2-13-10	133.67	80	3	83
26	2-14-5	38.93	56	2	58
27	2-17-2	95.16	78	0	78
28	2-24-5	75.05	51	9	60
29	2-24-6	82.93	74	1	75
$\bar{x}$		83.27			
CV %		48.64			
LSD .05		82.96			

Table 10. Chemical treatments and rates applied to African bermudagrasses and Tifgreen hybrid bermudagrass.

Trade name	Common name	Chemical name	Rate lb ai A^{-1}
DMC Weed Control	Metsulfuron Methyl	Methyl 2-[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)-amino]carbonyl]amino]	0.008
Dimension	Dithiopyr	3,5-pyridinedicarbothioic acid, 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)- S, S-dimethyl ester	0.500
Banvel	Dicamba	Dimethylamine salt of dicamba (3,6-dichloro-o-anisic acid)	0.098
Weedestroy MCPP-4 Amine	MCPP	Dimethylamine salt of 2-(-methyl-4-chlorophenoxy)propionic acid	0.500
Trimec Bengrass Formula	2, 4-D	Dimethylamine salt of 2, 4-Dichlorophenoxyacetic acid	0.152
	Dicamba	Dimethylamine salt of Dicamba (3,6-dichloro-o-anisic acid)	0.152
	MCPP	Potassium salt of 2-(2-methyl-4-chlorophenoxy) propionic acid	1.016
Weedar 64A brand	2, 4-D	Dimethylamine salt of 2, 4-Dichlorophenoxyacetic acid	1.945
Daconate 6	MSMA	Monosodium Acid Methanearsonate	1.016
Daconate 6	MSMA	Monosodium Acid Methanearsonate	2.041
Kerb 50-W	Pronamide	5-dichloro-N-(1, 1-dimethyl-2-propynyl)-benzamide	0.500

Table 11. Percent cover of turf in 1993 Putting Green Bermudagrass Trial.

Cultivar	14 July	3 August	9 September
CTR1111	25.00A	38.33CD	41.67CDEF
Tifgreen	25.00A	48.33B	61.67AB
CTR 2849	23.33AB	28.33EFG	38.33DEF
CTR 2352	20.00AB	40.00BCD	50.00BCD
CTR 2718	18.33AB	26.67FG	38.33DEF
CTR 2552	16.67AB	25.00FG	35.00EF
CTR 2302	16.67AB	28.33EFG	38.33DEF
Uganda	16.67AB	70.00A	71.67A
OKC 90-16	16.67AB	33.33CDEF	43.33CDEF
CTR 1120	15.00B	41.67BC	45.00CDE
CTR 2946	15.00B	26.67FG	35.00EF
CTR 2306	15.00B	31.67DEFG	41.67CDEF
CTR 2747	15.00B	28.33EFG	36.67EF
Tifdwarf	15.00B	23.33G	31.67F
CTR 2570	15.00B	36.67CDE	45.00CDE
CTR 3048	15.00B	38.33CD	51.67BC
LSD $_{(0.05)}$	9.50	9.20	12.66

[1]Means followed by the same letter are not significantly different at the 95% certainty level.

Table 12. Mean LT_{50} values (±SE) of forage and turf bermudagrasses following acclimation in a growth chamber for 4 weeks at 8/2°C day/night cycles with a 10 hour photoperiod.

Genotype	LT_{50}
Tifton 85	-5.3 ± 0.3 a
Tifton 44	-6.9 ± 0.2 b
Coastal	-7.0 ± 0.3 b
Tifgreen	-7.5 ± 0.1 b
Tifway (authentic)	-7.6 ± 0.3 b
Tifway (retested)	-10.7 ± 0.3 c

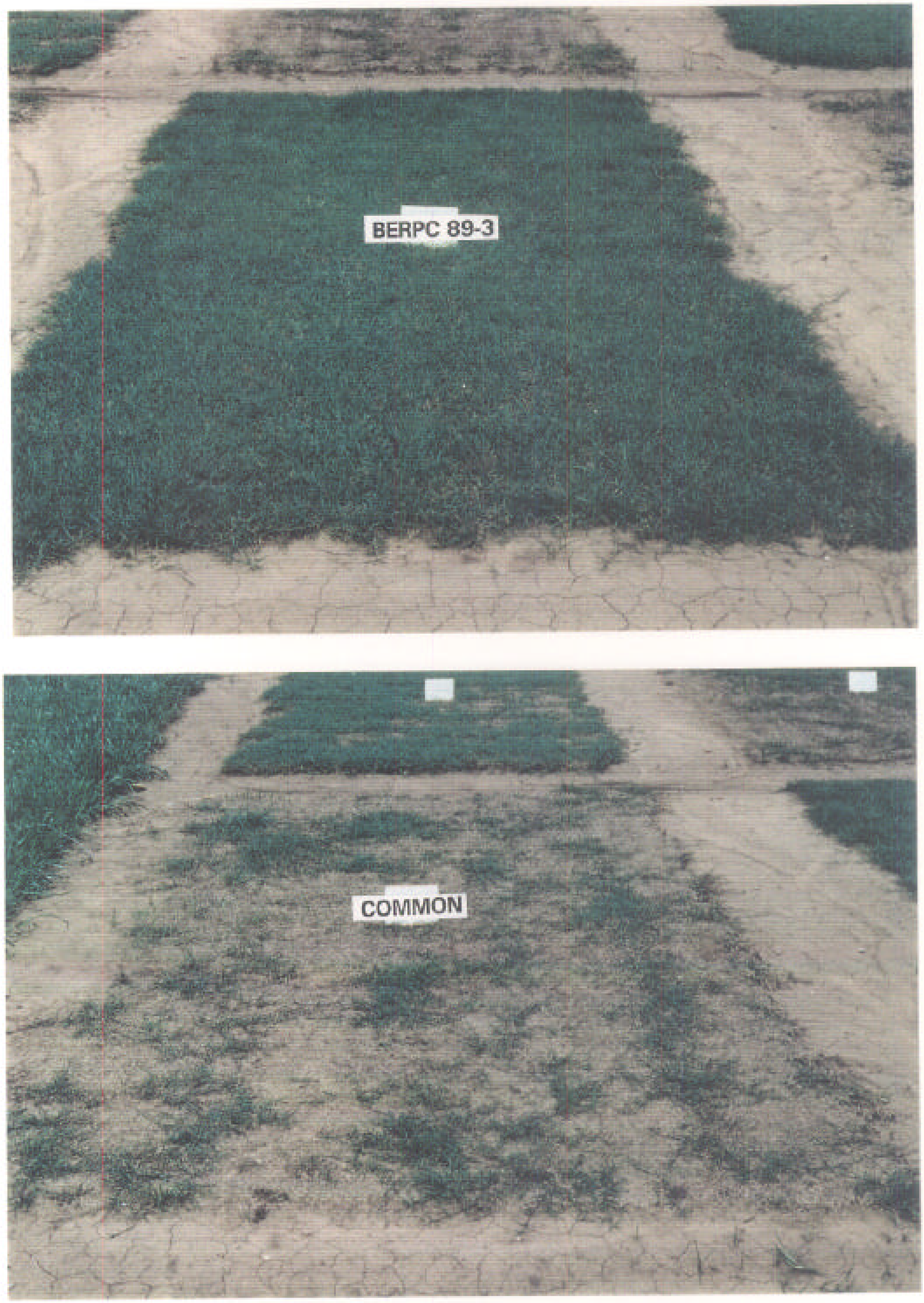

Fig. 1. Spring growth of BERPC 89-3 and Arizona Common bermudagrasses in early May 1993. Plots were seeded July 20-23, 1992.

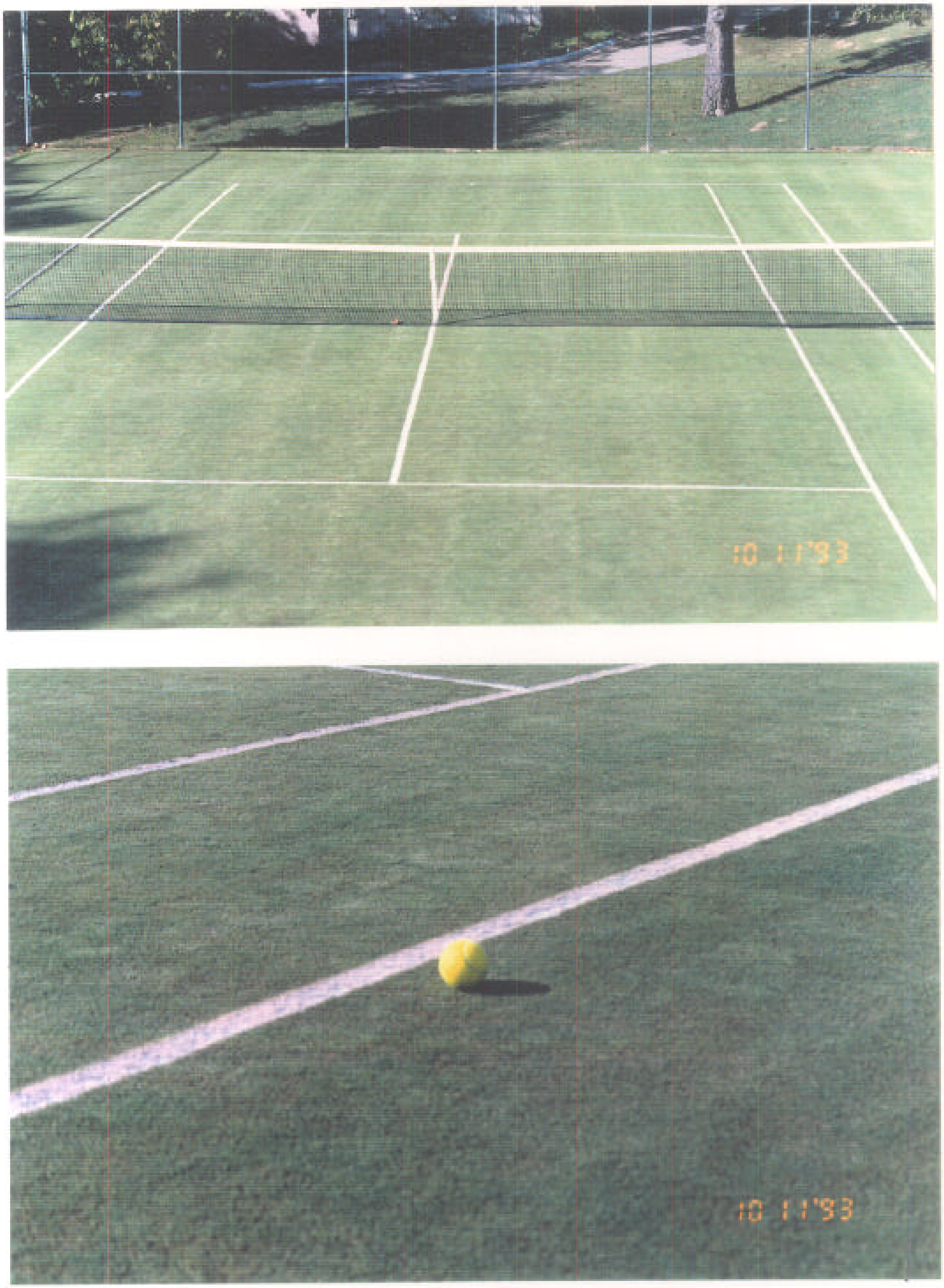

Fig. 2. Tennis court sodded to Ctr 2747 July 1993. Location is the home of Mr. Rick Nelson, owner of Mingo Tree & Turf, Tulsa OK.

Fig. 3. Cynodon transvaalensis plots at the Palm Beach Country Club, July 1993. (A) Difference in performance of selected strains planted May 1992. (B) Original screening nursery planted Oct. 1990 showing continued sorting individual plants (nursery was established with 100 plants spaced 3' apart).

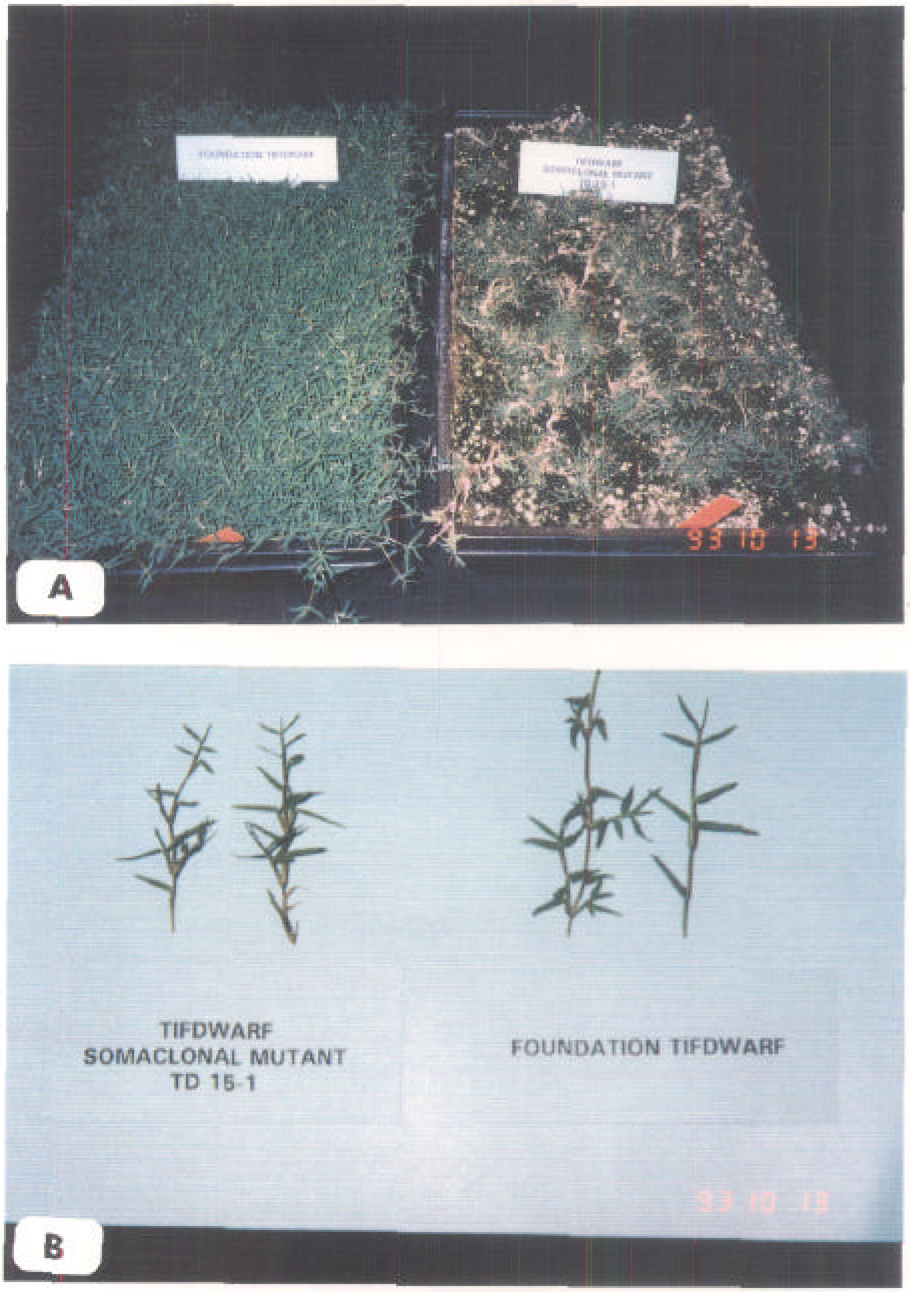

Fig. 4. Appearance of foundation Tifdwarf and superdwarf somaclonal variant Tifdwarf plant Td 15-1. (A) Flats of the two grasses planted at same time in same manner. (B) Shoots of the two grasses.