Kansas State University Agricultural Experiment Station and Cooperative Extension Service

K-STATE TURFGRASS RESEARCH 2004

Report of Progress 929

FOREWORD

Turfgrass Research 2004 contains results of projects done by K-State faculty and graduate students. Some of these results will be presented at the Kansas Turfgrass Field Day at the Rocky Ford Turfgrass Research Center in Manhattan on August 5. The enclosed articles present summaries of research projects have been recently completed, or will be completed in the next year or two. Specifically, this year's report presents summaries of research on environmental stresses, turfgrass establishment and culture, and cultivar evaluations.

Personnel changes arose in 2004 that will put additional strain on existing personnel until the vacancies are filled. Dr. Matt Fagerness, turfgrass specialist, left K-State in April for other opportunities. We wish Matt well in his new endeavors.

Dr. Ned Tisserat, horticulture pathologist, is leaving K-State in August after 20 years of service to the horticulture industry. Ned has an opportunity to return to Colorado State University, and Colorado is home for him. Ned's contributions to K-State Research and Extension and the College of Agriculture have been immeasurable, and he will be sorely missed. Moreover, we will miss Ned as a colleague and friend. With the current state budget situation, these positions will not be filled immediately. If you would like to voice your concern regarding the fate of these two vacant positions, we encourage you to do so. Letters should be addressed to: Dean of Agriculture, 115 Waters Hall, Kansas State University, Manhattan, Kan. 66506.

What questions can we answer for you? The K-State research team is responsive to the needs of the industry. If you have problems that you feel need to be addressed, please let one of us know. In addition to the CD format, you can access this report, those from previous years, and all K-State Research and Extension turfgrass publications on the web at: www.oznet.ksu.edu/dp_hfrr/welcome.htm.

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Table of Contents

Environmental Stresses and Physiology

Establishment and Culture

Cultivar Evaluations

TITLE: Drought Resistance of Two Cultivars of Texas Bluegrass Hybrids Compared with Kentucky Bluegrass and Tall Fescue

OBJECTIVES: Evaluate the visual qualities of Texas bluegrass hybrids, Kentucky bluegrass, and tall fescue under varying irrigation regimes and deficits. Investigate the effects of mowing height and irrigation deficit on the visual qualities and the drought-, cold, and heat-tolerance of Texas (hybrids) and Kentucky bluegrass.

AUTHORS: Dale Bremer, Kemin Su, Jack Fry, and Steve Keeley

SPONSORS: The Scotts Co. Inc., Golf Course Superintendents Association of America, and the Kansas Turfgrass Foundation

INTRODUCTION:

Kentucky bluegrass (*Poa pratensis L.*) is a cool-season grass that is commonly used on fairways and roughs of golf courses in the United States. Tall fescue (Festuca arundinacea Schreb.), also a cool-season grass, is sometimes used in roughs. In some areas of the country these grasses are subjected to frequent drought, which results in either heat and drought symptoms or high irrigation rates in order to maintain acceptable quality. Kentucky bluegrass commonly goes dormant and loses color during periods of high temperature and drought. Tall fescue has good drought resistance, but some superintendents prefer the finer texture of Kentucky bluegrass.

New Texas bluegrass (*Poa arachnifera Torr.*) hybrids, which are genetic crosses between Kentucky bluegrass and native Texas bluegrasses, have the appearance of Kentucky bluegrass but may be able to withstand higher temperatures and extended drought without going dormant, and may maintain their green appearance during all but extreme conditions. In warm-season climates such as the South, Texas bluegrasses stay green all year. Furthermore, Texas bluegrass hybrids may use significantly less water than other cool-season species while maintaining their green color. The latter is important, given the increasing competition for water and rising costs of irrigation.

At least one hybrid of Texas bluegrass (Reveille) has demonstrated disease resistance to leaf rust, powdery mildew, and summer patch, although it shows susceptibility to brown patch, especially when overfertilized. Reveille also has shown resistance to fall armyworms and white grubs, but tests have revealed that it performs poorly in saline soils. Observations of other Texas bluegrass hybrids have suggested that disease resistance and susceptibility are similar to Kentucky bluegrasses.

Texas bluegrass (Reveille) is advertised as a multiuse cool-season grass for the Eastern Seaboard, transition zone, arid West, and Southern United States with similar water requirements to common bermudagrass. Tests with Reveille revealed no significant decline in visual quality ratings when irrigation was decreased from 2/3 to 1/3 of open-pan evaporation (in Texas; James Read, personal communication). This suggests that Texas bluegrass is a high quality, low water use, and high heat-tolerant turfgrass that may be well suited for golf course fairways and roughs in some parts of the United States, including the transition zone.

Despite the promising role that Texas bluegrass may play on U.S. golf courses, scientific data are sparse regarding its qualities under the various forms of management and stress that it would be subjected to on golf courses. For example, the effect of different mowing heights on the drought- and heat-tolerance characteristics of Texas bluegrass is unknown. Some parts of the transition zone are subject to extreme cold during winter months, and the cold-hardiness of Texas bluegrass compared to Kentucky bluegrass has not been evaluated. It is also uncertain how it compares in quality to Kentucky bluegrass under various irrigation regimes and deficits.

OBJECTIVES:

The main objectives of this study are to: 1) compare the drought resistance characteristics of two cultivars of Texas bluegrass hybrids to those of Kentucky bluegrass and tall fescue; and 2) compare the drought-, cold-, and heat-tolerance of a Texas bluegrass hybrid with Kentucky bluegrass under different irrigation regimes and mowing heights.

MATERIALS AND METHODS:

Study 1

Plots for Study 1 were reseeded in September 2002, after billbugs destroyed a number of plots during that summer. Two cultivars of Texas bluegrass hybrids (seed provided by the O.M. Scotts Co.) will be compared with Kentucky bluegrass (Apollo) and tall fescue (Dynasty) in this water-deficit trial at the Rocky Ford Turf Research Center near Manhattan, Kan. Two irrigation treatments and a control will be applied to plots. Irrigation treatments include the replacement of 60% or 100% of the water lost from plants and soil via evapotranspiration (ET). Control plots will receive minimal irrigation (i.e., only enough to maintain survival). Water will be applied using a portable sprinkler system with a metering device built at K-State. The split-plot design includes twelve main plots (8 x 3 meters each) of one irrigation treatment each that is arranged in a randomized block design (i.e., 3 blocks). Each main plot is subdivided into 12 subplots (2 x 1 meters each) that are arranged in 3 rows (i.e., 4 subplots per row). The subplots in each row contain 1 each of Kentucky bluegrass, tall fescue, and each of 2 Texas bluegrass hybrids (Thermal Blue, formerly HB 129; and HB 329). Each species or cultivar was replicated three times within each main irrigation plot, and species/cultivar will be blocked by row. All plots will be mowed at a height of 2.5 inches once or twice weekly, depending upon growth rate. Turf will receive 3 to 4 lb. N/1,000 sq.ft./yr. Pesticides will be applied as needed. Billbug populations will be monitored with insect traps by a turf entomologist, and pesticide applied accordingly. Presumably this will include a systemic application and perhaps a contact variety, if required. This study will be conducted through the end of 2004. ET will be calculated using empirical equations and data obtained from the weather station at the research center. Precipitation is monitored with a tipping-bucket rain gauge.

All plots are evaluated biweekly for visual quality. This will include a relative ranking of the overall density, uniformity, texture, and color of the turfgrass in each plot. Visual evaluations will also be conducted for drought resistance, which will include observations of leaf firing and appearance of wilt. Plots will also be rated upon observation of any insect or disease infestations.

Study 2

Heavy rains two days after planting in fall 2002 caused severe washing of seed among plots. Furthermore, billbugs damaged those plots during the summer of 2003. A large rainout shelter became available at Rocky Ford Turfgrass Research Farm last fall, so a second array of plots was reestablished at that facility. It precisely controls the amount of water applied to the plots and will greatly improve this study. The objective is to evaluate the effect of mowing height and irrigation treatment on the various qualities of a Texas bluegrass hybrid (Thermal Blue, formerly HB 129) and Kentucky bluegrass (Apollo). Treatments will include 2 mowing heights of 0.9 and 2.5 inches. Two irrigation treatments will be applied to plots. Irrigation amounts are tentatively the replacement of 100%, and 60% of the water lost from plants and soil via evapotranspiration (ET), which will be estimated with the Penman-Monteith equation and checked with microlysimeters. In addition, dual-probe heat capacity sensors will be used to monitor soil moisture to prevent the overapplication of water. Water will be applied by hand, using a meter to control precisely the amount applied to each plot. The split-split plot design will include eight main plots (2.72 x 3.52 m each) of one irrigation treatment each that will be arranged in a randomized block design (i.e., 4 blocks). Each main plot will be subdivided into 2 subplots (1.36 x 3.52 m) that will consist of the 2 mowing treatments. Each subplot (mowing treatment) will then be divided into 2 sub-subplots. The 2 sub-subplots will contain 1 each of Apollo and Thermal Blue. This study will be conducted through the end of 2005.

Plots will be evaluated visually for quality, color, and density using the same methods as described in the first study. Photosynthesis measurements will be collected on plots to determine the effects of mowing and water deficit on basic plant processes.

Cold- and Heat-Tolerance Studies

Cold-tolerance experiments will be conducted on plugs collected from plots of Apollo and Thermal Blue in the second study. Field samples of each species will be collected from plots under each mowing height and irrigation treatment to determine the impact of mowing height and irrigation deficit on cold tolerance, including any interactions between mowing and irrigation treatments within species. The samples will be collected in December or January, when they will be naturally acclimated to cold temperatures. Additional samples may be collected periodically from November to March to evaluate seasonal impacts on cold tolerance. The plugs will be placed into a programmable chamber and frozen at increasingly lower temperatures, by 5°C increments (hourly), from -10 to -40°C. At each test temperature, samples of each species and from each mowing and irrigation treatment combination will be removed from the freezer. Samples will be thawed slowly and all plugs will be potted. They will be placed in a greenhouse and the regrowth evaluated to determine the lethal temperature for each species under each treatment.

Similarly, heat tolerance experiments will be conducted on leaf tissue collected from the same plots of Kentucky and Texas bluegrass in the second study. Leaf tissue of each species will be collected from plots under each mowing height and irrigation treatment to determine the impact of mowing height and irrigation deficit on heat tolerance, including any interactions between mowing and irrigation treatments within species. The leaf samples will be collected in the summer months when they will already be acclimated to warmer temperatures. The tissue will be placed into vials containing 20 mL of distilled water and allowed to fully hydrate. The vials will then be placed into a controlled-temperature chamber and exposed to increasingly higher temperatures, by 3°C increments (hourly), from 35 to 50°C. At each test temperature, vials containing leaf tissue of each species and from each mowing and irrigation treatment combination will be removed from the chamber. After their exposure to heat, the vials will be stirred and the electrical conductivity of the leachate will be measured. Electrolyte leakage occurs as cell membranes burst, and occurs rapidly at or near lethal temperatures. Presumably, lethal temperatures vary by species (e.g., higher for Thermal Blue), and also may vary according to mowing and irrigation treatment. An additional heat tolerance test will be conducted to determine the survivability of the species (under each mowing x irrigation treatment) during prolonged periods of extreme heat. Fresh leaf samples will be placed in vials with 20 mL of distilled water and will be exposed to high temperatures (near but not exceeding the predetermined lethal temperatures) for 24 hours. The electrical conductivity of the leachate from each sample will be measured every 2 hours during the 24-hour period to determine when tissue death occurs for each species under each treatment combination.

RESULTS:

Preliminary results from Study 1

Establishment was most rapid in Dynasty, which reached 100% cover by May 7, 2003 (Fig. 1). Apollo and Thermal Blue (formerly HB 129) established slower than Dynasty and were similar to each other: Thermal Blue reached 100% cover by June 13 and Apollo by June 28. HB 329 was slowest to establish, and had only reached 96% cover by July 19.

Billbugs damaged Thermal Blue, Apollo, and HB 329 plots again in 2003, despite three applications of pesticide that included a systemic (Merit) and two applications of contact (Scimitar and Talstar); Dynasty plots were not infested. Data from insect traps indicated extremely high billbug populations at Rocky Ford Turfgrass Research Center in 2003 (Robert Bauernfeind, K-State entomologist, personal communication). For example, from April 4 to October 17, 2003, 16,000 adult billbugs were counted in the traps at Rocky Ford (the site of this study) compared with only 700 from the nearby Colbert Hills Golf Course. In 2004, pesticide applications for billbug control will be coordinated with data from insect traps at Rocky Ford. Dr. Bauernfeind has agreed to cooperate with us in this respect. Quality ratings taken during the billbug infestation illustrate the effect billbugs had on quality of the bluegrasses (Fig. 2). The quality of Dynasty, which was not attacked by billbugs, was high compared to Apollo, Thermal Blue, and HB 329. Variability in billbug damage was significant among individual plots within each bluegrass cultivar; some plots exhibited severe damage while others showed no damage. The slightly lower rating of HB 329 compared with Apollo and Thermal Blue was likely because of its lower density during establishment. Because of moderate billbug damage, no irrigation treatments were applied during the summer of 2003 to allow plots to recover by fall.

Quality ratings during the growing season were generally highest in Dynasty (Fig. 3). Billbug damage caused lower ratings in the bluegrasses until September, when they had recovered from billbug damage (after pesticide applications and daily irrigation). By late October, all turfgrasses were of acceptable quality (>6) and all plots are slated for irrigation treatments during the summer of 2004. Color ratings showed Apollo and HB 329 in the lead early in the growing season (Fig. 4). However, later Dynasty was higher than the others. Density ratings also were higher in Dynasty throughout the growing season (Fig. 5). Early density ratings of HB 329 were lowest because of its slower establishment rate (Fig. 1). After August 22 (day of year 234), all density ratings were between 8 and 9, but Dynasty maintained the highest.

Vertical growth rates were highest in Dynasty and in Thermal Blue and lowest in Kentucky bluegrass until late October, when all were essentially the same (Fig. 6). Although Thermal Blue's growth rate was as high as Dynasty's, the rate of increase in aboveground biomass (canopy growth - dry weight) was lower in Thermal Blue than in Dynasty (Fig. 7). Dynasty exhibited the greatest daily gain in aboveground biomass throughout the season, and Apollo and HB 329 were the lowest.

Photosynthesis measurements were collected on only 2 days during the summer and were curtailed after billbugs damaged the plots (Fig. 8). Photosynthesis was highest in Dynasty on both dates and lowest in Apollo and HB 329. Thermal Blue was slightly higher than Apollo and HB 329 on July 24. The lower rates in the bluegrasses reflected damage caused to those plots by billbugs.

Study 2

Because of heavy rain damage to newly seeded plots in the fall of 2002, and because of damage by billbugs in summer 2003, there are no data to report for Study 2. However, the relocation to the rainout shelter will allow precise control of the amount of water applied to the plots and will greatly improve this study. Plot establishment at the rainout shelter has been good.

A graduate student, Kemin Su, is working on both projects, Study 1 and Study 2. Kemin will conduct research in these studies in collaboration with the principal investigators during the next two years.

Conclusions

Overall, Dynasty was the most robust of the four turfgrasses throughout establishment and into the fall, as indicated by most measurements and ratings (Figs. 1-8). Billbugs attacked all three bluegrass cultivars/varieties during the summer, but did not attack Dynasty. Although pesticide applications prevented plots from permanent damage that had occurred in the previous summer, we were not able to apply irrigation treatments because of billbug damage during the middle of summer. The plots are in good shape and are slated for irrigation treatments during summer 2004. An aggressive billbug control program is in place for spring and summer 2004 to effectively control infestations in these plots.

Figure 1. Visual estimates of percent cover during plot establishment. Varieties/cultivars include two Texas bluegrass hybrids (Thermal Blue and HB 329); Kentucky bluegrass (Apollo); and Tall Fescue (Dynasty).

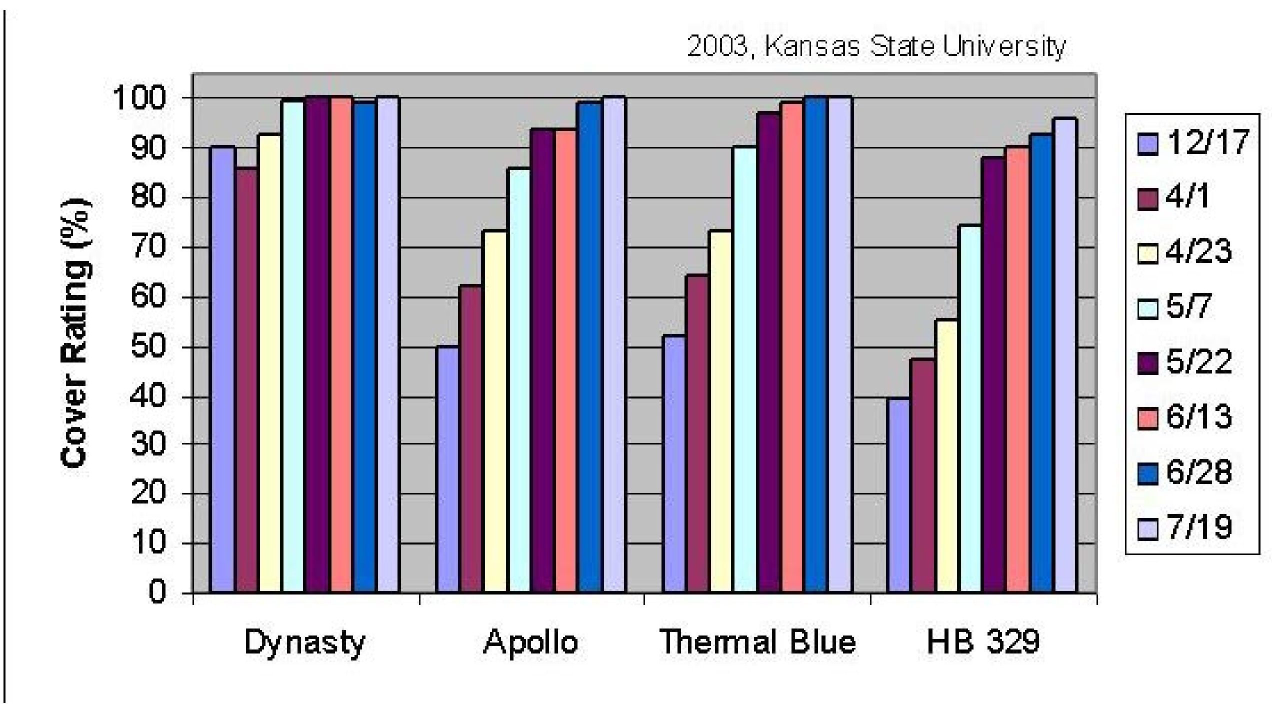


Figure 2. Visual quality ratings of the varieties/cultivars during the height of the billbug infestation. Ratings are on a scale of 1 to 9: 9 = best; 6 = minimally acceptable; and 1 = poor. Error bars represent one standard error (9 replicates each).

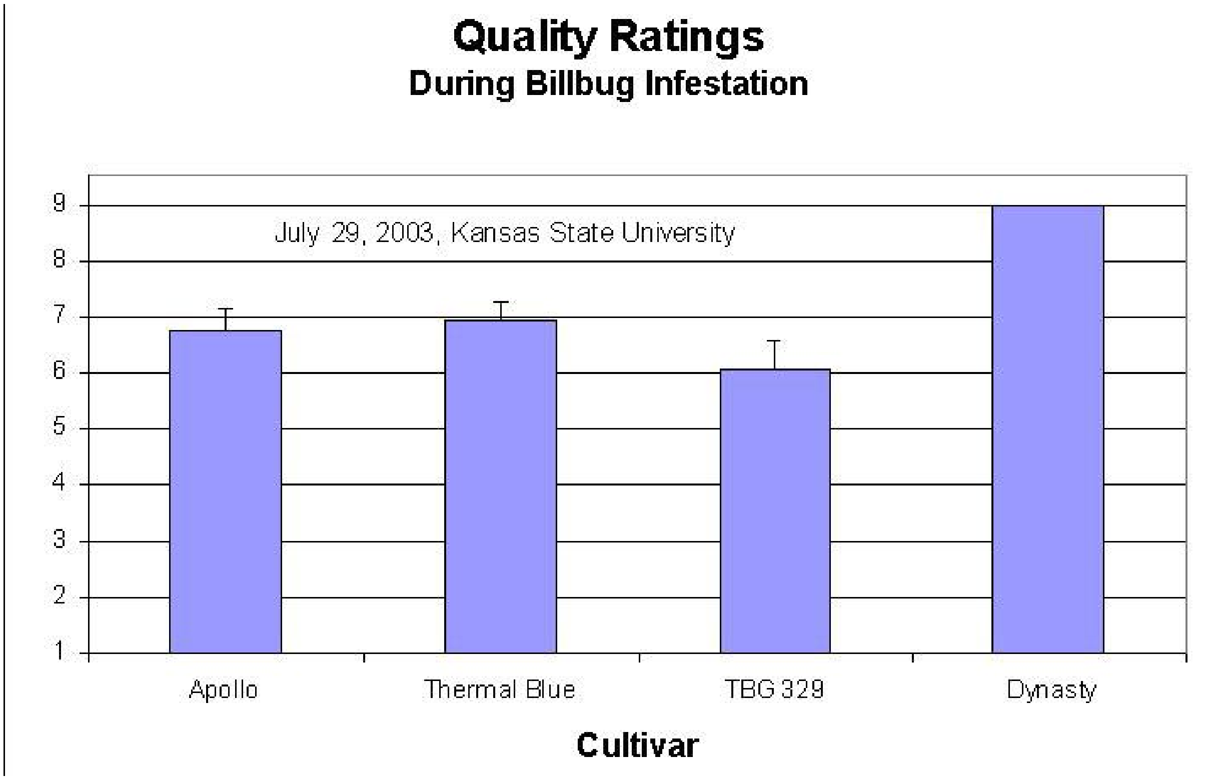


Figure 3. Visual quality ratings of the four varieties/cultivars of turfgrasses. Ratings are on a scale 1 to 9: 9 = best, 6 = minimally acceptable, and 1 = poor. Ratings were conducted June 13 to October 21 (Day of year 164 to 294), 2003. Error bars represent one standard error (9 replicates each).

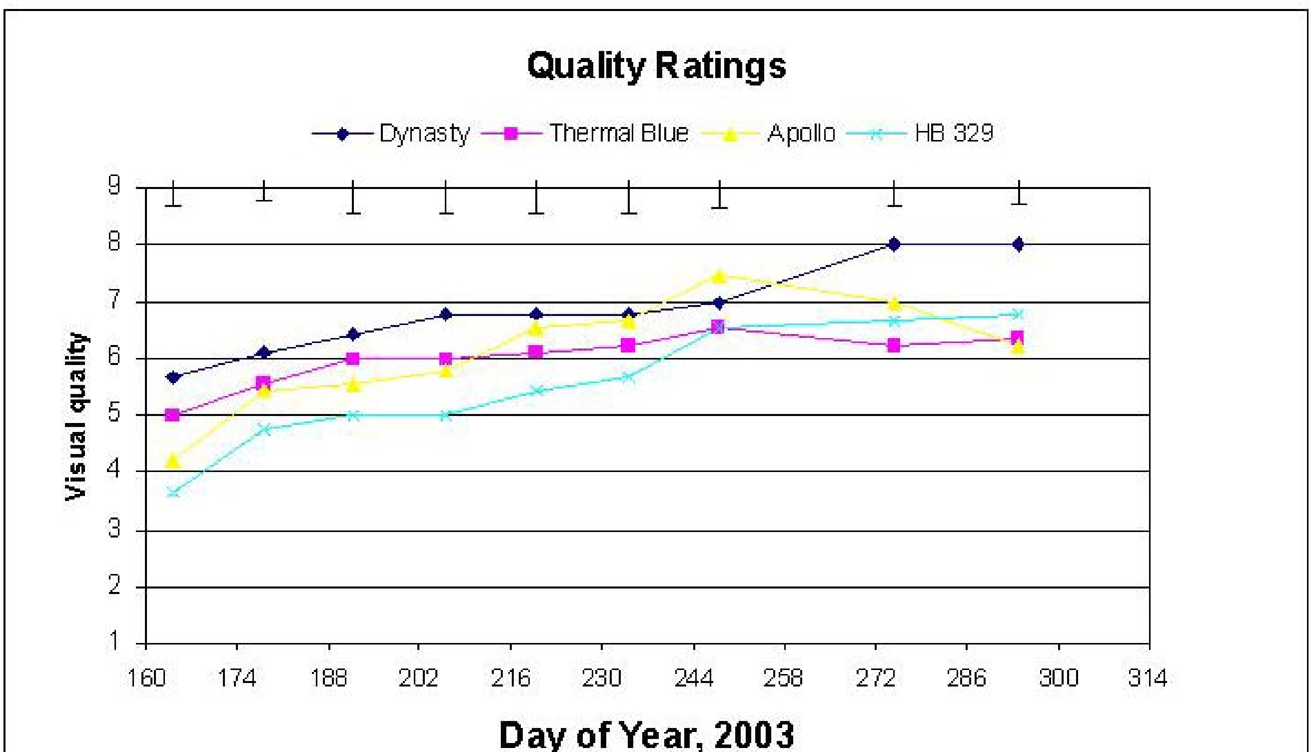


Figure 4. Visual color ratings of the four turfgrasses from day of year (DOY) 164 through 294 (June 13 through October 21) on a scale of 1 to 9; 9 = dark green and 1 = yellow.

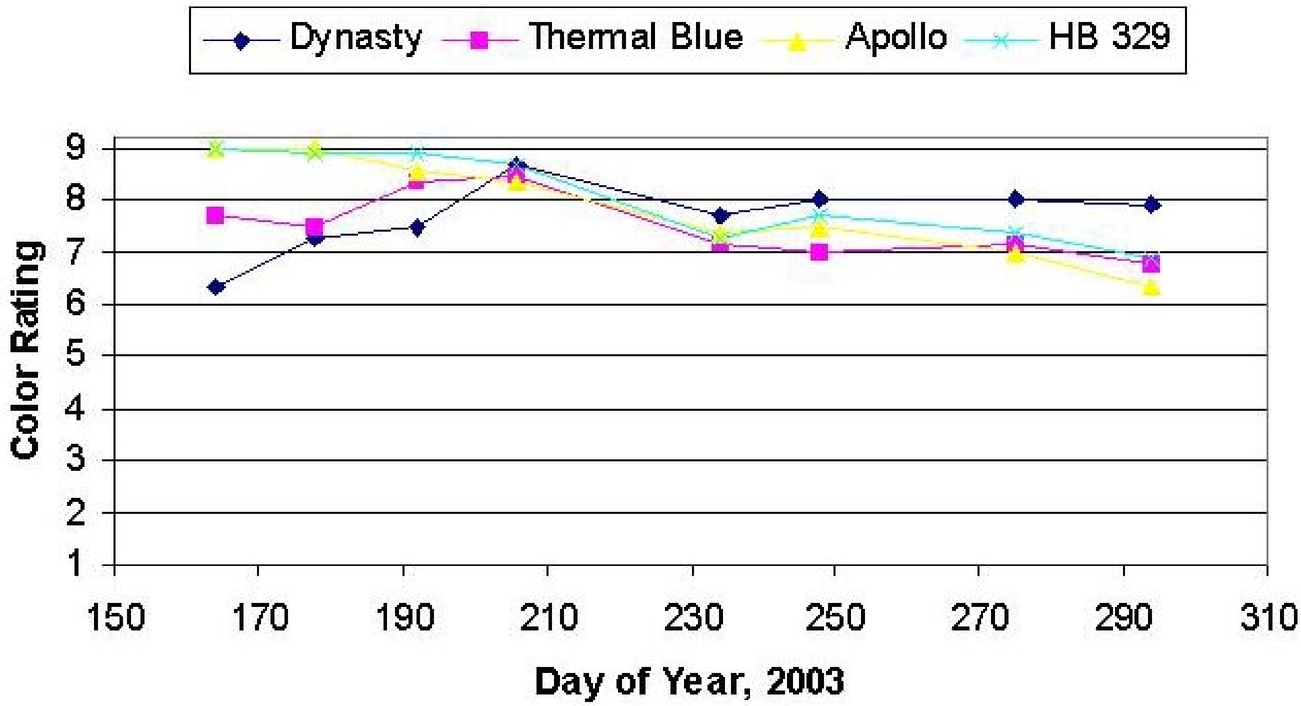


Figure 5. Density ratings for the four turfgrasses from day of year (DOY) 164 through 294 (June 13 through October 21) on a scale of 1 to 9; 9 = total cover and 1 = no cover. Error bars represent one standard error (9 replicates each).

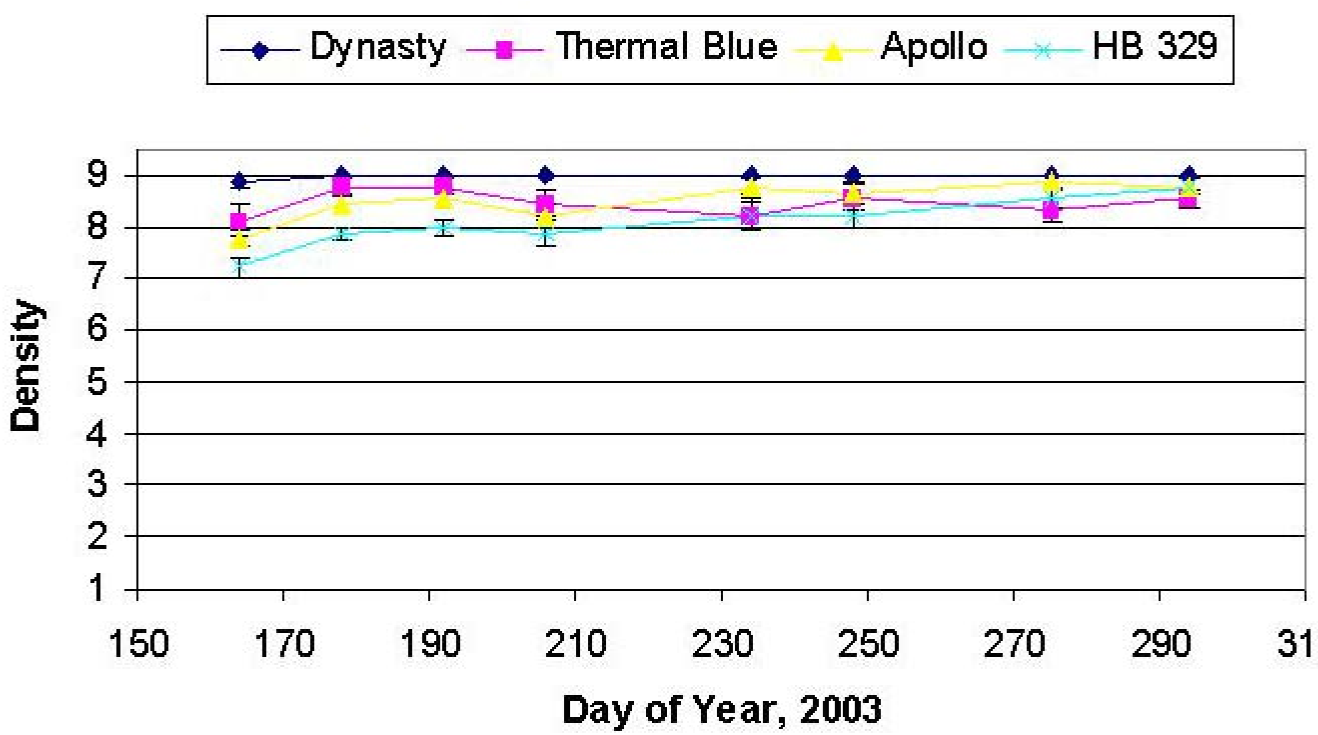


Figure 6. Canopy vertical growth rates (millimeters per day) of the canopy in the four turfgrasses on four dates during the growing season. Error bars represent one standard error (9 replicates). Asterisks along the abscissa indicate significant differences among varieties/cultivars on the corresponding date.

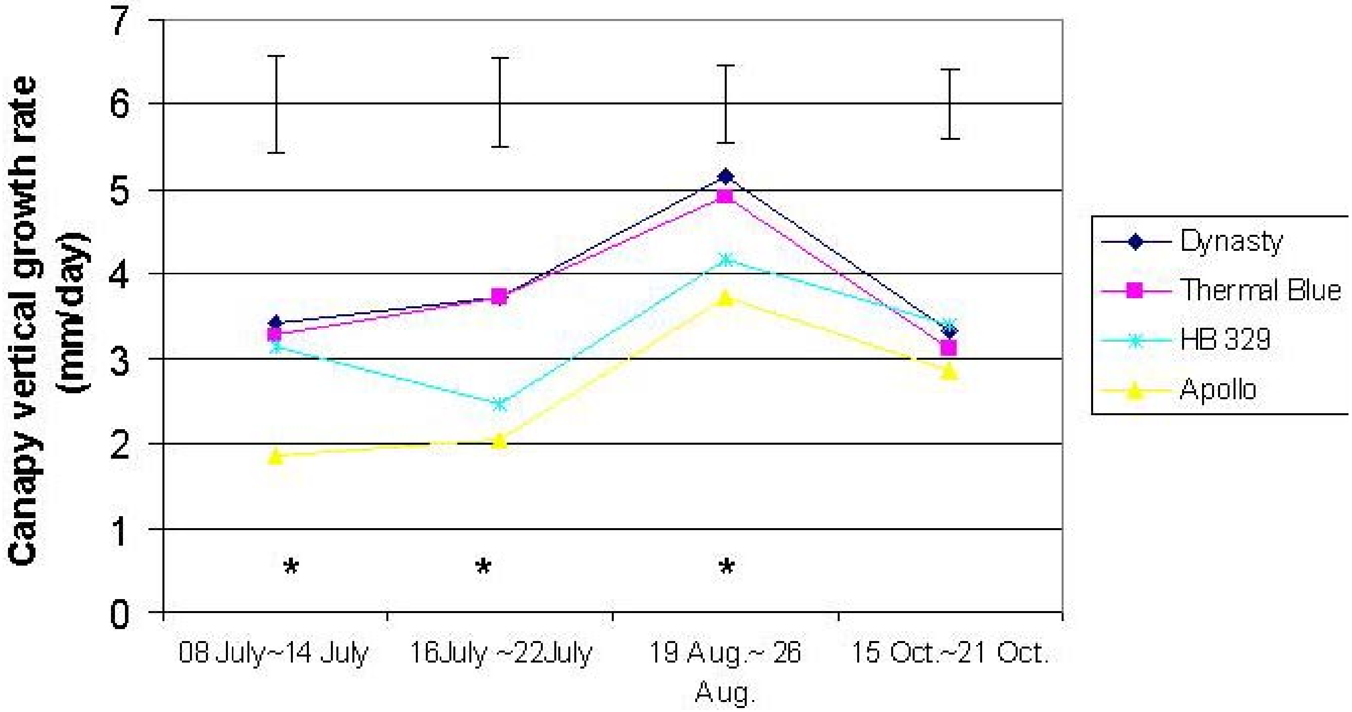


Figure 7. Canopy growth rate (biomass - dry weight per square meter per day) of the four turfgrasses. Error bars represent one standard error (9 replicates). Asterisks along the abscissa indicate significant differences among varieties/cultivars on the corresponding date.

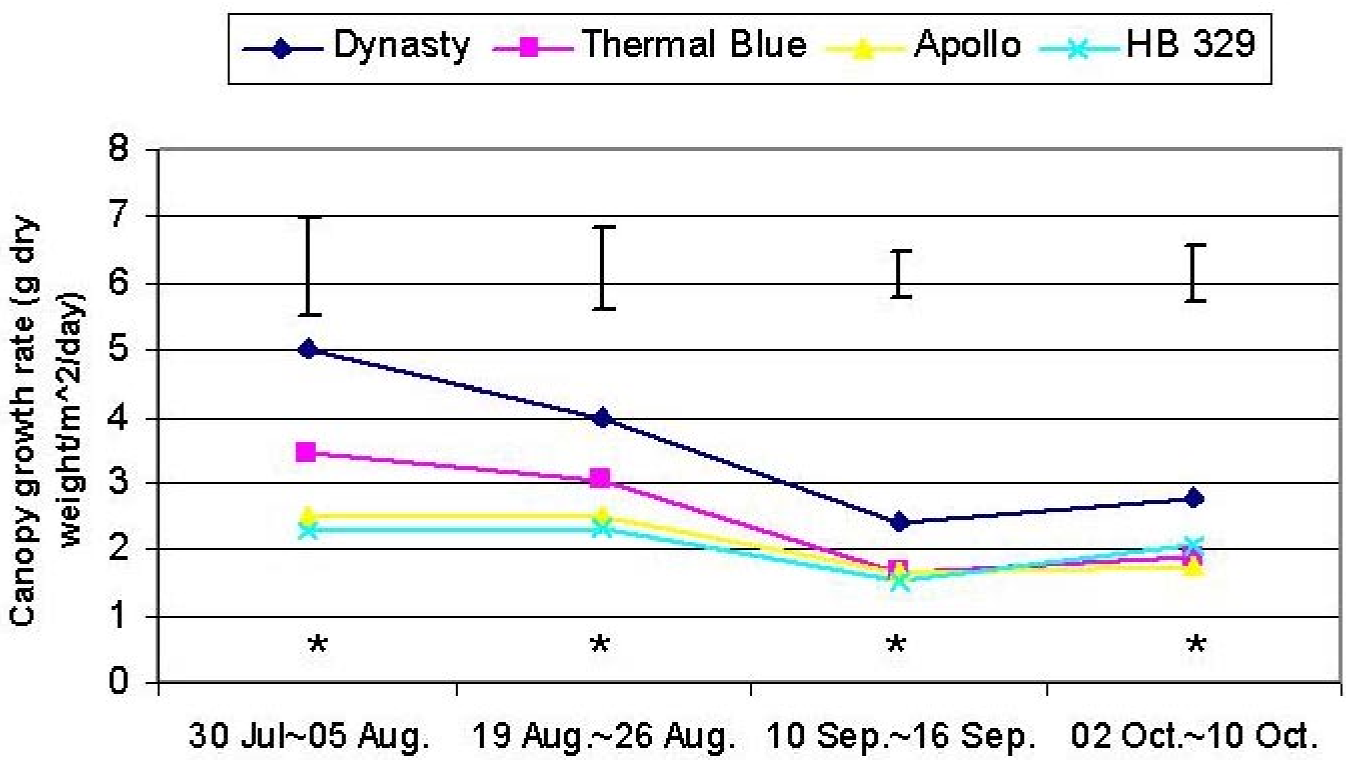
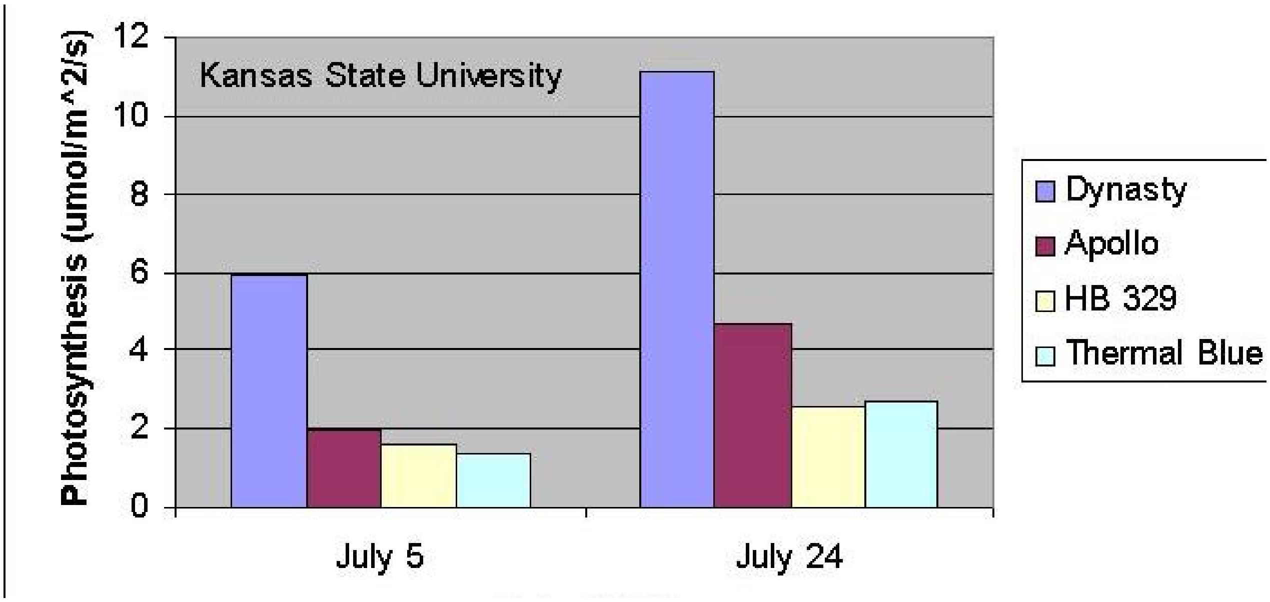


Figure 8. Measurements of photosynthesis in the four turfgrasses on July 5 and on July 24, 2003.



TITLE: Nitrous Oxide Fluxes in Turfgrass: Effects of Irrigation and Nitrogen Fertilization Rates

OBJECTIVE: Quantify the magnitude and patterns of nitrous oxide (N_2O) fluxes in turfgrass and determine how management practices can be used to reduce those fluxes and mitigate the greenhouse effect.

AUTHORS: Dale Bremer

SPONSORS: Kansas NSF EPSCoR and Kansas Turfgrass Foundation

INTRODUCTION:

Anthropogenic activities have contributed to an increase in concentrations of atmospheric nitrous oxide (N_2O), and agriculture is considered a significant source. A number of studies have determined that N_2O fluxes into the atmosphere are higher in croplands where N-fertilization and irrigation rates are high. However, urbanization in the United States and elsewhere is replacing significant tracts of land that were once occupied by natural or agricultural ecosystems. More than 20 million hectares of urbanized land are covered by turfgrass (e.g., golf courses, sports fields, parks, home lawns, etc.), which is often irrigated and heavily fertilized with N. Therefore, urban areas may represent an unappreciated – but significant – contributor to atmospheric N_2O. Adapting best management practices (BMPs) in turf ecosystems may help to mitigate the greenhouse effect by reducing effluxes of N_2O, which has 310 times the warming power of CO_2. Research is needed to determine BMPs in turfgrass ecosystems.

Little information is available in the literature on the effect of management practices on N_2O fluxes in turf. In one study, flux rates of 2021 ng N_2O-N m^{-2} s^{-1} were reported in turfgrass following N fertilization. In that study, it was also determined that fertilizer type had significant effects on N_2O fluxes, with urea-based fertilizers resulting in lower N_2O emissions than other fertilizer types. Others reported that soil temperatures of 30°C or higher, coupled with saturated soil conditions, increased denitrification rates in Kentucky bluegrass sod; higher denitrification rates typically result in higher N_2O emissions. Soil texture and soil organic carbon also may affect N_2O fluxes.

Modelers have determined that patterns of N_2O fluxes are evident at the ecosystem scale in forest, cropland, and rangeland ecosystems, which may be useful in predicting regional and global N_2O fluxes. Although N_2O emissions from urbanized land (e.g., turfgrass ecosystems) also may be important on regional and global scales, the role of turfgrass ecosystems in the N_2O inventory of the United States is unknown. Therefore, N_2O flux data from turfgrass are needed to test and improve N_2O flux models.

In this study, currently in progress, N_2O emission data from turfgrass are being collected under various forms of irrigation and N-fertility management regimes. The site for this project is the Rocky Ford Turfgrass Research Center, which was established more 40 years ago and contains approximately 5.25 hectares of turfgrass.

The specific objectives for the 14-month period of this proposed research are to:

1) Quantify the magnitude and patterns of N_2O flux rates in a turfgrass ecosystem;
2) Determine the effect of nitrogen fertilization rates on N_2O fluxes in turfgrass;
3) Determine the effect of irrigation rates on N_2O fluxes in turfgrass;
4) Determine any irrigation by N-rate interactions on N_2O fluxes; and
5) Make a rough order of magnitude estimate of N_2O fluxes from an average-size golf course and from a large metropolitan area (e.g., Kansas City) by scaling up data obtained in this study.

Although the latter objective will be a rough estimate, it will be useful in analyzing the potential impact of urban areas on regional N_2O budgets.

MATERIALS AND METHODS:

Description of the Experimental Site

Six whole plots and 36 subplots were established in an area of perennial ryegrass (Lolium perenne). Whole-plot treatments include two irrigation rates replicated three times each, and subplots include three N-fertility treatments replicated two times each within each whole plot.

Irrigation treatments include: 1) 75% evapotranspiration (ET) replacement, and 2) frequency irrigation (approximately 120% ET replacement). Frequency irrigation represents a high water treatment (i.e., overwatering) that is typical in many turfgrass ecosystems. Irrigation amounts (i.e., ET) are calculated from a nearby weather station, and application is measured by a flow meter attached to the irrigation system.

Fertility treatments include: 1) 50 kg N ha^{-1} yr^{-1}; and 2) 250 kg N ha^{-1} yr^{-1}. Fertilizer types will be urea – which reportedly minimizes N_2O emissions in turfgrass compared to other fertilizer types and therefore, may represent a BMP – and ammonium sulfate. In the high N treatment, urea and ammonium sulfate will be applied in split-applications of: 75 kg N ha^{-1} in September; 50 kg N ha^{-1} in November, March, and May, respectively; and 25 kg N ha^{-1} in July. In the low N treatment, 50 kg N ha^{-1} of urea will be applied in September. Thus, four treatment combinations will be included in this test: 1) high N (urea and ammonium sulfate) and high irrigation rates; 2) high N (urea and ammonium sulfate) and low irrigation rates; 3) low N (urea only) and high irrigation rates; and 4) low N (urea only) and low irrigation rates. Plots are mowed once or twice weekly, as needed, at 6.5 to 7.5 centimeters.

Measurements of N_2O fluxes

Soil-surface N_2O fluxes are measured using 12 vented, closed chambers that were built for this study. Collars were placed at one location in each subplot, and were driven approximately 8 centimeters into the soil. Gas samples from inside the chambers are removed with 12 mL polypropylene syringes at 0, 30, and 60 minutes after the chambers are installed onto the collars. Gas samples are then transported to the lab and analyzed by gas chromatography using an electron capture detector. The sampling frequency is at least once per week throughout, including during winter. Because N_2O fluxes may vary diurnally, attempts will be made to measure diurnal fluxes of N_2O on selected dates during the growing season. In particular, those dates would include the period immediately after fertilization and irrigation events when temporal variations in fluxes may be greatest.

Additional Measurements

Measurements of soil temperature and volumetric soil water content will be measured at 5 centimeters in each treatment using dual-probe heat-capacity sensors. These devices were built by the turf team at Kansas State University and have been used extensively in the lab and field (including under turfgrass).

Soil properties, including texture and bulk density, will be measured in the 0-10 centimeter and 10-20 centimeter profiles. Ammonium and nitrate levels will be measured in those profiles periodically, and more frequently after N applications. The microbial population at the test site will be characterized for denitrifiers, and soil respiration will be measured as an indication of microbial activity. Climatological variables will be measured at a weather station at Rocky Ford Turfgrass Research Center.

RESULTS:

Note: Because this project is in progress, the data presented are preliminary. A full report will be available next year.

Two sizes of chambers (20 and 25 centimeters in diameter with a height of 9.5 centimeters) were evaluated before placing chambers in the plots. Data were collected from chambers of both sizes for several days until sufficient data allowed evaluation. Results indicated that 20-cm-diameter chambers were adequate, and subsequently twelve 20-cm chambers were fabricated for the project. Once these chambers were fabricated, collars were installed in the field and measurements of N_2O fluxes began.

Initial measurements of N_2O fluxes were collected from all plots October 3, 2003, before fertilization. Plots were fertilized on October 6 with either urea at high or low rates (250 or 50 kg N ha^{-1} yr^{-1}) or ammonium sulfate at a high rate (250 kg N ha^{-1} yr^{-1}). After fertilization, measurements were collected for three days within the next week to capture any post-fertilization peaks in N_2O fluxes. In mid-November and again in late March, plots receiving high fertility rates were fertilized, and measurements were collected on two days within the following week. Otherwise, measurements have generally been collected once a week. Heavy snow cover for one month during late January and early February prevented collection of data during that period.

Major findings to date

Fluxes of N_2O were greatest following applications of fertilizer in plots with the high rates of urea (UH) and ammonium sulfate (AS), and AS was generally (slightly) lower than UH (Figs. 1 and 2). Lowest emissions were found in plots fertilized with urea at the low rate (UL). Within two weeks after fertilization in September, fluxes among treatments had converged and were essentially the same (Fig. 1). In November, plots in the high fertility treatments (UH and AS) were fertilized again. Four days after the November fertilization, fluxes in UH and AS plots were higher than UL plots. However, fluxes in UH plots decreased again and were equivalent to UL plots one week after fertilization. In AS plots, N_2O fluxes remained higher than UL plots for two weeks after fertilization. Thereafter, fluxes among treatments converged and remained constant for the remainder of November and into early December. Maximum fluxes occurred in AS plots after fertilization in early October, when they reached 2,326 μg m^{-2} h^{-1}. Fluxes were about 150 to 350 μg m^{-2} h^{-1} among plots before fertilization, and by late November had decreased to about 50 μg m^{-2} h^{-1}. Fluxes during the winter were near zero. In the spring, fluxes began to increase as the canopy began to photosynthesize, and fluxes were generally similar among treatments (Fig. 2). Following fertilization of UH and AS plots in March, flux rates increased and were significantly greater than UL plots on the second day after fertilization. However, by the seventh day, fluxes again were similar among treatments. These data indicate that the majority of N_2O emission "spikes" from fertilized turfgrass occur during a 2- to 7-day period after fertilization. The effects of irrigation on N_2O fluxes will be examined during the 2004 growing season.

Figure 1. Fluxes of nitrous oxide (N_2O) from perennial ryegrass during the fall and early winter, 2003. Fertilizer treatments included urea at high (U-Hi) and low (U-Lo) rates and ammonium sulfate at the high rate (AS-Hi). Vertical lines represent fertilization dates. The first day of year represented is January 1, 2004.

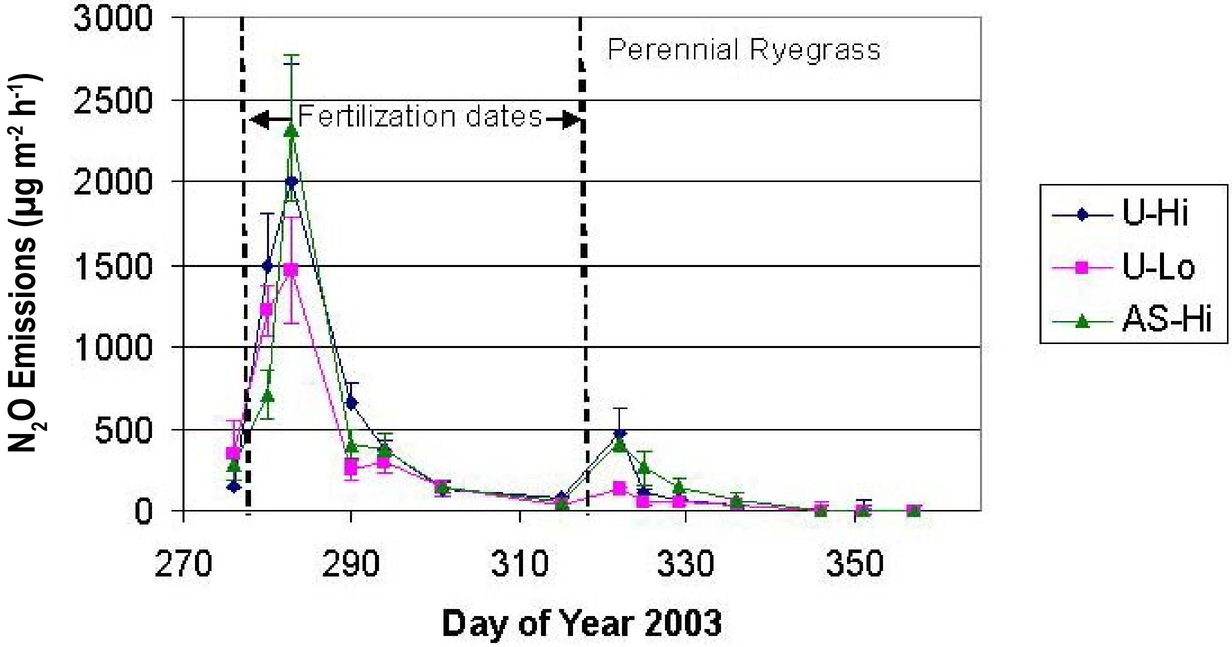
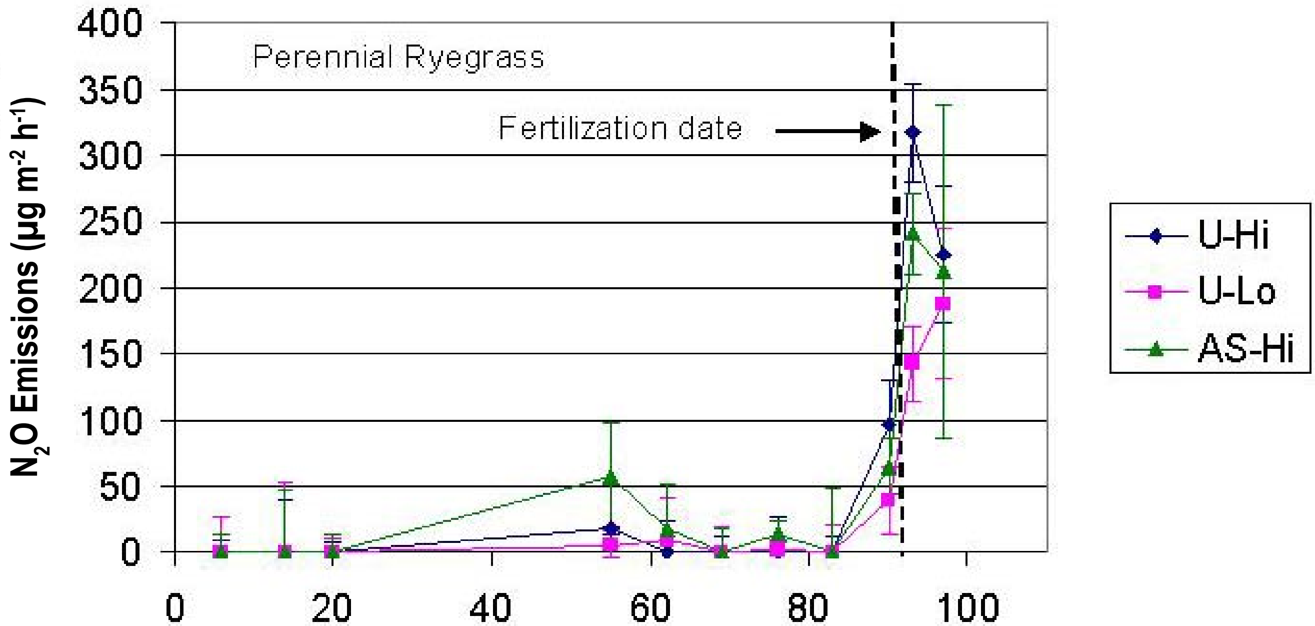


Figure 2. Fluxes of nitrous oxide (N_2O) from perennial ryegrass during late winter and early spring, 2004. Fertilizer treatments included urea at high (U-Hi) and low (U-Lo) rates and ammonium sulfate at the high rate (AS-Hi). Vertical line represents fertilization date. The first day of year represented is January 1, 2004. Note: Different scale of y-axis compared to Fig. 1.



TITLE: Preliminary Examination of the Heat Tolerance of a Texas Bluegrass Hybrid Compared with Kentucky Bluegrass and Tall Fescue

OBJECTIVES: Main objectives are to: 1) investigate the effects of high temperature on the turf quality of a Texas bluegrass hybrid (Thermal Blue, The Scotts Co. Inc.), Kentucky bluegrass (Apollo), and tall fescue (Dynasty); and 2) determine the highest temperature at which a later, expanded growth chamber study could be conducted.

AUTHORS: Dale Bremer, Kemin Su, Steve Keeley, and Jack Fry

SPONSORS: The Scotts Co. Inc., Golf Course Superintendents Association of America, and the Kansas Turfgrass Foundation

INTRODUCTION:

Kentucky bluegrass (*Poa pratensis L.*) is a cool-season grass commonly used on fairways and roughs of golf courses in the United States. Tall fescue (*Festuca arundinacea Schreb*.), also a cool-season grass, is sometimes used in roughs. In some areas of the United States, these grasses are subjected to frequent drought, which results in either heat and drought symptoms or high irrigation rates to maintain acceptable quality. Kentucky bluegrass commonly goes dormant and loses color during periods of high temperature and drought. Tall fescue has good drought resistance, but some superintendents prefer the finer texture of Kentucky bluegrass.

New Texas bluegrass (*Poa arachnifera Torr.*) hybrids, which are genetic crosses between Kentucky bluegrass and native Texas bluegrasses, have the appearance of Kentucky bluegrass but may be able to withstand higher temperatures and extended drought without going dormant, and may maintain their green appearance during all but extreme conditions. In warm-season climates such as the South, Texas bluegrasses stay green all year. Furthermore, Texas bluegrass hybrids may use significantly less water than other cool-season species while maintaining their green color. The latter is important given the increasing competition for water and the rising costs of irrigation.

At least one hybrid of Texas bluegrass (Reveille) has demonstrated disease resistance to leaf rust, powdery mildew, and summer patch, although it shows susceptibility to brown patch, especially when overfertilized. Reveille also has shown resistance to fall armyworms and white grubs, but tests have revealed that it performs poorly in saline soils. Observations of other Texas bluegrass hybrids have suggested that disease resistance and susceptibility are similar to Kentucky bluegrasses.

Texas bluegrass (Reveille) is advertised as a multiuse cool-season grass for the Eastern Seaboard, transition zone, arid West, and South. It has similar water requirements to common bermudagrass. Tests with Reveille revealed no significant decline in visual quality ratings when irrigation was decreased from 2/3 to 1/3 of open-pan evaporation (in Texas; James Read, personal communication). This suggests that Texas bluegrass is a high quality, low water use, and high heat-tolerant turfgrass that might be well suited for golf course fairways and roughs in some parts of the country, including the transition zone.

Despite the promising role that Texas bluegrass may play on U.S. golf courses, little scientific data is available about its qualities under the various forms of management and stress that it would be subjected to on golf courses. For example, the effect of different mowing heights on the drought- and heat-tolerance characteristics of Texas bluegrass is unknown. Some parts of the transition zone are subjected to extreme cold during winter months, and the cold hardiness of Texas bluegrass compared to Kentucky bluegrass has not been evaluated. It is also uncertain how it compares in quality to Kentucky bluegrass under various irrigation regimes and deficits.

MATERIALS AND METHODS:

On February 25, 2003, sods (10 cm diameter by ~1 cm depth) of Kentucky bluegrass (Apollo), tall fescue (Dynasty) and a Texas bluegrass hybrid (Thermal Blue, The Scotts Co. Inc.) were planted in 12 lysimeters (10 cm diameter by 60 cm depth) filled with a mixture of sand and topsoil (1:2, v: v) and established in a greenhouse. Each cultivar was replicated 4 times for a total of 12 lysimeters. Air temperatures in the greenhouse averaged 20°C during day (400 -1600 CST) and 15°C at night. Turfgrass was mowed twice a week at 5 centimeters, kept well watered, and fertilized as needed.

On May 26, the lysimeters were transferred to a growth chamber. Initial air temperatures in the growth chamber were 20°C during the 14 hours of daytime (i.e., lights on) and 15°C during the 10 hours of nighttime (i.e., lights off). Temperatures were maintained at the same regime for a period of two weeks, and thereafter were increased incrementally every two weeks (Table 1). On July 26, air temperatures were raised to 40°C during the day and to 29°C during the night. These temperatures were maintained until all turfgrasses had died. Turf visual quality was rated on the final day of each two-week period. Quality was visually rated on a scale of 1-9 with 1 being poorest and 9 being best; 6 was deemed minimally acceptable for use in lawns, sports fields, or golf courses.

RESULTS:

Visual qualities of all turfgrasses were 8 or above through July 25, which followed the 2-week treatment of 35°C daytime and 25°C nighttime air temperatures (Table 1). However after two weeks of air temperature regimes of 40°C during day and 29°C during night, the quality of tall fescue dropped dramatically to only 1.5 and Apollo dropped to 5, which was below acceptable levels (Table 1, Fig. 1). Thermal Blue was rated at 6.5, which was still acceptable, although it also showed signs of stress. This indicates that the heat tolerance is greater in Thermal Blue than either Apollo or Dynasty. One precaution is that root temperatures were also higher than they would be in the field, since the entire lysimeters were maintained at the same temperature. However, the results are encouraging that Texas bluegrass hybrids may tolerate hot Kansas summers better than Kentucky bluegrass or tall fescue.
A complete, statistically rigorous growth chamber study will be conducted in 2004. It will include additional parameters such as photosynthesis and soil water content at different depths will be measured in the same three cultivars under high temperature regimes. In that study, the effect of water deficit on these turfgrass qualities also will be examined.

Table 1. Schedule for increasing air temperatures in growth chambers and resulting turfgrass qualities at the end of each period.

Air temperature	Period	Mean quality		
		Apollo	Dynasty	Thermal Blue
20 °C day/15 °C night	5/26 to 6/9	8.8	8.3	8.3
26 °C day/18 °C night	6/10 to 6/23	8.5	8.5	8.5
30 °C day/21 °C night	6/24 to 7/11	8.8	8.8	9
35 °C day/25 °C night	7/12 to 7/25	8	8.3	9
40 °C day/29 °C night	7/26 to 8/9	5	1.5	8
40 °C day/29 °C night	8/10 to 8/22	1.8	1= Dead	6.5
40 °C day/29 °C night	8/23 to 9/5	1 on 8/29	1	1

Figure 1. Appearance of Apollo (front row), Dynasty (middle row), and Thermal Blue (back row) August 9, 2003, after 2 weeks at 40°C during 14 hours of daytime and 29°C during 10 hours of darkness.

TITLE: Measurement and Partitioning of In situ CO_2 Fluxes in Turfgrasses Using a Pressurized Chamber

OBJECTIVES: Develop a protocol for using a surface chamber (attached to a portable photosynthesis system and used to measure photosynthesis in turfgrasses) to measure net canopy photosynthesis (gross photosynthesis minus canopy respiration) and eliminate the impact of soil respiration.

PERSONNEL: Dale Bremer and Jay Ham

SPONSOR: Kansas Turfgrass Foundation and Kansas NSF EPSCoR

INTRODUCTION:

Photosynthesis is fundamental to plant function and can be a good indicator of plant stress and growth. In turfgrass studies, the effects of various stresses (e.g., drought, heat, cold) on turf health are important in determining turfgrass suitability for certain environments such as in various geographic regions or in golf courses, sports fields, etc. Small custom surface chambers that are attached to steady-state, portable photosynthesis systems and that cover a small portion of the turf's canopy are becoming increasingly popular to measure canopy photosynthesis in the field. However, results from these measurements include the various components of the turf's ecosystem carbon (C) balance including photosynthesis, canopy respiration, and soil respiration and thus, do not explicitly represent canopy photosynthesis.

The instantaneous CO_2 balance in turfgrass can be represented by:

$$NEE = P_g - R_c - R_s \qquad \text{[Equation 1]}$$

where NEE is net ecosystem exchange of CO_2, P_g is gross photosynthesis, R_c is canopy respiration, and R_s is soil respiration, all in μmol m^{-2} s^{-1}. Thus, measurements with the surface chamber placed over the top of turfgrass actually represent NEE rather than net canopy photosynthesis ($P_{c,\,net}$; μmol m^{-2} s^{-1}):

$$P_{c,\,net} = P_g - R_c \qquad \text{[Equation 2]}$$

Consequently, differences among treatments from chamber measurements of CO_2 flux in turfgrass include differences in R_s as well as in $P_{c,\,net}$.

Soil respiration is sensitive to changes in chamber pressure, which may further confound results from the chamber. For example, positive pressure differences of a few tenths of a Pascal between the chamber and the outside (i.e., pressurization) may result in a partial suppression of R_s whereas negative pressures of as little as -1 Pa (i.e., suction) may cause an increase CO_2 flux measurements by an order of magnitude. When portable photosynthesis systems such as the Licor 6400 (Licor, Lincoln, Neb.) are adapted for turfgrass studies, the chamber is pressurized, although the exact amount of pressurization is usually not known. Because the amount of R_s suppression may vary with chamber pressure and soil conditions, the R_s suppressed by the chamber is also unknown. Therefore, measurements with the surface chambers may partially suppress R_s and overestimate NEE.

The sensitivity of R_s to chamber pressure is affected by factors such as soil water content and soil properties. In general, dry and coarse soils show the most sensitivity to chamber pressure anomalies because of their greater soil permeability. Therefore, in drought studies in turfgrass in which plots may differ significantly in soil water content, a greater percentage of R_s may be suppressed in dry plots than in wet plots. Similarly, if comparisons are made among plots with differences in soil types, a greater percentage of R_s may be suppressed in coarser soils.

Because of the sensitivity of R_s measurements to chamber pressure, and because chamber pressure typically is not known in an open-flow system, CO_2 flux measurements may be suspect because they do not necessarily represent either NEE or $P_{c,net}$ (Equations 1 and 2). Observed differences in chamber measurements among treatments may be more related to differences in R_s than to differences in $P_{c,net}$. Research is needed to develop a chamber measurement protocol that accounts for the effects of pressure on R_s in turfgrass studies. In this project, it is proposed that the chamber can be intentionally pressurized to almost completely suppress R_s and obtain independent measurements of P_g and R_c.

Objectives were to: 1) fabricate and test a chamber connected to a portable photosynthesis system in which chamber pressure could be manipulated; 2) measure CO_2 fluxes at neutral pressure to obtain estimates of NEE; 3) apply increasing pressure until R_s is prevented from entering the chamber (the result would be a more accurate indicator of treatment effects on $P_{c,net}$); and 4) attempt to partition the various components in the turf C balance, including P_g, R_c, and R_s in three cool-season turfgrasses.

The NEE (Equation 1) of turfgrass could be determined by measuring CO_2 fluxes with the chamber at neutral pressure (i.e., the pressure inside the chamber is equal to the pressure outside). Because the chamber in steady-state (i.e., open) systems normally has positive pressure, the air stream would need to be exhausted or pumped from the chamber at the same rate that it enters. This would result in better equilibrium between the chamber and atmospheric pressure.

Because it is known that positive chamber pressures suppress R_s, it was hypothesized that R_s could be completely suppressed from chamber measurements if the pressure was purposely increased sufficiently. Suppressing R_s from chamber measurements would eliminate R_s from Equation 1 and thus, would yield $P_{c, net}$ (Equation 2). Furthermore, R_s could be estimated by the difference between neutral-pressure (Equation 1) and overpressure (Equation 2) measurements.

Covering the chamber with an opaque container during overpressurized measurements would result in R_c separately, assuming photosynthesis (P_g) could be sufficiently eliminated by shading and R_s was eliminated by pressure (Equation 1). Thus, sunlit and shaded measurements under pressurization on the same area would yield $P_{c,net}$ and R_c, respectively. From Equation 2 it is evident that P_g can be estimated from the sum of the sunlit ($P_{c,net}$) and shaded (R_c) readings. This strategy for partitioning the CO_2 balance is summarized in Table 1.

From the method just described, P_g, R_c, and R_s, could be estimated separately. Those values are more directly related to the biophysics of the canopy and would provide significantly more information about the effects of various stresses on the individual components of the turf C balance. This information would also be of use to modelers who may be interested in predicting the effects of various environmental stresses on the individual components in turfgrass C balances.

The study was conducted from mid-July to October 2003 at the Rocky Ford Turfgrass Research Center and Ashland Bottoms, both near Manhattan, Kan. Gas exchange measurements were collected from bare soils and from established stands of three cool-season turfgrasses: perennial ryegrass (Lolium perenne L.), tall fescue (Festuca arundinacea Screb.), and Kentucky bluegrass (Poa pratensis L.). Turfgrasses were mowed once to twice weekly at 6.35 centimeters.

Measurements of gas exchange

Whole canopy gas exchange measurements were collected with a portable photosynthesis system (Licor 6400) equipped with a 0.64-L custom chamber that covered a surface area of 70.9 square centimeters). The custom chamber was constructed from Plexiglas and the chamber interior was lined with Teflon tape to improve water sorption and desorption properties of the chamber walls. A thin aluminum edge (2 centimeters wide) was attached along the base of the chamber to push into the soil and improve the seal between the chamber and surface. The chamber was modified to allow for adjustment and measurement of chamber pressure (Fig. 1). Three ports were installed on the custom chamber. Flow rate and chamber pressure were adjusted by pumping air into and out of the chamber through one port with an adjustable air pump. A second port was used to measure chamber pressure using a digital micro-manometer with a resolution of 0.1 Pa. The third was an exit port to exhaust the air stream. An adjustable valve was installed on the exit port to restrict airflow out of the chamber. By restricting airflow out of the chamber, higher chamber pressures could be achieved. Flow rate from the pump into the chamber was measured with a mass flowmeter. When additional airflow was introduced to create higher pressures, it diluted CO_2 concentrations in the chamber, making it necessary to modify the gas exchange calculations. Raw output from the Licor 6400 was transferred to a software program, and the corrections were made on a spreadsheet.

Chamber measurements of CO_2 flux were collected from well-watered, intact turf canopies under full sunlight and when shaded with an opaque covering. Measurements of R_s also were collected from bare soil surrounded by perennial ryegrass, big bluestem (*Andropogon gerardii)*, and in an open sandy area devoid of vegetation. Polyvinyl chloride (PVC) collars (9.5 centimeters in diameter by 8 centimeters) were driven 6 centimeters into the ground at each measurement site at least 24 hours before gas exchange measurements were collected. The 24-hour delay allowed for dissipation of any soil CO_2 that may have been released by disturbance of wet soils during collar installation. A foam gasket was constructed to improve the seal between the chamber base and the collars. Measurements were collected first at neutral chamber pressure by withdrawing air with the KNF pump. Then by closing the shut-off valve on the exhaust line and adding air using the KNF pump, data were collected at sequentially higher pressures until R_s was suppressed. Measurements were collected sequentially under full sunlight and shaded conditions, respectively, at each increasing pressure increment.

Green leaf area index, aboveground biomass, and soil water content

On October 14, 2003, green leaf area index (LAI) and aboveground biomass were harvested and measured from each collar immediately after gas exchange measurements were collected. Green LAI was measured with an area meter (Licor 3100), and total aboveground biomass was determined gravimetrically after samples had been dried in a forced-air oven for 48 hours at 60°C. Gravimetric soil water content data were collected from 0 to 10 centimeters at each site whenever gas exchange measurements were collected.

RESULTS:

Measurements at neutral pressure

Maintaining neutral chamber pressure using the manometer and variable rate air pump was extremely difficult in the field. Windy conditions, which were nearly always present during midday measurements of gas exchange, caused fluctuations in manometer readings and contributed to the difficulty in controlling pressure. Fluctuations in pressure of ±1.0 Pa often were uncontrollable and caused large differences in CO_2 exchange (Fig. 2). For example, CO_2 exchange at apparent “zero” Pa in a shaded ryegrass canopy was apparently 44.5 μmol m^{-2} s^{-1} (Fig. 2B), which was unrealistically large and was likely inflated by a slight negative pressure (i.e., suction) inside the chamber. Conversely, exchanges of CO_2 in the sunlit canopy were apparently greater at "zero" Pa (8.60 μmol m^{-2} s^{-1}) than at 0.5 Pa (3.27 μmol m^{-2} s^{-1}; Fig. 2A). However, the actual chamber pressure may have been greater than zero, which may have suppressed R_s and inflated CO_2 exchanges in the "apparent zero" reading. Measurements of R_s were also erratic between 0 and 1 Pa (Fig. 2C). Because of the problems associated with maintaining neutral chamber pressures, measurements of NEE could not be collected in this study. This was a setback in the attempt to partition the C balances as described in Table 1. However, overpressurization to suppress R_s could still potentially lead to estimates of P_g and R_c.

Pressure chamber measurements

Data collected on bare soil showed that R_s was substantially suppressed as chamber pressure increased (Figs. 2C and 3). For example, R_s in silt loam decreased from 14.35 μmol m^{-2} s^{-1} at low chamber pressures to 1.58 μmol m^{-2} s^{-1} at 50 Pa (Fig. 3A). Likewise, R_s was suppressed in sand as chamber pressure increased, although the fluxes were initially smaller in sand than in silt loam (Figs. 3B and 3C). Less organic matter and drier conditions likely caused smaller R_s in sandy soils; gravimetric soil water content was 14% in the silt loam and 8 to 10% in the sands. In Figure 2C, the suppression of R_s (bare soil) with increasing chamber pressure caused the corresponding increase in net CO_2 uptake during the sunlit reading (Fig. 2A) and the decrease in CO_2 emissions during the shaded reading (Fig. 2B).

Manometer readings indicated that under normal operation (i.e., without intentionally pressurizing the chamber), pressure in the chamber ranged from 7 to 78 Pa. Therefore, the amount of R_s suppressed during normal operation probably varied spatially and temporally because of differences in chamber pressure (Figs. 2C and 3). Lower chamber pressures under normal operation would allow more R_s into the chamber and thus, reduce "net assimilation" measurements compared to higher pressures where R_s was prevented from entering the chamber. Comparisons between chamber measurements under normal operation and when overpressurized confirmed that R_s was typically only partially suppressed under normal operation (Fig. 4). For example, CO_2 exchange measurements with the chamber under normal operation ranged from 6 to 23% lower than when the chamber was overpressurized. Measurements in Figure 4 were collected from perennial ryegrass, tall fescue, and Kentucky bluegrass when gravimetric soil water content in these turfgrasses ranged from 22 to 29%.

Although R_s could be significantly reduced with intentional chamber pressurization, R_s could not be completely eliminated (Figs. 2C and 3). In a wet silt loam soil (26% gravimetric soil water content), R_s remained at 1.92 μmol m^{-2} s^{-1} despite chamber pressures as great as 714 Pa (Fig. 2C); between 100 and 714 Pa, only an additional 0.36 μmol m^{-2} s^{-1} was suppressed. In another silt loam soil with 14% gravimetric soil water content, R_s remained at 1.58 μmol m^{-2} s^{-1} at the highest pressure that could be maintained at that location (50 Pa; Fig. 3A). Although a greater amount of R_s was suppressed in drier sands than in silt loams, R_s still could not be completely eliminated and remained at 0.34 to 0.64 μmol m^{-2} s^{-1} (Figs. 3B and 3C).

Recommended protocol for pressurized measurements

Because not all R_s could be eliminated from chamber measurements, an alternative procedure was developed to account for this small soil flux that could not be suppressed and yet allow for estimates of $P_{c,net}$, R_c, and P_g. This was accomplished by measuring CO_2 fluxes with an overpressurized chamber in sunlit and shaded canopies and then immediately taking another pressurized reading after clipping the turf canopy at ground level from an area in or near the plots. This provided an estimate of the R_s', the soil flux entering the chamber when it was overpressurized. Thus, three measurements (i.e., from sunlit, shaded, and clipped canopies) with an overpressurized chamber provided estimates of the following components of the C balance:

$$\text{Sunlit chamber} = P_g - R_c - R_s' \qquad \text{[Equation 5]}$$

$$\text{Shaded chamber} = R_c - R_s \qquad \text{[Equation 6]}$$

$$\text{Clipped canopy} = R_s' \qquad \text{[Equation 7]}$$

From Equations 5 through 7, estimates of $P_{c,net}$, P_g, and R_c could be calculated:

$$P_g = \text{Sunlit chamber} - \text{shaded chamber} \qquad \text{[Equation 8]}$$

$$P_{c,net} = \text{Sunlit chamber} - \text{clipped canopy} \qquad \text{[Equation 9]}$$

$$R_c = \text{Shaded chamber} - \text{clipped canopy} \qquad \text{[Equation 10]}$$

Overpressurization was achieved by closing the valve in the chamber's exhaust line and pumping additional air into the chamber at a rate of about 700 μmol s^{-1} (~1.0 L min^{-1}). The chamber pressure when overpressurized varied considerably with location. For example, chamber pressure on a bare silt loam was 714 Pa, while the maximum pressure over a nearby ryegrass canopy was only 200 Pa (Fig. 2). Presumably chamber pressure can vary with soil type and soil moisture. However, the tightness of the seal between the chamber base and the collar may have been equally important in maintaining higher pressures. A foam gasket was constructed to improve the seal and in general, resulted in higher chamber pressures than when no gasket was used.

When using this technique, field measurements suggested that chamber pressures of 50 Pa should be maintained where possible, with no less than 20 Pa. For example, measurements over bare soils indicated that 83 to 94% of R_s was suppressed at chamber pressures of 50 Pa or greater, while 76 to 89% of R_s was suppressed at 20 Pa. Below chamber pressures of 20 Pa, the amount of R_s suppressed declined rapidly (Figs. 2C and 3).

Measurements from clipped areas (i.e., R_s') with the overpressurized chamber ranged from 2.13 μmol m^{-2} s^{-1} in Kentucky bluegrass to 4.71 μmol m^{-2} s^{-1} in tall fescue (Table 2), which was slightly greater than pressurized measurements from nearby bare soil (Figs. 2C and 3). Despite careful clipping near the ground, it was not possible to remove crowns of the turfgrass plants; crowns are regions of high meristematic activity. Thus, measurements in clipped areas likely contained crown respiration as well as the small amount of soil flux entering the pressurized chamber. Therefore, crown respiration was included in R_s' and not in R_c; R_c was primarily respiration from green leaves.

Estimates of $P_{c,net}$ ranged from 11.54 to 14.33 μmol m^{-2} s^{-1} and P_g from 14.07 to 17.37 μmol m^{-2} s^{-1} (Table 2). Estimates of $P_{c,net}$, R_c, and P_g were greater per unit ground area in perennial ryegrass and tall fescue than in Kentucky bluegrass. Interestingly, when data were normalized for LAI, $P_{c,net}$, P_g, and

R_c were similar among all species. Leaf area index was 1.91 m^2 m^{-2} in perennial ryegrass, 2.06 m^2 m^{-2} in tall fescue, and 1.72 m^2 m^{-2} in Kentucky bluegrass. Aboveground biomass was 3.09 g m^2 in perennial ryegrass, 3.79 g m^2 in tall fescue, and 2.52 g m^2 in Kentucky bluegrass.

Measurements of CO_2 fluxes at the beginning and end of a one-week drydown showed a 19 and 11% reduction in P_g, a 21 and 16% reduction in $P_{c,net}$, and an 11% reduction and 10% increase in R_c in perennial ryegrass and tall fescue, respectively (Fig. 5). Comparatively, measurements with the unmodified chamber showed that decreases in soil water content caused a 26 and 21% reduction in CO_2 fluxes in perennial ryegrass and tall fescue, respectively. The greater reductions in C fluxes with the unmodified chamber were likely caused by a large decrease in R_s, which is significantly affected by soil water content.

Conclusions

Soil respiration was suppressed with increasing chamber pressure, which had significant impacts on gas exchange measurements. The greatest sensitivity of R_s to chamber pressure occurred between 0 and 20 Pa; chamber pressure under normal operation ranged from 7 to 78 Pa. The original, unmodified chamber in the open system did not account for chamber pressure and yielded results that did not represent NEE or $P_{c,net}$. Comparisons between chamber measurements under normal operation and when overpressurized confirmed that R_s was typically only partially suppressed under normal operation; measurements with the chamber under normal operation ranged from 6 to 23% lower than when the chamber was overpressurized.

Most but not all R_s could be eliminated with the overpressurized chamber. However, a protocol was developed to partition C fluxes among P_g, $P_{c,net}$, and R_c using the modified, pressurized chamber consecutively on sunlit, shaded, and clipped turfgrass canopies. Measurements of turf canopies under sunlit and shaded conditions and from turf clipped at ground level provided estimates of P_g - R_c - R_s', R_c - R_s', and R_s', respectively. Clipped areas provided estimates of R_s' by eliminating P_g and R_c from chamber measurements.

Estimates of P_g ranged from 14.07 to 17.37 μmol m^{-2} s^{-1}, $P_{c,net}$ ranged from 11.54 to 14.33 μmol m^{-2} s^{-1}, and R_c ranged from 2.53 to 3.28 μmol m^{-2} s^{-1} in perennial ryegrass, tall fescue, and Kentucky bluegrass. During a one-week drydown, P_g was reduced by 19 and 11%, $P_{c,net}$ was reduced by 21 and 16%, and R_c was reduced by 11% and increased by 10% in perennial ryegrass and tall fescue, respectively.

Partitioning of C fluxes provided more sensitive and meaningful comparisons between treatments than did measurements with the unmodified chamber because of the direct relationship of P_g, $P_{c,net}$, and R_c to the biophysics of the turfgrass canopy. Further research is needed to develop technology for a chamber that can be maintained at neutral pressure and thus, to allow for partitioning of NEE and R_s. Although testing was done on turfgrass, theoretically this method could be used on any low-growing vegetation.

Table 1. Proposed strategy for partitioning the CO_2 balance in turfgrasses with measurements from a surface chamber modified to manipulate chamber pressure. Individual components include net ecosystem exchange (NEE) of CO_2, gross canopy photosynthesis (P_g), canopy respiration (R_c), soil respiration (R_s), and net canopy respiration ($P_{c,net}$).

Pressure	Radiation	Flux Measured
Neutral	Sunlit	$NEE = P_g - R_c - R_s$
Overpressure	Sunlit	$P_{c,net} = P_g - R_c$
Overpressure	Dark	R_c
By calculation		$R_s = NEE - P_{c,net}$
By calculation		$P_g = P_{c,net} + R_c$

Table 2. Measurements of CO_2 fluxes in turfgrasses with the overpressurized, modified chamber and subsequent estimates of net canopy photosynthesis ($P_{c,net}$), canopy respiration (R_c), and gross photosynthesis (P_g). Measurements were collected in perennial ryegrass (PR), tall fescue (TF), and Kentucky bluegrass (KBG) on October 14, 2003.

	Chamber Measurements/ Canopy Conditions			Carbon Balance Components: Per Unit Ground Area			Carbon Balance Components: Normalized for Leaf Area		
Species	Sunlit	Shaded	Clipped	$P_{c,net}$	R_c	P_g	$P_{c,net}$	R_c	P_g
	μmol m^{-2} ground s^{-1}						μmol m^{-2} leaf s^{-1}		
PR	10.16	7.17	3.89	14.05	3.28	17.33	7.37	1.73	9.10
TF	9.62	7.75	4.71	14.33	3.04	17.37	6.94	1.48	8.42
KBG	9.41	4.66	2.13	11.54	2.53	14.07	6.70	1.47	8.17

Figure 1. Conceptual diagram that illustrates the design of the pressurized chamber system. A variable-flow air pump and micro-manometer were used to regulate chamber pressure. A mass flow meter was used to monitor the air flow into the chamber, and results were used to correct fluxes for the effect of gas concentration dilution in the chamber.

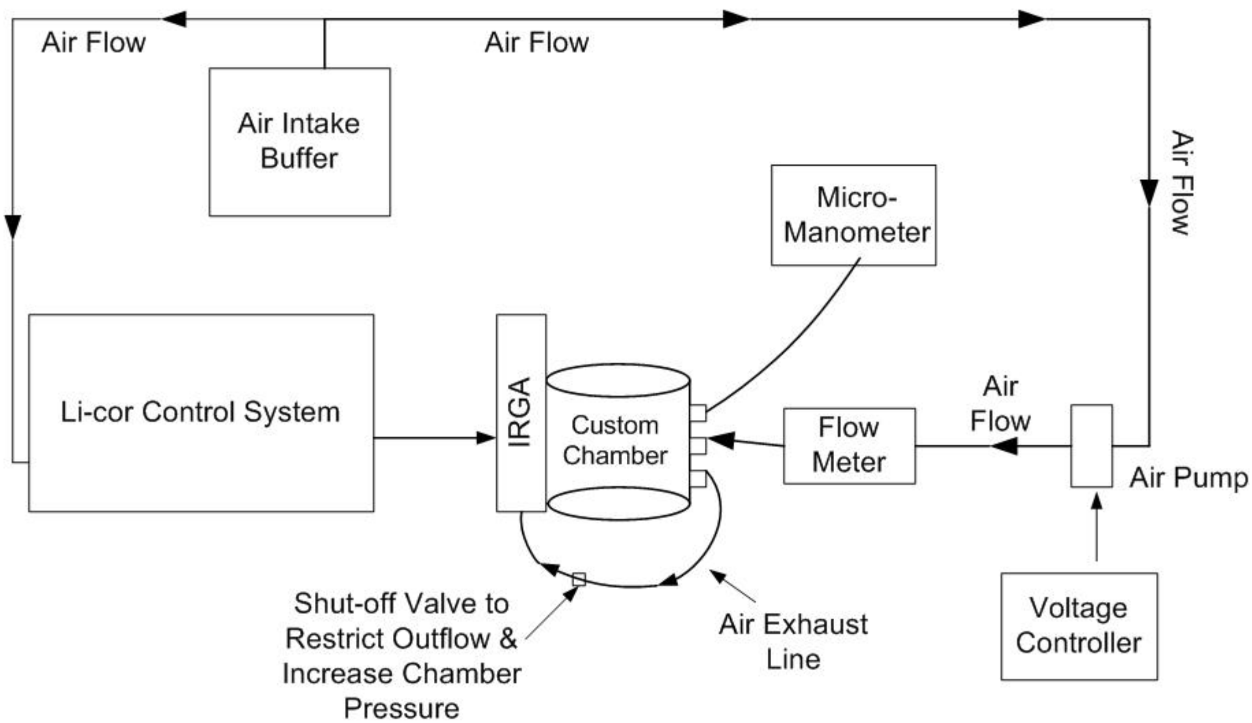


Figure 2. Responses of carbon fluxes in perennial ryegrass to changes in chamber pressure under sunlit (A), shaded (B), and bare-soil (C) conditions; the bare soil area was surrounded closely by perennial ryegrass. The increase in CO_2 exchange with chamber pressure in the sunlit canopy (A) was caused by suppression of soil respiration (i.e., bare-soil measurement (C)) entering the chamber. Note: Scale of y-axis of 2B is different from 2A and 2C.

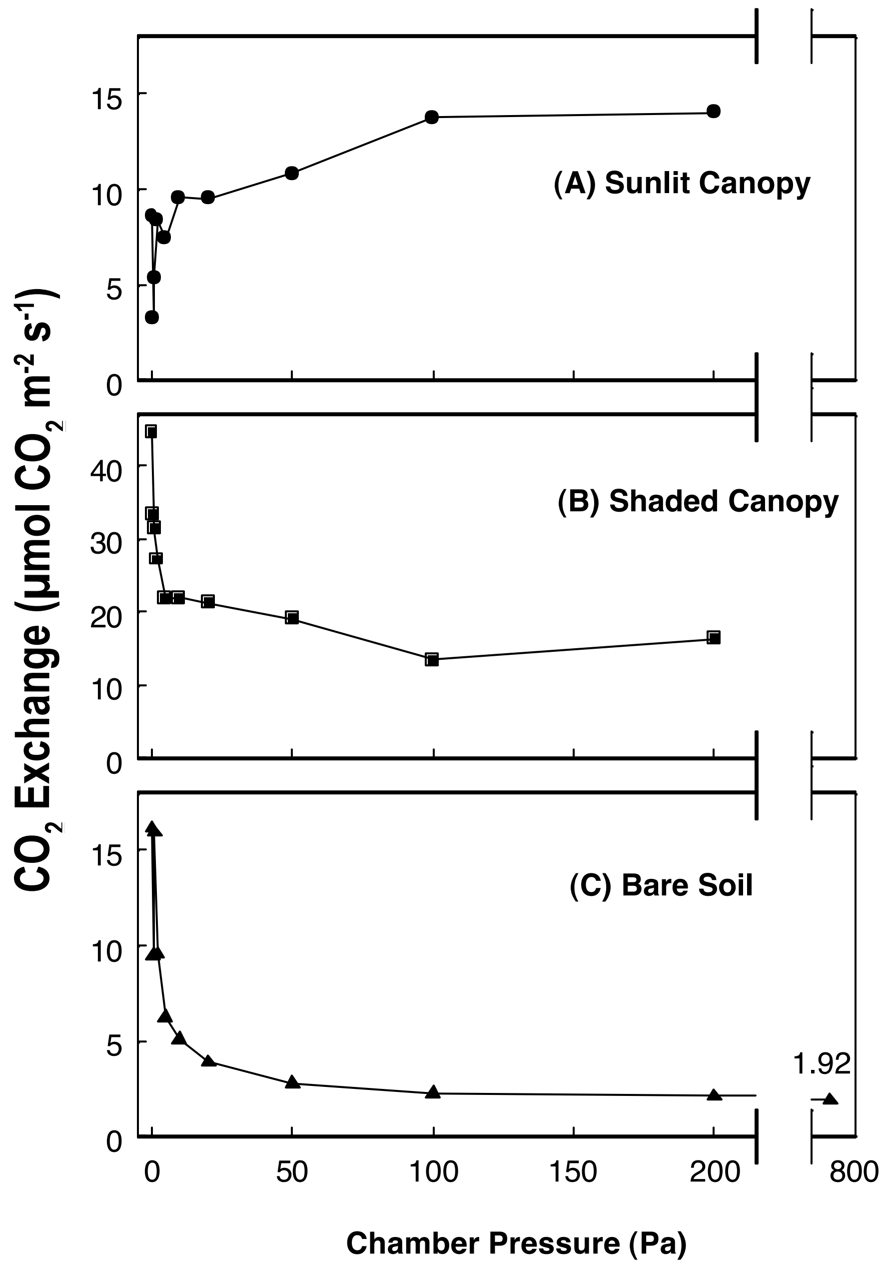


Figure 3. Measurements of soil respiration from bare soil in silt loam surrounded by Kentucky bluegrass (A), sand between crowns of big bluestem (B), and sand in an area devoid of vegetation (C). Note: Scale of y-axis of 3A is different from 3B and 3C.

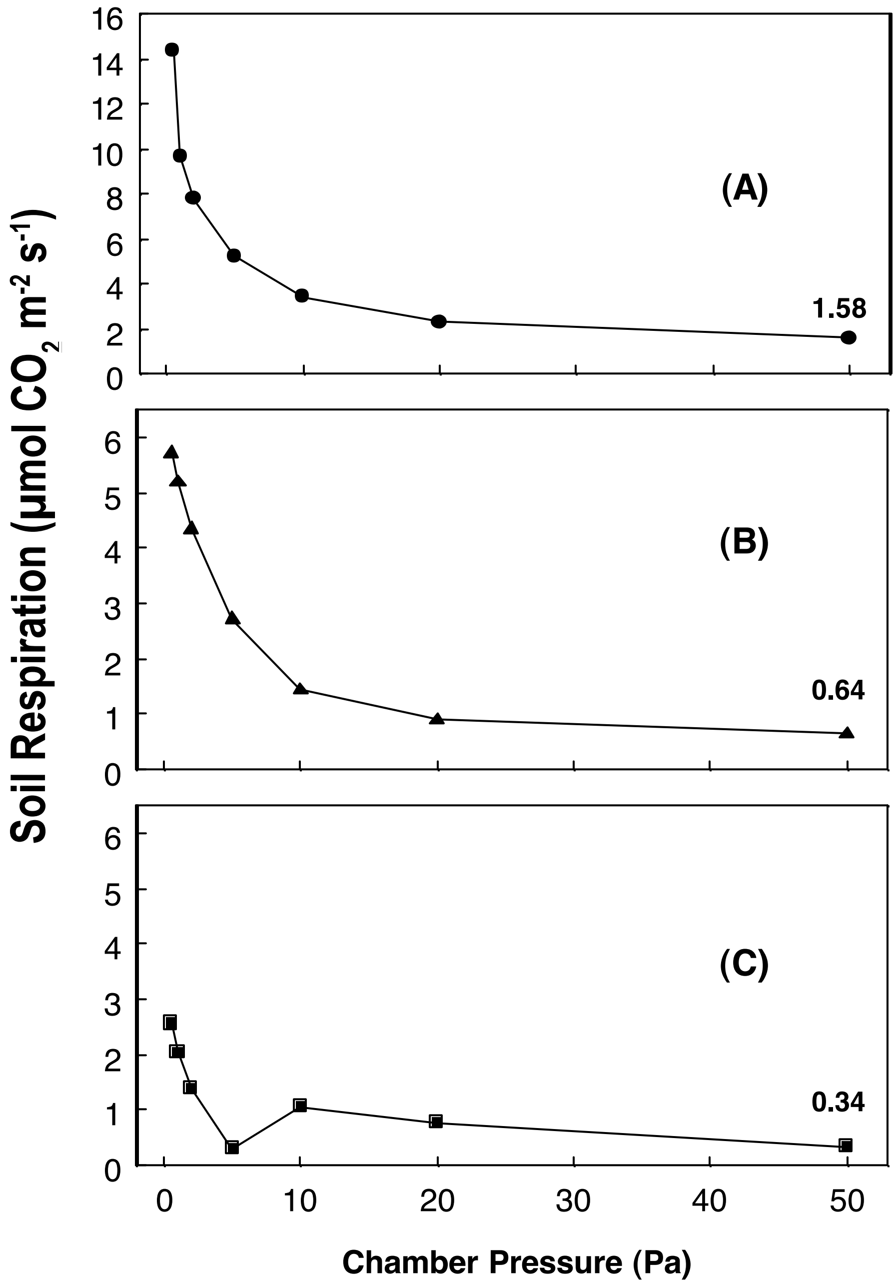


Figure 4. Comparison between measured CO_2 fluxes with normal chamber operation (unmodified) and with pressurized chamber (modified) in perennial ryegrass (PR), Kentucky bluegrass (KBG), and tall fescue (TF). PR and TF were measured on multiple dates.

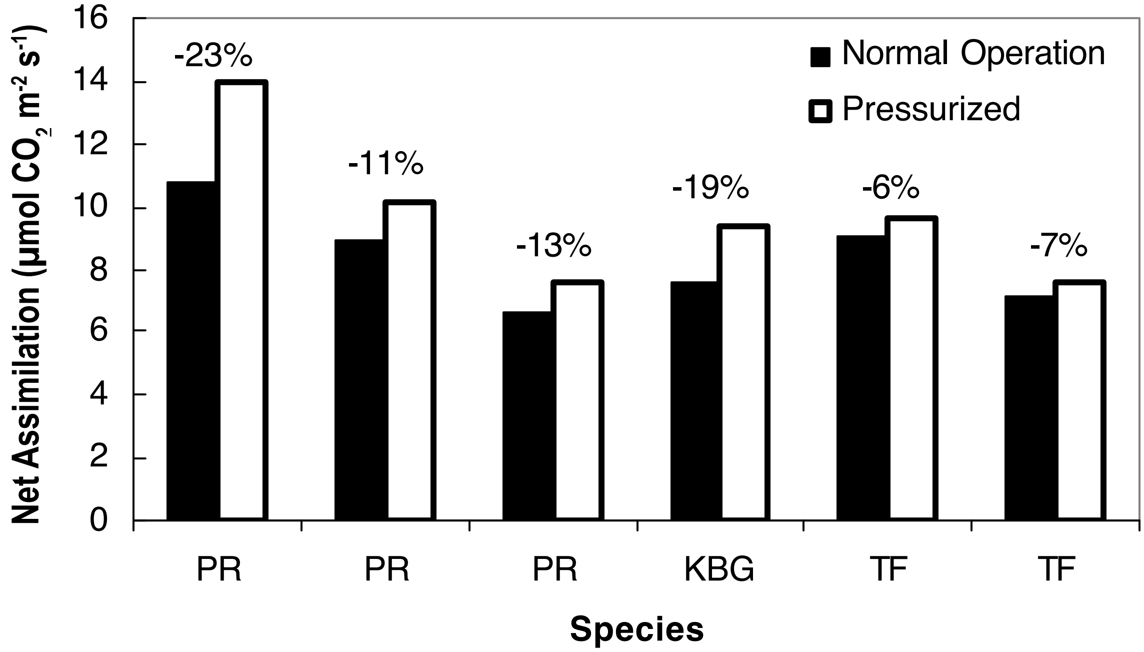
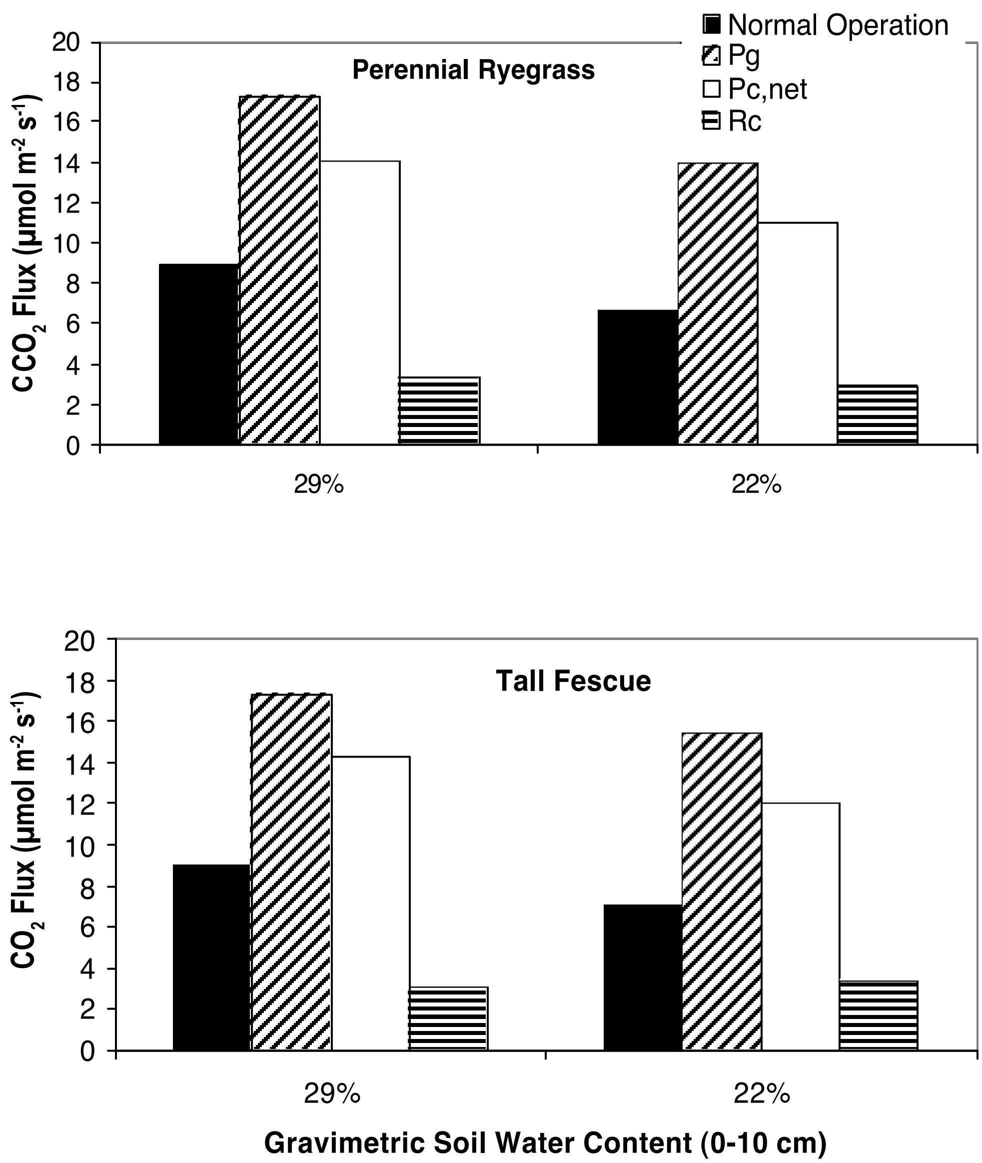


Figure 5. Carbon fluxes measured with normal chamber operation (unmodified) and with pressurized chamber (modified) on perennial ryegrass and tall fescue during a one-week drydown. The variables of gross photosynthesis (P_g), net canopy photosynthesis ($P_{c,net}$), and canopy respiration (R_c) were partitioned by using the modified chamber consecutively on sunlit, shaded, and clipped turfgrass.



TITLE: Evaluation of a Minimal Disturbance Seeder for Converting Cool-Season Turfgrass Stands to Warm-Season Grasses

OBJECTIVE: To test establishment of warm-season grasses at minimal cost.

INVESTIGATORS: Jack Fry, Randy Taylor, Bob Wolf, Dick Stuntz, and Alan Zuk

INTRODUCTION:

With the cost of maintaining cool-season golf and sports turfs increasing due to water and fungicide requirements, there is interest in alternative warm-season grasses that can be established at relatively low cost. These grasses include Yukon and Riviera bermudagrass, seeded cultivars released from Oklahoma State University that have exhibited cold-hardiness on par with Midlawn and Quickstand, commonly used cold-hardy vegetative bermudagrasses. Zenith zoysia, a cold-hardy cultivar only slightly coarser in texture than Meyer, is also an option for those interested in establishing warm-season turf from seed.

Conversations with Dick Stuntz, director of golf course operations at Alvamar in Lawrence, Kan., led to this project. He provided a slit-seeder to K-State that was modified by Randy Taylor, Department of Biological and Agricultural Engineering, to create a rudimentary minimal disturbance (MinD) seeder that has been subjected to preliminary tests at the Rocky Ford Turfgrass Research Center in Manhattan, Kan. Simply described, the MinD seeder plants rows of warm-season turf seed into existing cool-season turfs. The seeded rows then begin to spread laterally during summer months until complete coverage occurs. The work reports on the potential use of this equipment for converting golf courses from perennial ryegrass to bermudagrass; however, it is likely that the same system could be used for athletic turf conversion.

METHODS:

A study to evaluate seeded bermudagrass conversion tactics was established on a mature stand of perennial ryegrass maintained under golf course fairway conditions. Plots measured 6 by 6 feet and were arranged in a randomized complete block design with four replicates. Treatments were: untreated, glyphosate (Roundup)-treated, scalped, planting with the minimal disturbance (MinD) seeder, and planting with the MinD seeder with rows oversprayed with glyphosate. Treated Riviera bermudagrass seed was obtained from Johnston Seed Co., Enid, Okla. The label indicated that purity was 51% and germination 85%, resulting in a pure live seed (PLS) content of 43%. The glyphosate treatment was applied with a backpack sprayer at the label-recommended rate to the entire area of the plot about one week before planting.

Before planting, all plots except those receiving the MinD seeder treatments were core aerated (12 holes per square foot, approximately 1 inch deep) and verticut (four passes). Bermudagrass seed was mixed with approximately 300 g Milorganite (6-2-0) and spread at 1.5 lb. PLS/1,000 sq.ft. in each plot using a shaker bottle. Turf in the scalping treatment was mowed three times weekly at 0.25 inch until July 31, when a regular fairway-height schedule began.

The MinD seeder was set to disturb four 2-inch-wide rows, 15 inches apart, the entire length of each plot. This resulted in disturbance of approximately 4 square feet in each plot (11% of the entire plot area). Seed was mixed with approximately 100 g Milorganite to apply bermudagrass PLS at 2.38 lb./1,000 sq.ft. in rows. A shaker bottle was modified to include a 0.25-inch-diameter tube in its lid to deliver the seed/Milorganite mixture in a narrow row. A glyphosate treatment was applied over the rows in one of the MinD seeder treatments immediately after seeding.

Application was done with a backpack sprayer to eliminate ryegrass 1 inch in either direction of the row.

Beginning the day after seeding (to allow the glyphosate to dry on leaves in the MinD seeder + glyphosate overspray treatment), irrigation was applied 2 to 3 times daily during the first 4 weeks to provide a total of about 1/10 inch of water in each session. After 4 weeks, irrigation was applied every 1 to 2 days to prevent bermudagrass stress. Nitrogen from urea was applied at 1 lb. N/1,000 sq.ft. on July 10 and on August 1 and 22.

Data were collected on bermudagrass coverage and turfgrass quality. A modification of the vertical point quadrant method was used to determine bermudagrass coverage within each treatment plot after growth had ceased in October. The vertical point quadrant was constructed of a PVC frame with an internal monofilament grid spaced on 4-inch centers. The grid was placed over each plot to estimate coverage in each treatment. The presence of any part of a bermudagrass plant under an intersection was recorded as a "hit." To determine percent coverage, the number of hits was divided by the number of intersections on the grid. Turf quality was rated weekly using a 0 to 9 scale where 0 = brown, dead turf; 7 = acceptable quality for a golf course fairway; and 9 = optimum color, density, and uniformity. Rating dates were July 10, 17, 23, and 31; August 6, 12, 20, and 27; September 3, 10, 18, and 25; and October 9. Quality data for each month were averaged for presentation. Data were analyzed using the Statistical Analysis System. The analysis of variance procedure was used to test for treatment effects. Means were separated using Tukey's least significant difference (LSD) test.

RESULTS:

Coverage

Complete bermudagrass coverage the first season was attained by treating entire plots with glyphosate (Table 1). In fact, visual observations indicated that complete coverage had occurred within 4 to 5 weeks after seeding (data not shown). Scalping the ryegrass turf for the first 4 weeks after planting resulted in 87% coverage by October 2002 and about the same when evaluated in October 2003.

The MinD seeder, although disturbing only 11% of the plot area at planting, resulted in 41% coverage by October 2002 and 71% by October 2003 (Table 1). Applying the glyphosate spray over rows resulted in an additional loss of 11% of the plot area (22% total), and about 15% greater coverage compared to the MinD seeder rows without a glyphosate overspray in 2002 and 2003. A separate test in 2003 indicated that the use of the MinD seeder + glyphosate overspray resulted in twice as many bermudagrass seedlings emerging per unit area compared to areas receiving the MinD seeder treatment alone.

Untreated ryegrass exhibited 12% bermudagrass coverage at the end of the first season and 60% coverage by the end of 2003.

If we assume a hypothetical 1-acre golf course fairway measures 90 feet by 484 feet (43,560 sq.ft.), a comparison in seed requirements can be made between planting using a traditional broadcast method vs. using the MinD seeder. Broadcasting seed over the acre at the rate used in this test (1.5 lbs. PLS/1,000 sq.ft.) would require 65.3 lb. of PLS. If bermudagrass were planted with the MinD seeder as described herein, there would be 72 2-inch-wide rows running the length of the fairway (484 ft.). These rows create a total seedbed area of 5,819.6 sq.ft., and at the seeding rate evaluated in this test (2.38 lb./1,000 sq.ft.), 13.9 lb. of PLS would be required. As such, a seed savings of 79% would have been realized using the MinD seeder vs. the broadcast method. If the MinD seeded rows were to be seeded at the same rate as the acre that was broadcast (1.5 lb. PLS/1,000 sq.ft.), only 8.7 lb. of PLS of bermudagrass would be required, and a seed savings of 87%, on a weight basis, would result.

Turf quality

Treatments had the greatest impact on turf quality during the initial month of establishment and the following autumn when bermudagrass was dormant. Poorest quality the initial month of establishment was observed where glyphosate was used over entire plots or over rows created by the MinD seeder. Scalping resulted in less than acceptable quality during the period in which it was performed. In general, treatments that resulted in the greatest reduction in perennial ryegrass quality provided the best bermudagrass establishment by the end of the season. When bermudagrass was dormant, a mottled appearance was evident in scalped and untreated plots, and a more organized striped appearance where the MinD seeder was used.

Table 1. Influence of ryegrass treatment on bermudagrass coverage by the end of the 2002 and 2003 growing seasons in Manhattan, Kan.[1]

Treatment	Bermudagrass coverate (% of plot area)[2]	
	October 2002	October 2003
Glyphosate	100 a[3]	100 a
Scalping	87 b	85 ab
MinD seeder	41 d	71 bc
MinD seeder + glyphosate overspray	56 c	87 ab
Untreated	12 e	60 c

[1]Riviera bermudagrass was seeded at 1.5 lb./1,000 sq.ft. in glyphosate-treated, scalped, and untreated plots on July 2, 2002, after core-aerating and verticutting plots. The MinD seeder created four 2-inch-wide rows 15 inches apart in each plot. The glyphosate overspray in MinD seeder plots was used to eliminate ryegrass up to 1 inch on each side of each row.

[2]Coverage was determined using a vertical point quadrant method. Numbers represent the mean of four replications.

[3]Means followed by the same letter in a column are not statistically different ($P < 0.05$).

The two primary advantages of the MinD seeding system on the golf course are: i) golfers can continue to play after the seeding process, so there is no loss of revenue; and ii) up to 87% less seed (on a weight basis) is required than if an area equivalent to the entire fairway were broadcast with seed (and seed of these grasses is costly). A hypothetical comparison of seeding Riviera bermudagrass using a broadcast technique vs. the MinD seeder is presented in Table 2.

Table 2. Comparison of broadcast seeding vs. use of the MinD seeder for an acre of golf course fairways, assuming a seeding rate of 65.3 lb. PLS/acre.

Method	Area	Total PLS required (lb.)	Cost per pound of PLS[1]	Total Cost
Broadcast	1 acre	65.3	$ 27.90	$ 1,821.87
MinD seeder	1 acre	8.7	$ 27.90	$ 242.73

[1]Based upon an estimated cost of $12/lb. of seed with 51% purity and 85% germination.

RESULTS:

The most rapid, and also most destructive method for converting ryegrass to bermudagrass is to treat the entire area with glyphosate; however, course closure is usually required. As such, courses can expect a loss of revenue during the period. Less destructive options for conversion that would allow golf to continue while converting ryegrass to seeded bermudagrass include scalping during the initial weeks of establishment, or the use of the MinD seeder. The MinD seeder allows conversion to take place with seed requirements being up to 87% lower (on a per-acre weight basis using the MinD seeder spacing evaluated in this test) than broadcasting seed over the entire area. Although complete coverage will not be achieved in the first season using the MinD seeder, it is likely that bermudagrass will encroach into the remaining plot area in the second season, depending upon weather conditions. During dormancy after the second season, it may be possible remove any remaining cool-season turf with an application of glyphosate.

Where do we go from here?

The development of this technology resulted in the submission of a provisional patent application in 2003 entitled "A Method and Equipment for Interseeding an Area of Ground to Convert the Existing Vegetation to New Vegetation or to Improve the Quality of the Existing Vegetation." (KSU Research Foundation Ref. no. 02-36). Plans include developing a prototype MinD seeder this spring that will prepare the ground, and apply seed and a glyphosate overspray all in one pass. On-site evaluations will be conducted with this equipment in summer 2004. Conversations are under way with entrepreneurs who may have interest in commercializing this method of turf conversion.

TITLE: Soil Preparation Effects on Bermudagrass Germination

OBJECTIVE: Compare bermudagrass seedbed preparation treatments for their effects on seedling emergence and growth.

INVESTIGATORS: Jack Fry, Randy Taylor, and Bob Wolf

SPONSOR: Kansas Turfgrass Foundation

INTRODUCTION:

Progress has been made in use of a minimal disturbance (MinD) seeder that can be employed to convert cool-season turfs to seeded warm-season grasses. More information was needed on how bermudagrass responds to preparation of the seedbed so that the equipment can be modified to encourage germination and establishment.

MATERIALS AND METHODS:

Treatments evaluated were: control (no seedbed preparation); MinD tilled (2-inch-wide tilled area); MinD tilled with glyphosate (Roundup) (2-inch-wide tilled area with 4-inch-wide glyphosate application); glyphosate (seed applied in 2-inch-wide strip, with 4-inch-wide gyphosate applied).

Turf evaluated was Riviera bermudagrass (51% purity, 85% germination) seeded at 2 lb. PLS/1,000 sq.ft. This was equivalent to 1.8 g Riviera per 5-foot linear row (2 inches wide). Each treatment was replicated four times.

Seed was applied on July 11, 2003, with a shaker bottle with a metal tube attached at the top to allow for a narrow avenue for seed flow. Seed was mixed with about 10 g of Milorganite per row to allow uniform distribution. Two replicates were harvested on August 1 and another two on August 5 to count seedlings (approximately 3 weeks after seeding). A 4-inch-wide cup cutter was used to remove three cores per linear seeded row. Plugs were returned to the laboratory so that seedlings could be counted. Data were collected on number of seedlings and number of tillered seedlings.

RESULTS:

Bermudagrass seedling numbers were highest where the ground had been tilled using the MinD seeder and glyphosate spray applied over the row. Next-best seedling numbers were observed where the ground was tilled only, or where glyphosate was applied without soil disturbance. Very few seedlings emerged where neither glyphosate was applied nor the ground tilled. Bermudagrass seeded in tilled rows that received a glyphosate overspray also had more tillers than that in all other treatments.

Establishment method	Seedling no. (per sq.ft.)	No. of tillered seedlings per sq.ft.
Tilled with Glyphosate	765 a[1]	162 a
Tilled	387 b	32 b
Glyphosate	234 bc	32 b
Control	4 c	0 b

[1]Means followed by the same letter in a column are not significantly different ($P < 0.05$).

TITLE: Evaluation of Ball Mark Repair Methods and Creeping Bentgrass Recovery

OBJECTIVE: This study was conducted to compare five ball mark repair strategies for their effects on a creeping bentgrass putting green surface.

PERSONNEL: Jack Fry, Steve Keeley, and Ty McClellan

SPONSOR: Greenfix Golf, Inc.

INTRODUCTION:

Unrepaired ball marks, created when a golf ball impacts the surface of a putting green, are a scourge of golf course superintendents and golfers who respect the game. There are traditional and new tools available to golfers to repair marks when they occur. To our knowledge, there is no science-based information characterizing ball marks and their recovery.

METHODS:

The study was conducted on a practice putting green at the Colbert Hills Golf Course in Manhattan, Kan. Turf was L-93 creeping bentgrass growing on a green constructed using the California-style method. The green was mowed daily at 0.12 inch and irrigated every 3 to 5 days to provide 1 inch of water when adequate rainfall did not occur. In spring 2003, 0.5 lb. N/1,000 sq.ft. was applied March 21 and 25, and May 27. An additional 0.35 lb. N /1,000 sq.ft. was applied May 29. Potassium as K_20 was applied at 0.6 lb. /1,000 sq.ft. December 18, and at 0.76 lb. /1,000 sq.ft. March 17 and June 3.

Fifty ball marks were created on May 27, 2003, by the impact of golf balls hit by a PGA professional using a pitching wedge from a distance of ~ 110 yards. Five ball mark repair treatments were randomly applied to the marks within 10 minutes after they were created; each treatment was replicated 10 times. An unmarked, untreated control was also included as a treatment. Repair strategies were: 1) no ball mark (control); 2) unrepaired ball mark; 3) Greenfix repair on putter grip; 4) traditional ball mark repair tool used improperly; 5) traditional ball mark repair tool used properly; and 6) Greenfix Pro ball mark repair tool. Unrepaired ball marks were not treated at any time during the recovery period.

The Greenfix putter grip repair tool was used following instructions of the manufacturer. Briefly, the tool was extended and locked into place, the putter was inverted, and the prongs were pushed into the ball mark surrounds 4 or 5 times at a 45-degree angle, starting at the back of the mark. The mark area was tamped with a putter after repair.

The traditional ball mark repair tool was a standard metal two-prong tool, similar to those available in most golf pro shops. The improper use of the traditional tool was accomplished by inserting the prongs at the back of the ball mark and pushing down on the back of the tool so that the prongs lifted the center of the mark. This was repeated 4 to 5 times around the perimeter of the mark. The mark area was tamped with a putter after repair.

Proper use of the traditional tool was accomplished using the method recommended by the Golf Course Superintendents Association of America (www.gcsaa.org). The prongs were inserted at the back of the mark and a twisting/weaving action was used 4 or 5 times around the perimeter of the mark. The mark area was tamped with a putter after repair.

The Greenfix Pro was used according to manufacturer's recommendations. Nine days after ball marks were made (June 6), dead turf in the ball mark area was removed using the tool's coring device to a 1.75-inch depth. After switching ends (core to prong), prongs were pushed in 4 to 6 times (45-degree angle) along the perimeter of the hole until it was no longer visible. The surface was then rolled with the handle end of the Greenfix Pro.

Data Collection and Analysis

Data were collected on ball mark volume and diameter, surface quality, turf quality, and days to complete ball mark recovery. Ball mark volume for all 50 marks was determined immediately after marks were made, and for the unrepaired marks once weekly thereafter. Volume was determined by placing a sheet of plastic food wrap over the mark and filling the depression with fine sand until it was level with the surface of the green. Sand was collected in the plastic wrap and taken to the laboratory. Volume of the mark was determined by pouring the sand into a graduated cylinder.

Ball mark diameter was measured 2 days after ball marks (ABM), and then weekly thereafter. A ruler was used to measure each mark in two directions, and the average diameter was calculated.

Surface quality of the ball mark area was rated 2 days ABM and then once weekly using visual and touch and feel observations on a 0 to 9 scale where 0 = an uneven surface with dead turf; 2 = maximum rating given for an area with a significant depression; and 9 = good turf quality and no surface disturbance.

Turf quality of the ball mark area was rated at 2 days ABM and then once weekly on a 0 to 9 scale where 0 = dead, brown turf; 7 = minimum acceptable quality for a putting green; and 9 = optimum color, density and uniformity. Surface smoothness was not taken into account.

Days to complete recovery were determined by inspecting the ball marks every 3 or 4 days. A ball mark was considered recovered when two observers concurred that the mark was not noticeable from eye level.

Treatments were arranged in a completely randomized block design with 10 replicates. Data were subjected to analysis of variance, and means were separated using the Waller-Duncan k-ratio t-test ($P < 0.05$).

RESULTS:

Ball mark volume

Average volume of all ball marks immediately after they were created was 6.8 cubic centimeters. Volume of unrepaired marks declined from 6.5 cubic centimeters on May 29 to 0 cubic centimeters on June 20 (Figure 1).

Ball mark diameter

Ball marks were visible for all treatments except the control mark areas. On May 29 and June 6, ranking of repair treatments for diameters (smallest to greatest) was no mark control < putter-end Greenfix < traditional (properly repaired) < traditional (improperly repaired) (Table 1). On June 13, rankings were similar, except that diameter of marks repaired with the putter-end Greenfix and Greenfix Pro were no different than the no mark control. On June 20 and 27, and July 3, the traditional (improperly repaired) marks had a diameter that was significantly greater than all other repair treatments. On June 27 and July 3, the traditional (improperly repaired) treatment was the only one where diameter could be measured; scars from all other treatments had recovered. Photographs of the chronological recovery of representative ball marks repaired using each strategy are presented in Figures 2 and 3.

Days to recovery

Fewest days to recovery occurred following repair with the Putter-end Greenfix and Greenfix Pro; neither was statistically different from the unrepaired mark. The traditional (properly repaired) was slower to recover than the Putter-end Greenfix and the Greenfix Pro, but was similar in recovery time to the unrepaired mark (Table 1). The traditional (improperly repaired) required more than 38 days for recovery, 22 days longer than the Putter-end Greenfix and 18 days longer than the traditional (properly repaired).

Surface quality

On May 29, ranking of treatments for surface quality (best to poorest) was no mark control > traditional (properly repaired) > putter-end Greenfix = traditional (improperly repaired) > unrepaired mark (Table 2). On June 6, similar rankings occurred, except the putter-end Greenfix was statistically similar to the traditional (properly repaired). On June 13, ranking for surface quality (best to poorest) was no mark control > putter-end Greenfix > traditional (properly repaired) > Greenfix Pro = unrepaired mark > traditional (improperly repaired). By June 20, the putter-end Greenfix had a surface quality similar to the no mark control. The next best qualities occurred in the traditional (properly repaired) and Greenfix Pro. Surface quality of the unrepaired mark was similar to the Greenfix pro and superior to the traditional (improperly repaired). Poorest surface quality on June 27 and July 3 occurred in the traditional (improperly repaired) mark areas, primarily because turf quality was low (data not shown).

Turf quality

On May 29, ranking of treatments for turf quality (highest to lowest) was no mark control > putter-end Greenfix = traditional (properly repaired) > unrepaired mark > traditional (improperly repaired) (Table 2). Similar rankings occurred on June 6, except that the putter-end Greenfix was superior in quality to the traditional (properly repaired). Rankings on June 13 were exactly the same as June 6; the Greenfix Pro repair resulted in similar quality to the putter-end Greenfix. On June 20, the putter-end Greenfix resulted in turf quality similar to the no mark control and the Greenfix Pro, and was also statistically similar to the unrepaired mark. Poorest turf quality occurred in the traditional (improperly repaired) mark areas after June 20 (data from June 27 and July 3 not presented).

Key Points

- Regardless of the ball mark repair tool used, a ball mark "scar" of necrotic turf occurred. This was probably influenced by the windy, desiccating environment at this site.
- Unrepaired marks held a volume of 6.5 cubic centimeters, but after 24 days a level surface was present with no evidence of a mark. Not repairing the ball mark resulted in recovery time that was not statistically different from any of the repair methods except the traditional (improperly repaired). This study did not take into account the potential problems an unrepaired mark would have on trueness of ball roll.
- Using a traditional ball mark repair tool improperly (lifting the prongs up to the center of the mark) increases the size (5 to 10 mm larger than other methods) and longevity > 17 days longer than the next nearest method) of the ball mark scar, and reduces surface and turf quality compared to other ball mark repair options.
- Compared to the traditional ball mark repair tool used properly, the putter-end Greenfix resulted in: a smaller diameter mark when evaluated at 10 and 17 days ABM; lower surface quality 2 days ABM, but higher surface quality at 17 and 24 days ABM; better turf quality at 10, 17, and 24 days ABM; and 4 fewer days to total recovery.
- Using the Greenfix Pro to remove the ball mark in a core 10 days ABM reduced evidence of the mark diameter to a level comparable to the no ball mark control at 17 and 24 days ABM; resulted in a surface quality slightly lower than the traditional repair tool (properly used) at 17 days ABM, but similar to the traditional tool (properly used) at 24 days ABM; provided a ball mark recovery time equivalent to the putter-end Greenfix, which was faster than all other repair options.

Acknowledgments

Thanks are extended to David Gourlay, Chad Meyers, and Paul Davids for their cooperation at Colbert Hills Golf Course. The statistical assistance provided by Qi Zhang was also appreciated.

Table 1. Ball mark diameter and days to recovery after creating marks May 27, 2003.

Treatment	Mark diameter (mm)[1]						Days to recovery
	5/29	6/6	6/13	6/20	6/27	7/3	
No mark	0 d[2]	0.0 d	0.0 d	0.0 b	0.0 a	0.0 a	0.0 d
Unrepaired mark	30.5 b	20.8 b	14.3 b	0.0 b	0.0 a	0.0 a	19.4 bc
Putter-end Greenfix	26.3 c	16.8 c	2.8 d	0.0 b	0.0 a	0.0 a	16.3 c
Traditional (improperly repaired)	35.0 a	31.8 a	25.5 a	18.5 a	9.5 b	6.5 b	38.2 a
Traditional (properly repaired)	25.5 c	21.0 b	7.5 c	4.3 b	0.0 a	0.0 a	20.6 b
Greenfix Pro[3]	30.0 b	22.0 b	1.5 d	1.5 b	0.0 a	0.0 a	16.9 c

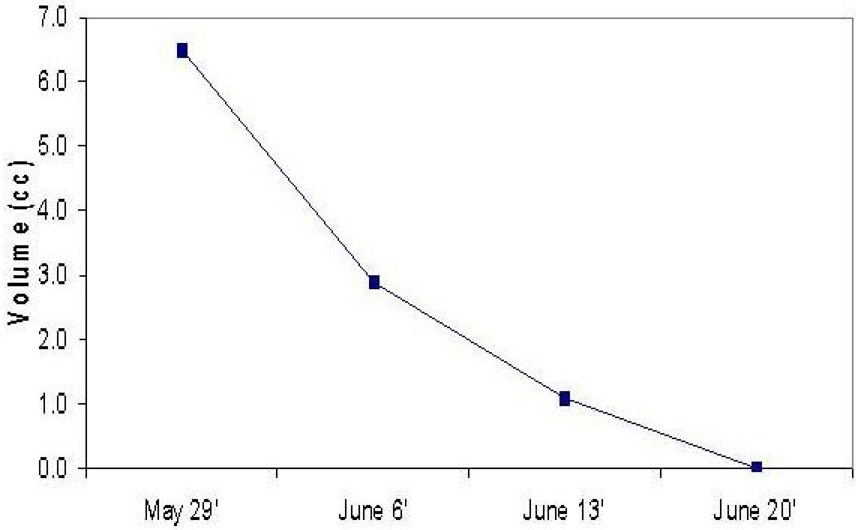
[1]Diameter is the average of two directions.
[2]Means are an average of 10 replicates. Numbers followed by the same letter in a column are not significantly different at $P < 0.05$.
[3]The Greenfix Pro was used immediately after rating on June 6.

Table 2. Surface quality and turf quality of ball mark areas after they were created on May 27, 2003.

Treatment	Surface quality[1]				Turf quality[2]			
	5/29	6/6	6/13	6/20	5/29	6/6	6/13	6/20
No mark	9.0 a[3]	9.0 a	9.0 a	9.0 a	8.0 a	8.0 a	8.0 a	8.0 a
Unrepaired mark	1.7 d	4.1 d	6.6 d	7.3 c	3.2 c	4.2 d	5.7 d	7.3 bc
Putter-end Greenfix	5.4 c	6.9 b	8.3 b	8.7 a	5.2 b	6.4 b	7.5 b	7.8 ab
Traditional (improperly repaired)	4.8 c	5.5 c	5.8 e	5.7 d	2.6 d	2.3 e	3.2 e	3.7 d
Traditional (properly repaired)	6.4 b	6.6 b	7.4 c	8.0 b	5.0 b	5.4 c	6.5 c	6.9 c
Greenfix Pro[4]	1.5 d	4.0 d	6.9 d	7.7 bc	3.2 c	5.0 c	7.1 b	7.9 a

[1]Surface quality was rated on a 0 to 9 scale where 0 = an uneven surface with dead turf; 2 = maximum rating given for an area with a significant depression; and 9 = good turf quality and no surface disturbance.
[2]Turf quality was rated without regard to the smoothness of the surface on a 0 to 9 scale where 0 = brown, dead turf; 7 = minimum acceptable rating for putting green quality; and 9 = optimum color, density and uniformity.
[3]Means are an average of 10 replicates. Numbers followed by the same letter in a column are not significantly different at $P < 0.05$.
[4]The Greenfix Pro was used immediately after rating on June 6.

Fig. 1. Change in volume of unrepaired ball marks over the duration of the study. Ball marks were created May 27, 2003.



TITLE: Erosion Control Studies on Coal Piles at the Jeffrey Energy Center

OBJECTIVE: Evaluate the potential for using turfgrass to stabilize slopes on storage coal piles at the Jeffrey Energy Center.

PERSONNEL: Jack Fry

INTRODUCTION:

Coal piles located on the grounds outside large electricity-generating plants occupy large areas of land and require extensive labor to maintain. Much of the labor is involved in recontouring slopes that have been subjected to water erosion. In addition, on windy days, a black cloud of coal dust can commonly be found hovering above and around these areas, reducing environmental quality. Turfgrass has a tremendous ability to stabilize soil, but when contacted in 2001 about stabilizing coal pile slopes with turfgrass, I could find no published information on whether turf could be established and grown on coal. This field study was a follow-up to greenhouse tests that demonstrated a range of grasses and legumes could be established in the coal.

METHODS:

Seeding was done on May 14, 2001. Smooth brome was seeded at 8 lb./1,000 sq. ft.; Wrangler bermudagrass seeded at 1.5 lb./1,000 sq. ft. An untreated control was included as well. Plots measured 60 high by 100 feet wide and were replicated three times in a randomized complete block design. Hydroseeding was used to apply seed and fertilizer (13-13-13 soluble at 40 lb./A). A paper-based mulch was included as well. Irrigation was done with large-nozzle rotary sprinklers that were periodically moved at positions along the base of the coal pile.

Plots were rated visually on June 14 and 22, July 27, and September 14 for percentage of turf coverage and erosion. Data were subjected to analysis of variance.

RESULTS:

Coverage

Best coverage on June 14 was observed in plots seeded with smooth brome. By June 22, coverage in brome-seeded plots was not significantly different from that observed in bermudagrass-seeded plots. In July and August, plots seeded with bermudagrass had higher coverage ratings than brome-seeded plots.

Erosion

No differences in erosion occurred until July 27 and September 14 when more erosion was observed in control plots.

Clearly, turfgrasses – and particularly bermudagrass – can be effectively established on storage coal piles and assist in reducing wind and water erosion.

Table 1. Smooth brome and bermudagrass coverage and erosion, after seeding grasses on the slope of a large coal pile in St. Marys, Kan., on May 14, 2001.

Treatment	June 14		June 22		July 27		Sep 14	
	% of Cover	% of Erosion	% of Cover	% of Erosion	% of Cover	% of Erosion	% of Cover	% of Erosion
Control	0.0 c	38.3	0.0 b	36.7	0.0 c	25.0 a	0.0 c	23.3 a
Brome	51.7 a	20.3	40.0 a	10.0	43.3 b	10.7 b	53.3 b	8.3 b
Bermuda	28.3 b	26.7	26.7 a	23.3	75.0 a	8.7 b	83.3 a	8.3 b
ANOV	*	NS	*	NS	*	*	*	*

NS means no significant difference.
* means significant difference at P <0.05 level.

TITLE: Evaluation of Calcium Silicate for Brown Patch Suppression in Tall Fescue

OBJECTIVE: Evaluate the efficacy of calcium silicate applied at two application rates alone and in combination with reduced rate of flutolanil (Prostar) for suppression of brown patch in tall fescue

PERSONNEL: Qi Zhang, Jack Fry, Kathie Lowe, and Ned Tisserat

SPONSORS: Kansas Turfgrass Foundation

INTRODUCTION:

Tall fescue (*Festuca arundinacea Schreb*.) is one of the most widely used turfgrasses for home lawns in the transition zone because of its heat and drought resistance and ease of establishment; however, tall fescue is susceptible to brown patch (*Rhizoctonia solani Kühn*). Due to economic and environmental concerns, lawn care operators are interested in finding fungicide alternatives. One potential tool is the use of silicon (Si) fertilizers. The efficacy of Si fertilizers has been reported in control of turf disease, such as dollar spot and brown patch, in creeping bentgrass.

MATERIALS AND METHODS:

Tar Heel (brown patch resistant) and Bonsai 2000 (brown patch susceptible) tall fescue were seeded at 7 lb./1,000 sq.ft. in September 2001 at the Rocky Ford Turfgrass Research Center at Manhattan, Kan. The experiment was designed as a split-plot with four replications. Each whole-plot measured 10 by 40 feet, and each sub-plot was 7 by 10 feet. Grass was mowed at about 3.5 inches twice weekly and watered as needed to avoid drought stress. Urea (46-0-0) was applied at 49 kg./hectare May 5 and 29 and September 22 , 2003. Calcium silicate (31% SiO_2, 22% Ca) was uniformly applied using a shaker bottle on May 14 and September 29, 2003. Flutolanil was applied on a 21-day interval with a CO_2-powered sprayer at 30 psi in water equivalent to 2 gal./1,000 sq.ft. from June 1 to September 30, 2003. Plant tissue was sampled on May 14, August 20, and October 5, 2003. Data were collected on turfgrass visual quality, brown patch severity, nutrient concentrations in plant tissue, and Si concentration in the soil.

RESULTS:

Turfgrass visual quality

Significant difference was observed in the visual quality in July and August (Table 1). In July, turf treated with flutolanil at 1.1 or 2.2 oz./1,000 sq.ft. provided better quality, while no difference was observed between untreated turf and turf treated with CaSi alone at either rate. In August, Tar Heel had better quality than Bonsai 2000. Turf treated with CaSi alone at 50 or 100 lb./1,000 sq.ft. had poorest quality, while turf treated with flutolanil at 1.1 or 2.2 oz./1,000 sq.ft. had the highest quality. An interaction between cultivar and sub-plot treatment was observed. Sub-plots in Tar Heel had better quality.

Brown patch

Tar Heel had brown patch 22% less than Bonsai 2000 (Table 2). Turf treated with CaSi alone at 50 or 100 lb./1,000 sq.ft. exhibited more brown patch than untreated turf by 30%. Turf treated with flutolanil at 1.1 or 2.2 oz./1,000 sq.ft. had 70% less brown patch than untreated turf. An interaction between cultivar and sub-plot treatment was also observed. Tar Heel increased the efficiency of sub-plot treatments.

Nutrients

Nutrients were not affected by cultivar (Table 3). There was no significant difference in Si tissue content among the sub-plot treatments, except in August. Silicon tissue concentration in the turf treated with CaSi at 50 lb./1,000 sq.ft. was higher than the turf without CaSi application or the turf treated with CaSi at the higher rate (100 lb./1,000 sq.ft.). Silicon soil concentration was increased with CaSi application rates in May and August.

SUMMARY:

There was not enough evidence to show that CaSi would suppress brown patch in tall fescue. In fact, turf treated with CaSi alone exhibited more brown patch, regardless of the application rate. Most CaSi fertilizer was left in the soil, instead of being absorbed by the grass.

Table 1. Turfgrass visual quality† in tall fescue as influenced by calcium silicate (CaSi) and flutolanil at Manhattan, Kan., in 2003.

Treatment		July	August	September
Whole-plot				
	Bonsai 2000	6.0	5.6 b	7.0
	Tar Heel	6.2	6.0 a	7.0
Sub-plot				
	Untreated	5.5 b	5.4 b	7.0
	CaSi (50 lb./1,000 sq.ft.)	5.2 b	4.9 c	6.0
	CaSi (100 lb./1,000 sq.ft.)	5.3 b	4.9 c	6.0
	CaSi (50 lb./1,000 ft^2)+flutolanil (1.1 oz/1,000 ft^2)	7.1 a	7.0 a	7.0
	flutolanil (2.2 oz./1,000 sq.ft.)	7.2 a	7.0 a	7.0
Analysis				
	Whole-plot	NS	*	NS
	Sub-plot	*	*	NS
	Whole-plot*Sub-plot	NS	*	NS

NS, not significant.
* indicates significance at the 0.05 probability level.
†Tall fescue visual quality was rated on a scale of 0 to 9, 0 = dead, 6 = acceptable quality for home lawn, 9 = best quality.
‡Means (an average of weekly ratings throughout each month) within a column followed by the same letter are not significantly different ($P < 0.05$).

Table 2. Brown patch (AUDPC†) as influenced by calcium silicate and flutolanil in the tall fescue field test at Manhattan, Kan., in 2003.

Whole-plot		
	Bonsai 2000	243 a
	Tar Heel	189 b
Sub-plot		
	Untreated	263 b
	CaSi (L)	342 a
	CaSi (H)	332 a
	CaSi (L)+flutolanil (L)	78 c
	flutolanil (H)	64 c
	Whole-plot	*
	Sub-plot	*
	Whole-plot*Sub-plot	*

NS, not significant.
* indicates significance at the 0.05 probability level.
†AUDPC = Area Under Disease Progression Curve
‡Means (an average of weekly ratings throughout each month) within a column followed by the same letter are not significantly different ($P < 0.05$).

Table 3. Calcium (mg kg^{-1}) in tall fescue plant tissue and Si (mg kg^{-1}) in both plant tissue and soil as influenced by calcium silicate (CaSi) and flutolanil at Manhattan, Kan., in 2003.

	In Plant Tissue						In Soil		
	-----May ----		----- Aug -----		----- Oct -----		May	Aug	Oct
	Ca	Si	Ca	Si	Ca	Si	Si	Si	Si
Whole-plot									
Bonsai 2000	4,662	29,617	9,672	27,278	5,343	19,859	206	214	277
Tar Heel	4,986	29,350	8,341	23,969	5,423	17,974	206	228	284
Sub-plot									
Untreated	4,857	30,548	8,031	24,537 b	5,214	16,788	173 b	158 c	184
CaSi (2,440 kg ha^{-1})	4,745	28,342	8,624	27,172 a	5,362	20,574	210 ab	256 b	287
CaSi (4,880 kg ha^{-1})	4,842	30,160	8,940	24,068 b	5,484	19,491	255 a	306 a	401
CaSi (2,440 kg ha^{-1}) + flutolanil (2.4 kg a.i. ha^{-1})	4,842	29,863	9,304	29,323 a	5,398	19,698	215 ab	231 b	346
flutolanil (4.8 kg a.i. ha^{-1})	4,836	28,504	10,132	23,018 b	5,459	18,030	176 b	152 c	185
Analysis									
Whole-plot	NS	NS	NS	NS	NS	NS	NS	NS	NS
Sub-plot	NS	NS	NS	*	NS	NS	*	*	NS
Whole-plot*sub-plot	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS, not significant.

* indicates significance at the 0.05 probability level.

‡Means (an average of weekly ratings throughout each month) within a column followed by the same letter are not significantly different ($P < 0.05$).

TITLE: Tall Fescue NTEP Cultivar Trial

OBJECTIVE: To evaluate tall fescue cultivars under Kansas conditions and submit data collected to the National Turfgrass Evaluation Program.

PERSONNEL: Linda R. Parsons and Jack D. Fry

SPONSOR: USDA National Turfgrass Evaluation Program

INTRODUCTION:

Tall fescue is the best adapted cool-season turfgrass for the transition zone in Kansas because it is drought- and heat-tolerant and has few serious insect and disease problems. Tall fescue possesses a rather coarse leaf texture; it lacks stolons and has only very short rhizomes. Efforts to improve cultivar quality include selection for finer leaf texture, a rich green color, and better sward density, while still maintaining good stress tolerance and disease resistance.

MATERIALS AND METHODS:

After incorporating 13-13-13 at a rate of 1 lb. NPK/1000 sq.ft. into 480 5 x 5 study plots at the John C. Pair Horticultural Center in Haysville, Kan., the area was seeded September 28, 2001, with 160 tall fescue cultivars and experimental numbers in a randomized complete block design at a rate of 4.4 lb. seed /1000 sq.ft. Fertility of plots was maintained at 0.25 to 0.5 lb. N/1000 sq.ft. per growing month. Plots are mowed weekly during the growing season at 2.5 inches and clippings removed. Irrigation is done as necessary to prevent stress, and weed, insect, and disease controls applied only when they present a threat to the trial.

During the course of the study, information is collected on spring green-up, genetic color, leaf texture, quality, and other measures when appropriate. Rating is done on a scale of 0 = poorest, 6 = acceptable, and 9 = optimum measure.

RESULTS:

During the summer of 2003, data were collected on turf green-up, quality, color, and texture. By April 23, the cultivars/experimental numbers BAR Fa 1CR7, Gremlin (P-58), and MRF 211were greenest (Table 1). Fescue plots were rated monthly throughout the growing season for turf quality. Ratings were influenced by degree of coverage and weed infestation as well as turf color, texture, and density. Those that performed best overall were Falcon IV (F-4), PST-5A1, PST-5BZ, CIS-TF-64, Avenger (L1Z), BAR Fa 1CR7, and Justice (RB2-01). At the end of the summer, in evaluating turf color and texture, MRF 28, SRX 805, CIS-TF-60, Daytona (MRF 23), MRF 210, MRF 29, and NA-TDD were the darkest green, and ATF-806, Dynasty, K01-8007, and K01-8015 had the finest texture.

Table 1. 2003 performance of tall fescue cultivars at Haysville, Kan.[1]

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Falcon IV (F-4)*[2]	6.7	7.0	7.3	6.3	6.3	6.0	5.7	5.7	5.7	6.0	6.0
PST-5A1	6.7	6.7	7.0	6.7	6.0	6.0	5.7	5.7	5.3	5.7	5.9
PST-5BZ	6.3	7.0	7.0	7.0	6.3	6.0	5.7	6.0	5.0	5.0	5.9
CIS-TF-64	6.3	7.0	7.0	6.0	7.0	6.3	6.0	5.0	5.3	5.0	5.8
Avenger (L1Z)*	6.0	7.3	7.0	6.0	6.3	6.3	6.0	4.7	5.3	5.7	5.8
BAR Fa 1CR7	7.0	8.3	7.0	6.0	6.0	6.0	6.0	5.7	5.3	5.3	5.8
Justice (RB2-01)*	6.3	7.0	7.0	5.7	6.0	6.0	6.0	5.3	5.3	6.0	5.8
EA 163	6.3	8.0	6.3	6.0	6.0	6.0	5.3	5.7	5.3	5.7	5.7
Scorpion*	6.3	7.0	7.3	5.7	6.0	6.0	5.7	5.7	5.3	5.7	5.7
01-RUTOR2	6.7	7.0	7.0	6.7	6.0	5.7	6.0	5.3	5.0	5.0	5.7
BE1	5.7	6.7	6.7	5.7	5.7	5.7	6.3	5.7	5.0	5.7	5.7
CAS-ED	6.0	7.0	6.3	6.0	6.0	6.0	6.0	5.3	5.0	5.3	5.7
Cochise III (018)*	6.7	7.0	6.7	6.3	6.0	5.7	6.0	5.3	4.7	5.7	5.7
Coyote*	6.3	7.3	7.0	5.7	6.3	6.0	5.7	5.3	5.0	5.7	5.7
Grande II*	6.3	7.0	7.0	6.0	5.7	6.0	5.7	5.7	5.3	5.3	5.7
PST-5JM	6.3	7.3	6.7	5.7	6.0	6.0	5.7	5.3	5.0	6.0	5.7
Picasso*	6.3	7.0	6.7	6.0	5.7	5.3	5.7	5.0	5.3	6.7	5.7
Raptor (CIS-TF-33)*	6.3	7.3	7.0	5.3	6.3	6.0	5.7	4.7	6.3	5.3	5.7
01-ORU1	6.3	7.0	7.0	6.0	5.7	5.3	6.0	5.7	5.3	5.3	5.6
ATF-593 (Constitution)*	6.3	7.0	6.3	6.0	6.0	6.0	5.3	5.7	5.0	5.3	5.6
Millennium*	6.7	7.0	6.7	5.7	6.0	5.7	6.0	6.0	5.0	5.0	5.6
SR 8550 (SRX 8BE4)*	6.7	7.0	6.3	6.0	6.0	6.0	5.3	5.3	5.0	5.7	5.6
CIS-TF-60	6.7	8.7	7.3	5.3	6.3	6.3	6.0	5.0	4.7	5.3	5.6
Finelawn Elite (DLSD)*	6.7	7.0	7.0	5.7	6.0	5.3	5.7	5.7	5.3	5.3	5.6
Legitimate*	5.7	7.0	6.0	5.3	5.7	5.7	6.3	5.3	5.0	5.7	5.6
MA 158	6.3	7.0	6.7	6.0	6.0	7.0	5.3	5.0	4.7	5.0	5.6
MRF 26	6.3	8.3	6.7	6.0	5.3	5.7	6.3	5.3	4.7	5.7	5.6
Matador*	6.7	7.0	7.0	6.0	6.3	5.7	5.7	5.3	5.0	5.0	5.6
BAR Fa 1003	6.0	7.0	6.3	5.7	6.0	5.7	6.3	5.0	5.0	5.3	5.6
Barrera*	6.3	7.3	7.0	6.0	5.7	6.0	5.7	5.3	4.7	5.3	5.5
Biltmore*	5.7	7.0	7.0	5.7	5.7	6.0	6.0	5.0	5.0	5.3	5.5
Cayenne*	6.0	6.7	7.0	6.0	6.3	6.0	5.3	5.0	5.3	4.7	5.5
Masterpiece*	6.3	7.0	6.7	6.0	5.7	5.7	5.7	5.3	5.0	5.3	5.5
Pick ZMG	6.3	7.0	6.0	5.7	6.0	5.7	5.7	5.0	5.7	5.0	5.5

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
UT-RB3	6.3	7.3	6.3	5.7	6.0	6.0	6.0	4.7	5.3	5.0	5.5
CIS-TF-77	6.7	7.0	7.0	5.7	6.0	5.7	6.0	5.0	5.3	5.0	5.5
ProSeeds 5301 (Riverside)*	6.7	7.0	7.0	6.3	5.7	6.0	6.0	4.7	5.0	5.0	5.5
Rendition*	6.0	7.0	7.0	5.3	6.0	6.0	5.7	5.3	5.0	5.3	5.5
Blackwatch (Pick-OD3-01)*	6.7	7.0	6.7	6.0	6.0	5.7	5.7	4.7	5.3	5.0	5.5
PST-5LO	6.0	6.3	6.7	5.3	5.7	6.7	5.7	4.3	5.7	5.0	5.5
Roberts SM4	6.3	7.0	6.3	5.7	5.7	6.0	5.7	5.0	5.0	5.3	5.5
MRF 210	6.7	8.7	6.3	5.7	6.0	5.7	5.7	5.0	5.3	5.0	5.5
MRF 27	6.0	7.3	7.0	5.7	5.7	6.0	6.0	4.7	5.0	5.3	5.5
Silverado II (PST-578)*	6.0	7.0	6.0	6.0	5.7	5.7	5.7	5.0	5.0	5.3	5.5
JT-18	6.0	7.7	7.0	6.0	6.0	6.0	5.3	5.0	4.7	5.0	5.4
JT-13	6.0	7.3	6.7	6.0	5.3	6.0	5.7	3.7	5.7	5.7	5.4
K01-E09	6.7	7.3	7.3	5.7	5.7	6.3	5.7	5.3	5.0	4.3	5.4
Signia*	6.0	7.7	6.7	5.7	6.0	5.7	6.0	5.0	5.0	4.7	5.4
TF66	6.3	7.3	6.7	6.0	5.7	5.3	5.7	5.3	5.0	5.0	5.4
Tar Heel*	6.7	6.0	6.0	5.3	5.3	5.7	6.0	5.3	4.7	5.7	5.4
Watchdog*	6.7	6.7	7.0	5.7	5.7	5.7	5.7	5.3	5.0	5.0	5.4
ATF 702	6.3	8.3	7.0	5.3	6.0	6.0	6.0	4.7	4.7	5.0	5.4
CAS-MC1 (Turbo)*	6.3	7.0	6.7	5.7	6.0	6.0	5.0	5.7	4.7	4.7	5.4
CIS-TF-67	6.3	7.3	7.0	5.7	5.7	5.7	5.3	4.0	6.0	5.3	5.4
Gremlin (P-58)*	7.0	6.7	6.7	6.0	6.0	5.7	5.7	4.3	5.0	5.0	5.4
Guardian-21 (Roberts DOL)*	6.3	7.3	6.7	5.7	5.3	6.0	5.7	4.7	5.3	5.0	5.4
JT-12	6.0	7.0	7.0	5.3	5.7	5.7	5.7	5.0	5.0	5.3	5.4
Kalahari*	6.3	6.7	7.3	5.7	5.7	5.7	5.3	5.0	5.0	5.3	5.4
Mustang 3*	6.7	7.0	6.7	5.7	5.3	5.7	5.7	5.0	5.0	5.3	5.4
Olympic Gold*	6.3	7.0	6.7	5.7	5.7	5.7	5.7	5.3	4.7	5.0	5.4
PST-5NAS	6.3	6.7	7.0	5.7	6.3	5.7	6.0	4.3	5.0	4.7	5.4
PST-5S12	6.7	6.7	6.7	5.7	5.7	5.7	5.0	5.0	5.3	5.3	5.4
PST-DDL	6.3	7.0	7.0	5.0	6.3	6.0	5.3	5.0	5.0	5.0	5.4
SR 8600*	6.3	7.0	6.3	6.0	5.7	5.3	5.3	4.7	5.0	5.7	5.4
Tahoe (CAS-157)*	6.0	7.0	6.3	5.3	5.3	6.0	5.3	5.0	5.3	5.3	5.4
2nd Millennium*	6.7	7.0	7.0	5.7	5.0	6.0	5.7	5.3	4.7	5.0	5.3
Daytona (MRF 23)*	5.3	8.7	6.0	5.0	5.7	5.3	5.7	5.7	4.7	5.3	5.3
JT-9	6.3	7.3	7.0	6.0	5.7	5.7	5.7	4.7	5.0	4.7	5.3
JTTFF-2000	6.3	7.0	6.3	6.0	6.0	6.0	5.0	4.3	4.7	5.3	5.3

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
K01-E03	6.0	7.0	7.0	5.0	5.3	5.7	5.7	4.7	5.3	5.7	5.3
MA 127	6.3	7.0	6.3	5.7	5.3	5.7	5.3	4.7	5.3	5.3	5.3
MRF 211	7.0	8.3	6.7	5.3	6.0	6.0	5.3	4.3	5.0	5.3	5.3
Magellan (OD-4)*	6.7	7.3	6.7	6.0	5.7	5.7	5.0	4.7	5.0	5.3	5.3
Pure Gold*	6.3	7.0	6.3	6.0	6.0	5.7	5.7	4.7	4.7	4.7	5.3
R-4	6.3	7.0	7.3	6.0	6.0	6.0	5.0	4.0	5.0	5.3	5.3
Rebel Sentry*	6.0	7.3	6.3	5.7	5.3	5.7	5.7	5.0	5.0	5.0	5.3
Rembrandt*	6.3	6.7	6.3	5.7	5.7	5.7	5.3	5.0	5.0	5.0	5.3
SBM (Titanium)*	6.0	7.0	7.0	5.3	5.0	5.7	5.0	5.3	5.3	5.7	5.3
Davinci (LTP-7801)*	6.3	7.0	7.3	6.0	5.7	5.3	5.3	4.7	5.0	5.0	5.3
Dynasty*	6.3	6.3	7.7	5.7	5.7	5.3	5.3	5.0	5.0	5.0	5.3
Falcon II*	6.0	6.3	7.0	5.3	5.3	5.3	5.3	5.3	5.3	5.0	5.3
Inferno (JT-99)*	6.3	7.0	7.0	5.3	6.3	5.7	5.3	3.7	5.3	5.3	5.3
JT-6	6.3	8.0	6.7	5.7	5.7	5.7	5.7	4.7	5.0	4.7	5.3
MRF 25	6.3	7.7	6.7	6.3	5.7	5.7	5.3	4.7	4.7	4.7	5.3
MRF 28	6.3	9.0	6.3	6.0	6.0	5.7	5.3	4.7	4.3	5.0	5.3
Quest*	6.3	7.0	7.0	6.0	5.3	6.0	5.0	5.3	4.7	4.7	5.3
Rebel Exeda*	6.0	6.7	7.0	5.3	5.7	5.7	5.3	3.7	5.7	5.7	5.3
Scorpion MCN-RC*	5.7	7.0	6.7	5.0	5.7	5.7	5.7	5.3	4.7	5.0	5.3
South Paw (MRF 24)*	6.0	7.3	6.0	5.7	5.7	5.3	6.0	4.7	4.3	5.3	5.3
B-7001	6.3	7.0	6.3	6.0	5.3	5.7	5.0	4.7	5.0	5.0	5.2
Bingo*	5.7	8.0	7.0	5.3	5.0	6.0	5.3	5.7	4.3	5.0	5.2
Finesse II*	6.3	7.7	7.0	5.3	5.7	5.3	5.7	5.0	5.0	4.7	5.2
Focus*	6.3	7.0	7.0	5.7	5.7	5.3	5.0	5.3	4.3	5.3	5.2
JT-15	6.0	7.3	7.3	5.7	5.7	5.7	5.3	5.0	4.7	4.7	5.2
K01-8015	5.7	6.3	7.7	5.7	6.3	6.0	5.0	4.7	5.0	4.0	5.2
Laramie*	6.3	7.0	6.3	5.7	5.7	5.3	5.3	5.0	5.0	4.7	5.2
Padre (NJ4)*	5.7	7.0	6.3	5.3	5.3	5.3	5.0	5.0	5.3	5.3	5.2
Prospect*	5.7	7.7	6.3	5.0	5.7	5.3	5.3	5.0	5.0	5.3	5.2
Silverstar (PST-5ASR)*	6.7	6.3	6.0	5.3	5.7	5.7	5.0	4.7	5.0	5.3	5.2
Wolfpack*	6.0	6.3	6.7	5.0	5.3	5.3	5.7	5.0	5.0	5.3	5.2
Bravo*	6.0	6.7	6.7	5.0	6.0	5.3	5.7	4.7	4.7	5.0	5.2
DLF-J210	5.7	7.3	6.3	5.3	5.3	5.3	5.7	5.0	4.7	5.0	5.2
Jaguar 3*	6.3	6.7	6.3	5.3	5.0	5.3	5.0	5.0	5.3	5.3	5.2
PST-5FZD	6.3	7.0	7.0	5.3	5.7	5.3	5.3	4.7	5.3	4.7	5.2

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
PST-5TUO	6.0	7.7	6.3	5.0	5.7	5.3	5.7	4.7	5.0	5.0	5.2
Southern Choice II*	6.3	7.7	6.0	5.3	5.7	5.7	4.7	4.7	5.0	5.3	5.2
PST-57E	5.7	6.7	7.0	5.0	5.7	5.7	5.3	4.7	5.3	4.7	5.2
PST-5KU	6.3	7.3	6.3	5.0	6.0	5.7	4.7	4.7	5.3	5.0	5.2
01-TFOR3	6.3	6.3	6.3	5.3	5.7	5.3	5.7	4.0	4.7	5.3	5.1
ATF 704	5.7	7.0	6.7	5.7	5.7	5.0	5.0	5.0	4.7	5.0	5.1
ATF 799	6.3	7.7	7.0	5.3	5.7	5.3	5.0	5.0	4.7	5.0	5.1
Barlexas II*	5.7	7.0	7.0	5.3	5.7	5.3	5.3	4.3	5.0	5.0	5.1
K01-8007	6.0	7.0	7.7	5.0	6.0	5.7	5.3	4.7	4.7	4.7	5.1
UT-155	6.0	7.3	6.0	5.3	5.3	5.7	5.0	4.7	4.7	5.3	5.1
ATF 806	6.0	7.0	7.7	5.3	5.7	5.3	5.3	5.0	4.7	4.7	5.1
DP 50-9226	5.7	6.7	6.7	5.0	5.0	5.7	5.7	5.0	4.7	5.0	5.1
MA 138	5.7	7.3	6.0	4.7	5.3	5.3	5.3	5.0	5.0	5.3	5.1
Plantation*	6.0	7.0	7.0	5.3	5.0	5.7	5.0	5.0	5.0	5.0	5.1
Titan Ltd.*	6.0	6.0	6.7	5.0	5.0	5.3	5.0	4.7	4.7	6.0	5.1
ATF-800	5.7	7.0	7.0	5.0	5.7	5.3	5.3	4.3	4.7	5.3	5.1
BAR Fa 1005	6.0	7.0	6.7	5.3	5.0	5.3	5.0	5.0	5.0	5.0	5.1
Pick TF H-97	5.7	6.7	6.7	5.0	5.7	5.3	5.3	4.7	4.7	5.0	5.1
Tar Heel II (PST-5TR1)*	6.3	5.7	6.0	5.3	5.0	5.0	5.0	5.0	4.7	5.7	5.1
Tempest*	6.0	7.3	6.3	5.3	5.7	5.3	5.3	4.7	4.7	4.7	5.1
ATF-803	6.0	7.0	6.7	5.3	5.0	5.3	5.3	4.3	4.7	5.3	5.0
Bonsai*	6.0	7.0	6.7	5.0	5.7	5.3	5.3	4.7	4.7	4.7	5.0
DP 50-9082	6.0	5.7	6.3	4.3	4.7	5.3	5.7	5.0	5.0	5.3	5.0
Forte (BE-2)*	6.0	7.3	6.7	5.0	5.0	5.7	5.0	5.0	5.0	4.7	5.0
GO-OD2	6.0	7.0	6.7	5.0	5.0	5.3	5.7	4.7	4.7	5.0	5.0
ATF 586	5.7	6.7	6.3	5.3	5.0	5.7	5.0	4.7	4.3	5.0	5.0
Barrington*	6.0	7.0	7.3	5.3	5.7	5.3	5.0	4.7	4.3	4.7	5.0
CIS-TF-65	6.3	8.3	7.0	5.3	5.0	5.3	4.7	4.7	5.0	5.0	5.0
MRF 29	6.0	8.7	6.3	5.0	5.3	5.7	5.3	4.3	4.3	5.0	5.0
PST-5T1	6.0	6.7	6.7	5.0	5.0	5.3	4.7	4.7	5.0	5.3	5.0
SRX 805	6.3	9.0	7.0	4.7	5.3	5.0	5.7	4.0	5.0	5.3	5.0
Tomahawk RT*	5.7	7.0	6.7	4.7	5.3	5.3	5.0	3.7	4.7	6.3	5.0
Tracer*	6.3	7.3	7.0	4.7	5.3	5.0	5.0	4.3	5.3	5.3	5.0
GO-RD4	5.7	6.7	6.0	5.0	5.3	5.3	5.3	4.7	4.3	4.7	5.0
PST-53T	6.0	7.7	6.7	5.0	5.3	5.3	5.3	4.7	4.3	4.7	5.0

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
ATF 707	6.0	7.0	6.7	5.3	5.3	5.3	5.0	4.7	4.3	4.7	5.0
Dominion*	6.3	5.7	5.7	5.0	5.0	5.0	5.3	4.7	4.7	4.7	4.9
Elisa*	6.3	5.0	5.7	4.7	5.0	5.0	5.3	5.0	4.3	5.0	4.9
PST-5BAB	6.0	7.0	6.7	5.3	5.0	5.0	4.7	4.7	4.7	5.0	4.9
SR 8250*	5.7	6.7	6.3	5.0	5.0	5.3	5.0	4.7	4.7	4.7	4.9
Barlexas*	6.3	7.0	6.7	4.7	5.0	4.7	5.3	4.7	5.0	5.0	4.9
Pick-00-AFA	5.7	6.3	6.7	5.3	5.0	5.3	4.7	4.7	4.7	4.3	4.9
ATF 802 (Covenant)*	5.7	7.3	6.7	4.7	5.7	5.0	4.7	4.7	4.3	4.7	4.8
T991	5.7	7.0	6.3	5.0	5.3	5.0	4.7	4.7	4.7	4.3	4.8
Kitty Hawk 2000*	6.0	7.0	7.0	4.7	4.7	5.3	5.0	4.3	4.7	4.7	4.8
Stetson*	5.7	6.0	6.7	4.7	5.0	5.0	4.7	4.3	4.7	5.0	4.8
Wyatt*	6.0	6.3	6.3	4.7	5.0	5.0	5.0	4.3	4.7	4.7	4.8
Endeavor*	5.7	6.3	7.0	4.7	4.7	5.0	4.7	4.0	4.7	5.0	4.7
Lancer*	6.0	7.0	6.7	4.7	4.7	5.0	4.7	4.3	4.7	4.7	4.7
NA-TDD	6.0	8.7	6.7	5.0	5.0	5.0	5.0	3.3	4.3	4.7	4.6
K01-WAF	6.0	6.7	6.3	4.7	5.0	4.7	4.3	4.0	4.3	5.0	4.6
GO-FL3	6.0	5.0	5.3	4.3	4.7	5.0	4.7	4.3	4.0	5.0	4.6
Tulsa II (ATF 706)*	5.7	6.7	6.3	4.7	5.0	4.7	5.0	4.3	3.7	4.3	4.5
PST-5KI	6.7	6.7	6.7	4.3	4.3	4.3	4.0	3.7	5.3	5.0	4.4
GO-SIU2	6.0	5.7	5.7	4.0	4.3	4.3	4.7	4.0	4.3	4.3	4.3
Ky-31 E+*	6.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.3	4.0	3.9
LSD[3]	*1.8*	*0.7*	*0.8*	*1.5*	*1.2*	*1.2*	*2.1*	*2.8*	*1.4*	*2.4*	*0.8*

[1]Ratings based on a scale of 0-9 with 9 = best measure.

[2]Cultivars marked with "*" will be commercially available in 2004.

[3]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

TITLE: Perennial Ryegrass NTEP Evaluation

OBJECTIVE: Evaluate Performance of New and Standard Ryegrass Cultivars in Kansas

PERSONNEL: Qi Zhang and Jack Fry

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION:

Perennial ryegrass is one of the widely used sports turfgrasses in the transition zone for areas such as golf course fairways and tees. There is interest in evaluating the performance of different ryegrass cultivars under field conditions.

MATERIALS AND METHODS:

On September 17, 1999, 134 perennial ryegrass entries were planted at the Rocky Ford Turfgrass Research Center. Turf was mowed at 0.5 inch three days weekly; received 1 lb N from urea in May, September, and November; and was irrigated to prevent drought stress. Turf quality was rated visually each month from May to October, using a scale from 0 to 9, where 0 = dead turf; 6 = acceptable quality for a golf course fairway or tee; 9 = optimum color, density, and uniformity.

RESULTS:

Genetic color

Headstart and Linn had poorer genetic color, although they were not significantly different from some other cultivars.

Leaf texture

Linn had the coarsest leaf texture among all cultivars, followed by Fiesta 3, DP LP-1, and DP 17-9496.

Quality

Visual quality differed among cultivars in May and July. Cultivars that did not provide acceptable quality in May were Premier, Monterey II (JR-187), ProSport (AG-P981), APR 776, DP LP-1, KOOS R-71, Phantom, MP88, Yatsugreen, DP 17-9496, and Linn.

In July, All Star2 (CIS-PR-78), LTP-ME, Churchill, Seville II, and Pennant II had the best quality, while MDP, Divine, PST-2CRR, MP88, Mach 1 (POBERTS-627), EP53, and Linn had unacceptable quality.

Table 1. Mean Turfgrass Quality and Other Ratings of Perennial Ryegrass Cultivars in the 1999 National Perennial Ryegrass Test at Manhattan, Kan., in 2003.

			Quality**						
Name	Color*	Texture	May	Jun	Jul	Aug	Sep	Oct	Mean
Churchill	8.0	8.0	7.0	7.7	8.0	7.0	8.0	8.0	7.6
Manhattan 3	8.0	8.0	7.0	7.7	7.3	7.0	7.7	7.7	7.4
Charger II	8.0	8.0	6.7	7.3	7.3	6.7	8.0	8.0	7.3
Admire (JR-151)	7.7	8.0	6.7	6.7	7.7	7.3	7.3	7.3	7.2
Courage (MB 410)	8.0	8.0	6.3	6.3	7.7	7.0	8.0	8.0	7.2
Inspire (R8000)	7.7	8.0	7.0	6.3	7.7	7.3	7.3	7.3	7.2
Pennant II	7.7	7.7	7.0	6.7	8.0	7.0	7.3	7.3	7.2
Seville II	7.3	8.0	6.3	6.7	8.0	7.7	7.3	7.3	7.2
SR 4420 (SRX 4820)	8.0	8.0	7.0	7.3	7.7	7.3	7.0	7.0	7.2
APR 1232	7.7	8.0	6.0	6.0	7.3	7.0	8.0	8.0	7.1
Gator 3 (CIS-PR-85)	8.0	8.0	7.0	6.7	7.7	6.7	7.3	7.3	7.1
Pinnacle II (Bar 9 B2)	7.3	8.0	6.3	7.0	7.7	7.3	7.0	7.0	7.1
Racer	7.0	8.0	7.0	6.3	7.7	6.7	7.3	7.3	7.1
SR 4220 (SRX 4801)	8.0	8.0	6.3	6.3	7.3	7.3	7.7	7.7	7.1
ABT-99-4.339	7.7	8.0	7.0	6.3	7.3	6.7	7.3	7.3	7.0
Charismatic (LTP 98-501)	8.0	8.0	7.0	6.3	7.3	6.7	7.3	7.3	7.0
Edge	7.0	7.5	7.0	6.0	7.0	6.5	7.5	7.5	7.0
Grand Slam 2L96 (PST-2L96)	8.0	8.0	7.0	7.0	7.7	6.7	7.0	7.0	7.0
Headstart	6.3	8.0	6.0	7.0	7.0	7.3	7.3	7.3	7.0
LPR 98-143	8.0	8.0	6.7	6.7	7.3	6.7	7.3	7.3	7.0
Palmer III	7.7	7.7	6.7	6.7	7.0	8.0	8.0	8.0	7.0
Panther	8.0	8.0	7.0	6.0	7.7	6.0	7.7	7.7	7.0
Pentium (NJ-6401)	7.7	8.0	7.0	7.3	7.0	7.3	6.7	6.7	7.0
Pick Prngs	7.0	7.7	6.7	7.0	6.7	7.0	7.3	7.3	7.0
Pizzazz	7.3	8.0	7.0	7.0	7.3	7.3	6.7	6.7	7.0
PST-2M4	7.3	8.0	6.7	6.0	7.7	6.3	7.7	7.7	7.0
PST-2SBE	8.0	8.0	6.7	6.7	7.0	7.0	7.3	7.3	7.0
Terradyne (A5C)	7.7	8.0	6.7	6.3	7.7	6.7	7.3	7.3	7.0
Brightstar II	7.7	8.0	6.3	7.0	7.0	6.7	7.3	7.3	6.9
Cabo (CIS-PR-80)	8.0	7.3	6.7	6.7	7.3	7.0	7.0	7.0	6.9
Calypso II	7.3	7.7	7.0	6.7	7.3	5.7	7.3	7.3	6.9
Dazzle (ABT-99-4.724)	7.5	8.0	7.0	5.5	7.0	7.0	7.5	7.5	6.9
Elfkin	7.3	8.0	6.7	7.0	6.7	6.7	7.3	7.3	6.9
Gallery (MB412)	7.7	8.0	7.0	6.7	6.7	7.3	7.0	7.0	6.9
Hawkeye (SRX 4RHT)	7.7	7.7	6.7	6.7	7.5	7.5	8.0	8.0	6.9
Pacesetter (6011)	7.7	8.0	6.7	6.0	7.0	6.3	7.7	7.7	6.9
Paradigm (APR 1236)	7.3	8.0	7.0	5.7	7.0	6.3	7.7	7.7	6.9
Premier II	8.0	8.0	6.7	6.3	7.3	6.7	7.3	7.3	6.9
Quest II (ABT-99-4.721)	8.0	8.0	7.0	6.7	7.0	6.7	7.0	7.0	6.9
Splendid (MB 411)	7.3	8.0	6.7	7.0	7.0	7.0	7.0	7.0	6.9
SRX 4120	8.0	8.0	6.7	6.3	6.3	7.0	7.7	7.7	6.9
Superstar (EP57	7.7	7.7	6.7	6.3	7.5	7.0	8.0	8.0	6.9
Wilmington	7.7	8.0	6.0	7.3	6.7	6.7	7.3	7.3	6.9
ABT-99-4.815	7.3	8.0	7.0	6.7	6.7	6.7	7.0	7.0	6.8

			Quality**						
Name	Color	Texture	May	Jun	Jul	Aug	Sep	Oct	Mean
Affinity	6.7	8.0	6.7	6.3	7.0	6.3	7.3	7.3	6.8
Applaud (Pennington-11301)	7.7	8.0	6.7	6.3	7.3	6.7	7.0	7.0	6.8
Arrival (CIS-PR-84)	7.0	7.7	6.3	6.7	7.7	6.7	6.7	6.7	6.8
Brightstar SLT (PST-2A6B)	7.3	7.7	6.7	6.3	6.0	6.0	7.3	7.3	6.8
BY-100	7.3	8.0	6.3	6.0	7.0	7.0	7.0	7.0	6.8
Catalina II (PST-CATS)	8.0	8.0	6.3	6.0	7.0	7.0	7.3	7.3	6.8
Cathedral II	7.7	7.7	7.0	6.3	7.7	6.0	7.0	7.0	6.8
Jet	7.3	8.0	7.0	6.0	6.7	7.3	7.0	7.0	6.8
LPR 98-144	8.0	8.0	6.7	7.0	7.0	6.0	7.0	7.0	6.8
Racer II (Pick RC2)	7.7	8.0	6.7	6.3	7.3	6.7	7.0	7.0	6.8
Renaissancae (APR 1233)	7.7	8.0	6.0	6.3	7.0	7.0	7.3	7.3	6.8
SR 4350 (APR 1237)	7.0	8.0	7.0	6.0	7.0	7.3	6.7	6.7	6.8
ABT-99-4.464	7.7	8.0	6.7	6.3	7.3	6.7	6.7	6.7	6.7
APR 776	7.3	8.0	5.7	6.3	7.3	6.3	7.3	7.3	6.7
DLF-LDD	7.7	7.7	6.7	5.7	7.0	8.0	8.0	8.0	6.7
DP 17-9391	7.3	8.0	6.0	6.3	7.0	7.0	7.0	7.0	6.7
Kokomo (CIS-PR-69)	8.0	8.0	6.0	6.7	7.7	6.0	7.0	7.0	6.7
Line Drive	8.0	8.0	6.7	6.0	6.3	7.5	7.5	7.5	6.7
Paragon	7.7	8.0	6.3	5.7	6.0	7.3	7.3	7.3	6.7
Protyme (ABT-99-4.625)	8.0	7.3	6.7	6.0	6.7	6.7	7.0	7.0	6.7
Summerset (MB 413)	8.0	8.0	7.0	6.3	7.0	6.7	6.7	6.7	6.7
WVPB-R-82	7.7	8.0	6.0	6.7	6.0	6.3	7.7	7.7	6.7
APR 1231	7.7	8.0	6.7	5.7	7.0	6.0	7.0	7.0	6.6
Ascend	7.7	8.0	6.7	6.3	6.7	6.3	6.7	6.7	6.6
Barlennium	7.3	8.0	6.0	5.7	6.3	7.3	7.0	7.0	6.6
Citation Fore (PST-2BR)	7.7	8.0	6.3	6.7	6.7	6.0	7.0	7.0	6.6
DP 17-9069	7.3	7.7	6.0	6.7	6.3	6.3	7.0	7.0	6.6
Exacta	7.0	8.0	6.3	6.0	6.7	6.7	7.0	7.0	6.6
Extreme (JR-317)	7.3	8.0	6.0	6.0	6.7	6.7	7.0	7.0	6.6
Majesty	7.7	8.0	6.3	6.3	6.7	6.7	6.7	6.7	6.6
Passport	7.3	7.7	6.3	6.0	6.5	7.5	7.5	7.5	6.6
Promise	8.0	8.0	7.0	6.7	6.7	6.5	6.5	6.5	6.6
PST-2JH	7.3	7.7	6.3	7.0	6.3	6.3	6.7	6.7	6.6
Salinas (PST-2SLX)	7.0	8.0	6.3	6.3	7.0	7.5	7.5	7.5	6.6
Skyhawk	7.3	8.0	6.7	7.3	6.7	6.0	6.3	6.3	6.6
Sunkissed (ABT-99-4.834)	7.3	7.7	6.7	6.0	6.7	7.0	6.7	6.7	6.6
All Star2 (CIS-PR-78)	7.0	7.7	6.3	6.7	8.0	7.0	7.0	7.0	6.5
Blazer IV (Pick MDR)	7.7	8.0	6.7	6.0	6.3	6.0	7.0	7.0	6.5
Icon (MB 414)	7.7	7.3	6.0	5.7	7.0	6.3	7.0	7.0	6.5
IQ (CIS-PR-75)	7.3	8.0	6.7	6.0	6.0	5.7	7.3	7.3	6.5
PST-2RT	7.7	8.0	6.3	5.3	6.7	6.0	7.3	7.3	6.5
Stellar (CIS-PR-72)	7.0	7.7	6.7	6.0	7.0	7.0	6.5	6.5	6.5
ABT-99-4.115	7.7	7.7	6.7	5.3	7.0	6.5	7.5	7.5	6.4
ABT-99-4.600	7.7	8.0	6.3	6.0	6.3	6.3	6.7	6.7	6.4

Name	Color*	Texture	Quality** May	Jun	Jul	Aug	Sep	Oct	Mean
ABT-99-4.965	7.0	7.7	6.7	6.0	6.5	6.5	7.0	7.0	6.4
Affirmed	7.7	7.7	6.7	6.3	6.5	6.5	7.0	7.0	6.4
APR 1234	7.0	7.3	6.0	6.3	6.7	6.7	6.7	6.7	6.4
Catalina	7.3	8.0	7.0	5.7	5.7	5.7	7.0	7.0	6.4
Divine	8.0	7.7	6.0	5.7	5.7	5.7	7.7	7.7	6.4
EPD	7.7	8.0	6.3	6.3	6.0	6.0	6.7	6.7	6.4
JR-128	7.3	7.7	6.3	6.0	7.0	6.5	7.5	7.5	6.4
LTP-ME	7.3	7.7	6.3	6.7	8.0	7.0	7.0	7.0	6.4
MACH 1 (Roberts-627)	7.7	8.0	6.0	7.0	5.3	6.7	6.7	6.7	6.4
MP103	7.7	8.0	6.3	6.3	6.0	7.0	6.3	6.3	6.4
Phantom	8.0	8.0	5.7	5.7	6.0	6.7	7.3	7.3	6.4
Pick PR 1-94	7.7	8.0	6.7	6.3	6.0	7.0	6.3	6.3	6.4
Pick PR B-97	7.7	7.7	6.3	6.7	7.5	7.0	6.5	6.5	6.4
Pick PR QH-97	8.0	8.0	6.0	6.3	6.3	6.3	6.7	6.7	6.4
Pleasure XL	7.7	7.7	6.3	5.7	7.5	7.0	7.5	7.5	6.4
Prowler (APR 777)	7.3	8.0	6.0	6.0	6.7	6.7	6.7	6.7	6.4
PST-2CRR	8.0	8.0	6.0	6.3	5.7	6.3	7.0	7.0	6.4
PST-2LA	7.3	8.0	7.0	6.7	6.0	6.3	6.3	6.3	6.4
WVPB-R-84	7.7	7.7	6.0	6.0	6.7	6.7	6.7	6.7	6.4
ABT-99-4.560	7.7	7.7	6.0	6.0	6.0	6.3	6.7	6.7	6.3
Allsport	7.7	8.0	6.3	6.7	6.3	6.0	6.3	6.3	6.3
Amazing (B1)	7.0	7.3	6.0	6.3	7.0	7.0	6.5	6.5	6.3
CAS-LP84	7.0	8.0	6.3	5.7	6.7	7.3	6.0	6.0	6.3
MP107	7.7	8.0	6.3	6.3	6.5	6.5	7.0	7.0	6.3
Radiant	7.3	8.0	7.0	5.7	6.5	6.5	6.5	6.5	6.3
APR 1235	7.3	8.0	6.0	5.7	6.0	6.0	6.7	6.7	6.2
Buccaneer	7.0	7.3	6.0	6.0	6.7	6.0	6.3	6.3	6.2
DP LP-1	7.3	7.0	5.7	5.0	6.7	6.7	6.7	6.7	6.2
EP53	7.7	7.7	6.0	6.7	5.3	5.3	7.0	7.0	6.2
Manhattan 4 (PST-2CRL)	7.7	7.7	6.3	5.3	7.0	7.0	7.0	7.0	6.2
MDP	8.0	8.0	6.3	6.3	5.7	5.7	6.5	6.5	6.2
Nexus	7.7	7.7	6.3	6.0	7.0	7.0	7.0	7.0	6.2
Premier	7.7	7.3	5.7	5.7	6.0	6.0	7.5	7.5	6.2
Secretariat	7.3	8.0	6.3	5.3	6.5	6.5	7.0	7.0	6.2
SR 4500	7.3	7.7	6.3	6.3	6.5	6.5	7.0	7.0	6.2
Cruiser (ABT-99-4.709)	7.3	8.0	6.0	5.7	6.3	5.7	6.3	6.3	6.1
Fiesta 3	7.3	7.0	6.3	5.7	6.0	5.3	6.7	6.7	6.1
Koos R-71	7.7	7.7	5.7	5.7	6.0	7.0	6.5	6.5	6.1
Mepy	7.3	8.0	6.0	6.0	6.3	5.3	6.3	6.3	6.1
MP88	7.7	8.0	5.7	6.0	5.7	5.7	6.7	6.7	6.1
Pick EX2	7.0	8.0	6.3	5.7	6.3	5.7	6.3	6.3	6.1
Prosport (AG-P981)	7.0	7.7	5.7	6.3	7.0	6.0	7.0	7.0	6.1
Yatsugreen	7.0	7.3	5.7	5.3	7.0	7.5	7.0	7.0	6.1
Monterey II (JR-187)	7.7	8.0	5.7	5.0	6.3	6.3	6.3	6.3	6.0

Name	Color*	Texture	Quality						
			May	Jun	Jul	Aug	Sep	Oct	Mean
DP 17-9496	7.0	6.7	5.0	6.0	6.5	7.0	6.0	6.0	5.8
LINN	5.7	5.0	4.0	4.0	3.3	4.7	4.3	4.3	4.1
LSD	1.6	0.7	1.5	5.3	2.4	3.2	4.0	4.0	1.8

*Color, texture, and quality were rated 0 to 9; 9 = best. A quality rating of 6 was considered acceptable for a golf course fairway.

**To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

TITLE: Kentucky Bluegrass NTEP Cultivar Trial

OBJECTIVE: To evaluate Kentucky bluegrass cultivars under Kansas weather conditions and submit data collected to the National Turfgrass Evaluation Program

PERSONNEL: Linda R. Parsons and Jack D. Fry

SPONSOR: USDA National Turfgrass Evaluation Program

INTRODUCTION:

Kentucky bluegrass is one of several cool-season turfgrasses suitable for use in Kansas lawns. Its dark to mid blue-green color and relatively fine texture enhance its desirability, and its rhizomatous nature contributes to its drought tolerance, allowing it to withstand low maintenance conditions. Even though, without care, it may go dormant and turn brown in hot, dry periods, it recovers well from injury and can be considered a water-saving grass. Under evaluation are bluegrass cultivars suitable for home lawns, golf course roughs, etc., that tolerate low maintenance conditions and yet retain a dark leaf color, fine texture, disease resistance, and good sward density.

MATERIALS AND METHODS:

On October 2, 2000, 528 study plots (5 x 5 feet in a 220- x 60-foot grid) were seeded at the John C. Pair Horticultural Center in Haysville, Kan., with 173 Kentucky bluegrass cultivars and experimental numbers in a randomized complete block design. Seeding rate was 2.0 lb. seed/1000 sq.ft. Before seeding, 13-13-13 NPK was incorporated into the study plots at a rate of 1.0 lb./1000 sq.ft. Plots were fertilized twice in 2003 at 1.0 lb. N/1000 sq.ft. Plots were mowed weekly during the growing season at 2.0 to 2.5 inches and clippings returned. Irrigation was done as necessary to prevent dormancy, and controls for weeds, insects, and diseases applied only when a threat to the trial was presented. Turfgrass performance was rated on a scale of 0 = poorest, 6 = acceptable, and 9 = optimum measure.

RESULTS:

The 2003 growing season began with an evaluation of spring green-up. By April 22 the cultivars/experimental numbers A96-427, A98-139, Brooklawn, R 2284 (SRX 2284), and SRX QG245 were the greenest (Table 1). Turf quality was rated monthly throughout the growing season. Quality ratings were influenced by degree of coverage and weed infestation as well as turf color, texture, and density. The best overall performers were Moon Shadow (Pick 113-3), Langara, an unknown entry, Sonoma, NU Destiny (J-2695), and SR 2284 (SRX 2284). At summer's end, turf color and texture were evaluated, with A97-1409, Ba 84-140, Bluemax (PST-B5-89), IB7-308, and Moonlight darkest green and A97-857, GO-9LM9, Kenblue, and Washington with the finest texture.

Table 1. 2003 performance of Kentucky bluegrass cultivars at Haysville, Kan.[1]

Cultivar/	Spring	Genetic		Quality							
Experimental Number	Green-up	Color	Texture	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Moon Shadow (Pick 113-3)*[2]	7.0	7.7	6.5	6.3	5.7	5.3	6.0	5.0	6.3	6.7	5.9
Langara*	6.3	7.0	6.7	5.3	6.3	5.7	6.0	5.7	5.7	6.3	5.9
Unknown	6.0	7.7	7.0	5.3	6.3	6.3	5.7	5.7	6.0	5.7	5.9
Sonoma*	6.3	6.3	6.7	6.0	5.7	5.7	6.3	5.3	5.3	6.0	5.8
NU Destiny (J-2695)*	6.0	7.3	7.0	5.7	6.3	5.7	5.3	4.7	6.0	6.3	5.7
SR 2284 (SRX 2284)*	7.3	7.0	6.7	6.0	5.7	5.3	5.7	6.0	6.0	5.3	5.7
Pick 417	6.7	7.3	6.3	6.0	6.3	5.7	5.3	5.0	5.7	5.3	5.6
B5-144	6.3	5.0	5.3	5.7	5.7	5.7	6.0	5.0	5.3	5.7	5.6
Freedom II*	6.3	7.3	6.7	5.3	6.3	5.3	5.3	5.3	5.3	5.7	5.5
Misty*	6.0	5.7	5.0	4.7	6.0	5.7	6.3	5.0	5.3	5.7	5.5
Award*	6.0	7.3	6.5	4.7	6.0	5.3	5.7	5.3	6.0	5.7	5.5
DLF 76-9037	6.3	6.0	7.0	6.3	6.0	5.3	5.3	5.0	5.3	5.3	5.5
Liberator*	6.3	6.7	7.0	4.7	6.0	5.7	5.7	5.3	6.0	5.3	5.5
Awesome (J-1420)*	6.0	7.3	7.0	5.3	5.7	5.7	5.7	5.3	5.7	5.0	5.5
Champagne*	6.3	5.7	7.0	6.0	5.3	5.7	5.7	5.0	5.7	5.0	5.5
Glenmont (H94-293)*	6.3	6.3	7.0	5.3	6.7	5.7	5.7	5.3	5.0	4.7	5.5
A96-451	6.3	7.7	6.0	5.0	6.3	5.3	5.7	5.3	5.3	5.0	5.4
Excursion (J-1648)*	6.0	7.3	7.0	5.7	5.7	5.3	5.3	4.7	5.7	5.7	5.4
Barrister (J-1665)*	5.7	7.7	7.0	5.7	6.3	5.0	5.0	4.3	5.3	6.0	5.4
Bordeaux*	6.0	8.0	6.5	5.7	5.3	5.3	5.7	5.3	5.3	5.0	5.4
Pro Seeds - 453	6.7	6.7	6.3	5.7	5.7	5.3	5.3	4.7	5.7	5.3	5.4
A97-1409	6.0	8.7	6.0	5.0	5.3	6.0	5.3	5.0	5.0	5.7	5.3
Baronette (Ba 81-058)*	6.7	7.3	6.7	6.0	5.3	5.3	5.0	5.0	5.0	5.7	5.3
Everglade*	5.7	7.7	6.7	5.3	6.3	5.3	5.0	4.0	5.7	5.7	5.3
Jewel*	6.7	5.7	7.3	6.0	5.7	5.3	5.3	4.7	5.3	5.0	5.3
Royce (A98-304)*	6.3	6.0	7.0	5.0	5.3	5.7	5.3	5.7	5.7	4.7	5.3
Baritone*	6.7	6.0	7.0	6.0	5.7	5.0	5.0	5.0	5.0	5.3	5.3
H92-203	6.7	5.7	6.7	6.0	5.3	5.0	5.7	5.0	4.7	5.3	5.3
Royale (A97-1336)*	6.7	6.3	6.7	5.0	5.7	5.0	5.7	5.0	5.3	5.0	5.2
Serene*	6.3	6.0	7.0	5.0	5.3	5.3	5.7	5.3	5.0	5.0	5.2
Bedazzled*	6.0	6.3	5.7	4.7	5.7	5.3	5.7	4.7	5.0	5.3	5.2
A98-139	7.3	6.7	7.0	6.0	4.7	5.3	5.0	5.3	5.3	4.7	5.2
J-1513	6.0	7.3	7.0	5.7	5.7	5.3	4.7	4.3	5.7	5.0	5.2
A97-1715	6.7	6.3	7.3	5.7	6.0	5.3	4.7	4.3	5.3	4.7	5.1
Bluestone (PST-731)*	6.0	8.0	7.0	5.3	5.7	5.3	4.7	4.3	5.7	5.0	5.1

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Lily*	6.7	5.7	5.5	5.0	5.0	5.3	5.3	5.3	5.0	5.0	5.1
Chateau*	6.0	5.7	6.0	4.3	5.3	5.7	5.7	5.3	4.7	5.0	5.1
Shamrock*	6.3	6.7	7.0	5.7	5.0	5.3	5.3	4.7	4.7	5.3	5.1
BAR Pp 0566	6.7	8.0	6.3	5.7	5.7	5.3	5.0	4.3	5.0	4.7	5.1
Blacksburg II (PST-1BMY)*	6.3	8.3	6.5	4.7	5.3	5.3	5.3	5.0	5.0	5.0	5.1
DLF 76-9032	6.3	5.0	8.0	5.7	5.7	5.0	5.0	4.3	5.3	4.7	5.1
Fairfax*	6.7	5.7	5.3	5.3	5.3	5.0	5.7	4.7	5.0	4.7	5.1
Goldstar (A98-296)*	6.3	7.3	6.3	5.3	5.7	5.0	5.3	4.7	5.0	4.7	5.1
A98-407	7.0	7.0	6.0	4.7	5.3	5.0	5.0	5.0	5.3	5.0	5.0
BAR Pp 0468	6.0	6.3	7.0	4.7	5.3	5.3	5.7	5.0	5.0	4.3	5.0
Limousine*	7.0	5.0	6.7	5.3	4.7	4.7	5.7	5.0	5.0	5.0	5.0
Odyssey*	5.7	7.7	7.0	4.3	6.0	5.3	5.0	4.3	5.0	5.3	5.0
PST-B4-246	6.3	7.0	7.0	5.0	5.3	5.0	5.7	5.0	4.7	4.7	5.0
Rugby II*	6.0	7.7	6.5	4.7	5.3	5.0	5.3	4.7	5.3	5.0	5.0
B5-45	7.0	5.7	6.3	5.0	5.0	5.0	5.3	4.7	5.0	5.0	5.0
BH 00-6002	6.7	5.7	6.0	5.7	5.0	5.0	5.0	4.7	5.0	4.7	5.0
Monte Carlo (A96-402)*	6.3	7.3	6.3	4.7	5.7	5.3	5.7	4.7	4.7	4.3	5.0
Eagleton*	6.3	4.7	6.5	5.7	5.0	5.0	4.7	5.0	4.7	4.7	5.0
Impact*	5.7	7.3	6.5	4.7	5.3	5.3	5.0	4.7	5.3	4.3	5.0
Voyager II (PST-1QG-27)*	6.0	6.0	7.0	4.7	5.3	5.0	5.3	5.0	5.0	4.3	5.0
Champlain (A98-1275)*	6.0	6.7	6.7	4.3	5.7	5.3	5.0	4.7	5.0	4.7	5.0
Coventry*	7.0	5.7	6.0	5.3	5.0	5.0	4.7	5.0	5.0	4.7	5.0
A96-427	7.3	6.7	6.5	5.3	5.0	5.3	4.7	4.7	4.7	4.7	4.9
A98-881	6.3	6.3	6.7	5.3	5.0	4.7	4.7	4.7	5.0	5.0	4.9
Abbey*	6.7	6.3	6.0	4.7	5.0	4.7	5.3	5.3	5.0	4.3	4.9
Ascot*	6.3	7.7	6.7	5.3	5.3	5.0	5.0	4.3	4.7	4.7	4.9
A98-1028	6.3	6.0	7.3	4.7	5.0	4.7	5.0	5.0	5.0	4.7	4.9
Mallard (A97-1439)*	6.7	8.0	6.0	3.7	5.0	5.0	5.3	4.7	5.3	5.0	4.9
Princeton 105*	5.7	6.7	7.0	4.0	5.0	5.0	5.0	5.3	5.0	4.7	4.9
Rambo*	6.0	6.0	7.0	5.0	5.3	5.0	4.7	4.7	4.7	4.7	4.9
Allure*	7.0	6.0	6.0	4.7	4.3	4.7	5.3	5.0	4.7	5.0	4.8
Ba 82-288	6.0	7.3	7.0	4.7	5.0	5.0	5.0	4.7	4.7	4.7	4.8
Blue Knight*	6.0	8.3	7.0	4.7	5.3	5.0	5.0	4.7	4.7	4.3	4.8
BAR Pp 0573	6.3	6.7	6.7	5.0	5.0	4.7	4.7	4.3	4.3	5.3	4.8
Baron*	6.0	6.0	6.3	4.7	5.3	5.0	4.7	4.7	4.7	4.3	4.8
Boutique*	7.0	7.7	6.0	5.0	5.3	4.7	4.3	4.7	4.3	5.0	4.8
J-2885	6.0	7.0	7.0	5.0	5.0	5.3	4.3	4.3	5.0	4.3	4.8

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
PST-108-79	6.3	5.3	7.7	4.7	5.0	5.0	5.0	4.7	4.3	4.7	4.8
PST-H5-35	6.3	7.0	6.3	4.3	5.7	5.0	4.7	4.7	4.7	4.3	4.8
A97-1330	6.0	6.0	7.0	4.7	5.3	5.0	4.7	4.7	4.3	4.3	4.7
A98-183	6.7	7.3	6.0	4.7	4.7	5.0	4.7	5.0	4.7	4.3	4.7
B3-171	6.0	6.7	6.7	4.7	5.0	4.7	5.3	4.3	4.7	4.3	4.7
Bluemax (PST-B5-89)*	6.3	8.7	5.7	4.0	5.0	4.7	5.0	5.0	4.7	4.7	4.7
Marquis*	6.3	6.3	5.5	5.0	4.3	4.7	4.7	4.7	5.0	4.7	4.7
SRX 27921	6.3	6.7	7.0	5.0	4.7	5.0	4.7	4.0	5.0	4.7	4.7
Alpine*	6.0	6.3	7.7	5.0	4.7	4.3	4.7	4.3	5.0	4.7	4.7
B5-43	6.7	6.0	5.5	5.0	5.3	5.0	4.3	4.0	4.3	4.7	4.7
PST-161	6.3	6.0	6.5	4.3	4.7	5.0	4.7	4.0	5.0	5.0	4.7
SRX 2394	6.7	6.3	7.3	5.0	4.7	4.7	5.0	4.3	4.7	4.3	4.7
Julius*	7.0	5.3	7.5	5.3	5.0	4.7	4.7	4.3	4.3	4.0	4.6
Lakeshore (A93-200)*	6.7	5.3	7.0	5.7	4.0	4.3	4.7	4.7	4.3	4.7	4.6
A97-857	5.7	4.7	9.0	5.0	4.7	4.7	4.7	4.0	4.7	4.3	4.6
BAR Pp 0471	6.3	5.7	7.0	4.3	4.7	4.3	5.0	5.0	4.7	4.0	4.6
Brooklawn*	7.3	6.3	6.5	5.0	5.0	5.3	4.3	4.3	4.0	4.0	4.6
Chicago II*	6.3	8.3	6.0	5.0	5.3	4.3	4.3	3.7	5.0	4.3	4.6
Midnight*	6.0	7.0	7.0	4.7	4.7	5.0	4.3	3.7	4.7	5.0	4.6
SRX 2114	5.7	7.7	7.0	4.7	4.7	5.0	5.0	4.3	4.3	4.0	4.6
SRX 26351	6.7	6.3	7.7	5.0	4.7	4.7	4.7	4.3	4.7	4.0	4.6
PST-222	6.0	8.0	5.0	3.7	5.7	5.0	5.0	4.3	4.0	4.3	4.6
A96-742	6.3	5.3	7.5	5.3	4.3	4.3	4.3	4.0	4.7	4.7	4.5
Unique*	6.3	6.3	7.0	4.0	4.3	4.7	5.0	4.7	4.7	4.3	4.5
Everest*	6.0	8.0	6.7	4.0	5.3	4.7	4.7	4.0	4.7	4.0	4.5
Pp H 6366	6.0	5.7	7.5	4.7	4.7	5.0	4.7	4.3	4.3	3.7	4.5
Washington*	6.7	5.3	8.7	5.3	4.3	4.3	4.3	4.3	4.3	4.3	4.5
A98-365	4.0	7.3	6.0	3.7	5.0	4.3	4.7	4.7	4.3	4.7	4.5
Cabernet*	6.7	6.0	7.0	4.3	4.7	5.0	5.0	4.3	4.3	3.7	4.5
B4-128A	6.0	6.3	7.7	4.7	4.7	4.7	4.0	4.0	4.7	4.7	4.5
Limerick*	6.0	4.7	8.0	4.7	4.7	5.0	4.3	4.3	4.0	4.3	4.5
DLF 76-9036	6.0	6.3	5.5	4.3	4.7	4.7	4.3	4.3	4.7	4.0	4.4
PST-B3-170	6.3	7.7	6.5	4.7	5.0	5.0	4.3	4.0	3.7	4.0	4.4
Pp H 6370	6.0	6.0	8.0	4.7	4.3	4.3	4.3	4.7	4.3	4.0	4.4
Pp H 7832	6.7	6.7	7.0	5.0	5.0	4.7	4.3	4.0	4.3	3.3	4.4
SI A96-386	6.0	6.7	6.0	5.3	4.3	4.3	4.3	4.0	4.3	4.0	4.4

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Ba 00-6001	7.0	7.0	7.0	4.7	4.3	4.3	4.3	4.0	4.3	4.3	4.3
PST-B5-125	6.3	7.3	7.5	5.0	4.7	4.7	4.3	4.0	4.0	3.7	4.3
PST-York Harbor 4	6.3	7.0	6.5	4.3	4.7	5.3	4.7	3.7	4.3	3.3	4.3
Perfection (J-1515)*	6.3	7.3	7.0	4.3	4.7	4.3	4.0	3.7	4.7	4.7	4.3
Quantum Leap*	6.3	8.0	6.5	4.3	5.0	4.0	4.0	4.0	4.7	4.3	4.3
Rita*	7.0	7.3	.	4.7	4.7	4.3	4.0	4.0	4.3	4.3	4.3
99AN-53	6.3	6.7	6.3	5.0	4.3	4.3	4.3	4.0	4.0	4.0	4.3
AVALANCHE (PST-1701)*	6.7	6.0	8.0	5.0	4.0	4.0	4.0	4.0	4.7	4.3	4.3
SRX QG245	7.3	6.3	7.0	4.3	4.0	4.7	4.3	4.3	4.3	4.0	4.3
Wellington*	7.0	4.3	8.0	5.0	4.0	4.0	4.0	4.3	4.3	4.3	4.3
Wildwood*	6.0	7.3	7.5	4.3	4.7	4.3	4.3	4.3	3.7	4.3	4.3
Blackstone*	6.7	7.7	.	4.7	4.3	4.0	4.3	4.3	4.0	4.0	4.2
Apollo*	6.0	6.0	7.0	4.0	4.3	4.3	4.3	4.3	4.0	4.0	4.2
DLF 76-9034	6.7	5.3	6.3	4.7	4.3	4.3	3.7	3.7	4.3	4.3	4.2
Jefferson*	6.3	5.7	7.0	4.3	4.0	4.3	4.3	4.0	4.3	4.0	4.2
CVB-20631	6.0	6.3	7.0	4.3	4.0	4.0	4.3	4.7	4.0	4.0	4.2
A97-1432	6.3	7.0	6.5	4.3	4.3	4.3	4.3	4.0	3.7	4.0	4.1
Baronie*	6.3	6.3	7.0	4.7	4.0	4.0	4.0	3.7	4.0	4.3	4.1
Midnight II (A98-739)*	6.3	7.3	7.0	3.7	4.7	4.3	4.3	4.0	4.0	3.7	4.1
Hallmark*	6.3	7.0	8.0	4.0	4.7	4.3	4.3	4.0	3.3	3.7	4.0
Julia*	6.3	6.3	7.0	4.3	4.0	4.3	3.7	4.0	4.3	3.7	4.0
NuGlade*	6.3	7.0	7.0	4.0	5.0	4.3	3.7	3.3	4.3	3.7	4.0
PST-H6-150	6.0	6.0	7.0	4.0	4.3	3.7	4.0	4.0	4.0	4.3	4.0
Bartitia*	6.0	6.0	.	4.7	4.3	4.0	4.0	3.7	3.7	3.7	4.0
Bodacious*	6.3	7.0	6.7	4.7	4.3	4.3	4.0	3.7	3.7	3.3	4.0
Chelsea*	6.3	5.7	8.0	5.0	4.0	4.3	4.0	3.7	3.7	3.3	4.0
Kenblue*	6.0	4.0	9.0	4.7	3.7	4.0	4.0	4.0	3.7	4.0	4.0
North Star*	5.7	6.0	7.0	3.7	4.7	4.3	4.0	4.0	3.7	3.7	4.0
Brilliant*	6.3	6.7	7.0	3.0	4.7	4.0	4.3	3.7	4.0	4.0	4.0
PST-604	6.3	8.0	6.0	4.7	4.3	4.0	3.3	3.7	4.0	3.7	4.0
Pick 453	6.3	6.3	7.0	4.3	4.3	4.0	4.0	3.3	4.0	3.7	4.0
Showcase*	6.7	6.5	7.0	4.0	4.7	4.3	3.7	3.7	3.7	3.7	4.0
Tsunami (J-2487)*	6.3	8.0	7.0	4.3	4.0	4.3	3.3	3.3	4.0	4.0	3.9
GO-9LM9	7.0	5.0	9.0	4.7	3.7	4.0	3.7	4.0	3.7	3.7	3.9
Total Eclipse*	6.0	6.5	.	3.7	4.0	3.7	4.0	4.0	4.0	4.0	3.9
BH 00-6003	4.3	8.3	6.0	4.0	4.0	3.7	3.7	4.0	4.0	3.7	3.9

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Pp H 7097	6.3	6.7	7.0	4.0	4.0	3.7	4.0	4.0	4.0	3.3	3.9
HV 140	6.0	5.7	7.0	4.0	4.3	3.7	3.3	4.0	4.0	3.7	3.9
Pp H 7929	6.3	6.7	6.7	4.3	4.3	3.7	4.0	3.7	3.7	3.3	3.9
J-2890	6.0	7.3	6.5	4.0	4.7	3.7	3.7	3.0	3.7	4.0	3.8
A96-739	6.0	7.7	6.0	4.3	4.0	4.0	4.0	3.3	3.3	3.3	3.8
Ba 84-140	6.7	8.7	6.0	3.7	4.3	4.0	3.7	3.7	3.7	3.3	3.8
Goldrush*	6.3	5.7	6.0	3.3	4.7	3.7	3.7	3.7	3.7	3.7	3.8
HV 238	6.7	6.0	.	3.7	4.3	4.0	3.7	3.3	3.3	3.7	3.7
IB7-308	6.3	8.7	6.0	3.7	4.0	3.7	4.0	3.7	3.3	3.3	3.7
PST-1804	6.7	5.5	7.0	4.7	3.7	3.7	3.7	3.3	3.3	3.3	3.7
Raven*	6.3	6.0	6.0	4.0	3.7	3.7	4.0	4.0	3.3	3.0	3.7
Envicta*	6.3	6.7	5.5	3.7	4.0	3.7	3.7	3.7	3.3	3.3	3.6
Blue Ridge (A97-1449)*	7.0	8.3	.	3.7	3.7	3.7	3.7	3.3	3.3	3.3	3.5
Bariris*	6.0	7.0	7.0	3.7	3.7	3.7	3.3	3.3	3.7	3.3	3.5
Barzan*	6.3	5.7	.	4.0	4.0	3.7	3.0	3.3	3.3	3.3	3.5
B3-185	6.3	6.0	7.0	3.7	3.0	3.7	3.7	3.7	3.3	3.0	3.4
Arrow (A97-1567)*	6.3	7.5	6.0	3.3	4.0	4.0	3.0	3.3	2.7	3.3	3.4
Ba 83-113	6.3	7.0	6.5	3.7	3.7	3.7	3.3	3.0	3.0	3.0	3.3
J-1838	6.3	8.0	6.0	3.7	3.7	3.3	3.0	3.3	3.3	3.0	3.3
Ginney (J-1368)*	6.0	7.5	7.0	3.3	3.7	3.7	3.0	2.7	3.3	3.3	3.3
Moonlight*	6.7	8.7	6.0	3.0	4.0	3.0	3.0	3.0	3.0	3.0	3.1
Beyond (J-1880)*	6.0	7.7	7.0	3.0	3.3	3.0	3.0	2.7	3.3	3.3	3.1
H92-558	6.0	7.0	7.0	2.7	3.3	3.0	2.7	3.3	3.0	3.0	3.0
Boomerang*	6.0	8.3	7.0	3.0	3.3	2.7	2.7	2.7	3.0	2.7	2.9
J-2561	6.0	7.5	7.0	3.0	3.0	3.0	3.0	2.3	3.0	2.7	2.9
Blue Sapphire (NA-K991)*	6.3	8.0	7.0	3.0	3.3	3.0	2.7	2.7	2.3	2.3	2.8
Mercury (Pick-232)*	7.0	7.5	7.0	3.3	3.3	3.3	2.7	2.3	2.0	2.3	2.8
Arcadia*	6.0	7.0	.	2.3	2.7	2.7	2.0	2.0	2.0	2.3	2.3
NA-K992	6.0	8.5	8.0	2.3	3.0	2.3	1.7	2.3	1.7	1.7	2.1
LSD[3]	*1.7*	*1.0*	*1.0*	*4.0*	*3.8*	*3.9*	*3.4*	*4.4*	*5.2*	*3.8*	*3.8*

[1]Ratings based on a scale of 0-9 with 9 = best measure.
[2]Cultivars marked with "*" will be commercially available in 2004.
[3]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

TITLE: Zoysiagrass NTEP Evaluation

OBJECTIVES: Evaluate performance of standard and experimental zoysiagrass selections

PERSONNEL: Jack Fry

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION:

Meyer has long been the standard zoysiagrass cultivar for use in the transition zone. There is interest in identifying vegetative and seeded selections that have finer texture and a more aggressive growth habit than Meyer, while retaining freezing tolerance.

METHODS:

Seeded and vegetative zoysiagrass selections were planted on June 27, 2002. Turf was maintained at golf course fairway height, and received 1 lb. N/1,000 sq.ft. in June and July. Irrigation was applied to prevent drought stress. Data were collected on spring coverage, genetic color, leaf texture, and quality. All ratings except coverage were done visually on a 0 to 9 scale, 9 = best. A quality rating of 7 was considered acceptable for a golf course fairway. Spring coverage was rated on a 0 to 100% scale.

RESULTS:

Spring Coverage

Selections that exhibited more than 90% coverage after one full growing season were BMZ 230, DALZ 0102, Zenith, Companion, J-37, and PZB 33.

Color

Selections in the highest rated group were DALZ 0101, PZA 32, PZB 33, Companion, Zorro, Emerald, Meyer, and GN-Z.

Leaf texture

Finest textured selections were DALZ 0101, Zorro, and Emerald. Coarsest selections were Chinese Common, BMZ 230, and Companion.

Quality

Quality ratings varied from month to month. Highest mean quality occurred with Zorro, DALZ 0102, Emerald, BMZ 230, DALZ 0101, and Zenith.

The 2002-2003 winter was not severe, and selections were not exposed to temperatures that might result in injury. Freeze injury will be evaluated in coming years when proper conditions exist.

Table 1. Mean turfgrass quality and other ratings of zoysiagrass cultivars in the 2002 National Zoysiagrass Test at Manhattan, Kan., in 2003.

Name	Color*	Texture	Spring Cover	Quality**						Mean
				May	June	July	Aug	Sept	Oct	
Zorro	7.7	9.0	80.0	3.0	5.0	6.7	7.0	8.0	7.0	6.1
Dalz 0102	6.7	5.0	91.7	5.0	5.7	5.0	5.3	7.7	6.7	5.9
Emerald	7.7	8.7	78.3	3.3	4.3	5.3	6.0	8.0	7.0	5.7
BMZ 230	7.3	4.3	90.0	4.7	5.7	5.0	4.0	6.0	5.7	5.2
Dalz 0101	8.0	9.0	81.7	3.7	4.7	4.3	4.7	7.0	6.7	5.2
Zenith	7.0	5.3	93.3	5.7	6.0	4.3	3.3	5.3	5.3	5.0
6186	7.3	6.0	40.0	2.3	4.0	4.3	4.7	6.7	6.0	4.7
Companion	7.7	4.7	95.0	5.3	5.7	5.0	3.0	4.7	4.7	4.7
PZA 32	8.0	5.0	88.3	4.7	5.7	5.0	3.3	5.0	4.7	4.7
PZB 33	7.7	5.7	95.0	5.0	5.7	4.3	3.0	5.0	5.0	4.7
Dalz 0104	7.0	7.3	38.3	2.0	3.5	5.3	5.0	6.7	5.0	4.6
Chinese Common	7.0	4.3	85.0	4.3	5.3	4.3	3.7	5.0	4.3	4.5
J-37	7.0	5.0	95.0	5.3	6.0	4.0	2.7	4.7	4.3	4.5
PST-R7MA	7.0	6.0	86.7	4.0	5.0	5.3	4.0	4.7	4.0	4.5
Dalz 0105	6.3	7.7	28.3	2.3	2.7	5.0	4.3	5.7	5.0	4.1
Himeno	7.3	5.0	76.7	3.3	4.7	4.3	3.3	5.0	4.0	4.1
Meyer	7.7	6.3	80.0	4.0	4.7	5.0	2.7	4.3	3.7	4.1
GN-Z	7.7	6.0	50.0	2.0	3.3	4.0	4.3	5.3	4.3	3.9
Dalz 9604	7.0	6.7	23.3	3.0	2.0	3.7	4.0	5.0	5.0	3.8
PST-R7ZM	7.3	6.7	61.7	3.0	3.7	4.7	3.0	4.0	4.0	3.7
Entry 21	7.0	5.0	15.0	3.0	2.3	3.3	2.3	3.7	3.3	2.9
LSD**	1.2	1.0	26.6	1.7	1.4	2.0	1.4	1.9	1.6	1.3

*All ratings except spring cover were done visually on a 0 to 9 scale; 9 = best.
**To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

TITLE: Buffalograss NTEP Cultivar Trial

OBJECTIVE: To evaluate buffalograss cultivars for use in Kansas

PERSONNEL: Steve Keeley

INTRODUCTION:

Buffalograss (Buchloe dactyloides) is a warm-season grass that is native to the Great Plains. It is considered the lowest-maintenance turfgrass for use in Kansas. After establishment, it can be grown without supplemental irrigation. Fertilizer requirements are also minimal – 1 lb. N/1000 sq.ft. per year is adequate. However, better turf quality can be obtained with occasional irrigation during very dry periods. An additional pound of nitrogen per 1000 sq.ft. will darken color and improve density.

MATERIALS AND METHODS:

Ten buffalograss cultivars were planted in July 2002 at the Rocky Ford Turfgrass Research Field in Manhattan, Kan. The trial was mowed at 2.5 inches and was fertilized with 2 lb. N/1000 sq.ft. per year. The turf was irrigated to prevent dormancy. No fungicides or insecticides were applied.

Turf quality was rated monthly from April to October on a visual scale of 0 to 9, where 0 = dead turf and 9 = optimum color, density, and uniformity. The cultivars were also rated for genetic color, spring green-up, leaf texture, establishment rate, fall color and dormant color.

RESULTS:

The 2003 growing season was the first full year after this trial was established. Therefore, the data reported here should be considered preliminary. Data are shown in Table 1.

Table 1. Quality, genetic color, spring green-up, leaf texture, fall color, dormant color, and percent establishment for buffalograss cultivars grown in Manhattan, Kan., in 2003.

Cultivar	Mean Quality[1]	Genetic Color[2]	Spring Green-up[3]	Leaf Texture[4]	Fall Color[5]	Dormant Color[6]	% Establish-ment: Aug. 2002	% Establish-ment: Sept. 2002	% Establish-ment: Oct. 2002
SWI-2000	6.4	5.7	6.3	8.0	4.0	5.3	48.3	81.7	94.7
Legacy	5.8	7.0	7.3	8.3	3.0	5.0	40.0	85.0	80.0
Bowie	5.3	5.3	6.0	8.0	3.3	6.0	21.7	58.3	66.7
Texoka	5.2	5.7	5.7	8.0	4.3	5.0	8.3	61.7	60.0
Density	5.1	4.0	4.7	8.0	6.0	8.0	83.3	94.7	92.7
378	5.0	6.3	7.3	8.0	2.0	5.3	26.7	60.0	66.7
Bison	4.9	6.0	6.3	8.0	4.3	5.0	30.0	78.3	80.0
NE 95-55	4.7	6.0	6.3	8.0	2.7	5.0	15.0	60.0	50.0
Frontier Turfallo	4.4	4.7	5.3	8.0	5.7	7.0	43.3	71.7	83.3
609	3.2	5.0	5.0	8.0	5.0	6.3	16.7	60.0	53.3
LSD(0.05)	0.7	0.7	1.0	0.3	0.8	0.5	23.5	30.5	23.8
C.V. (%)	9.1	7.3	10.0	2.3	12.8	5.5	41.8	20.6	18.0

[1] 1-9 scale; 9 = Ideal turf.
[2] 1-9; 9 = Dark green.
[3] 1-9; 9 = Completely green.
[4] 1-9; 9 = Very fine.
[5] 1-9; 9 = Complete color retention (rated in early October).
[6] 1-9; 1 = brown, 9 = golden (rated in January).

TITLE: Bermudagrass NTEP Cultivar Trial

OBJECTIVE: To evaluate bermudagrass cultivars under Kansas conditions and submit data collected to the National Turfgrass Evaluation Program

PERSONNEL: Linda R. Parsons and Matt Fagerness

SPONSOR: USDA National Turfgrass Evaluation Program

INTRODUCTION:

Bermudagrass is a popular warm-season turfgrass that is heat- and drought-tolerant as well as wear-resistant. It has a wide range of uses and is especially suited for athletic field turf. Kansas represents the northernmost extremity in the central United States where bermudagrass can be successfully grown as a perennial turfgrass. Historically, few cultivars that have both acceptable quality and adequate cold tolerance have been available to local growers. New introductions of interest are continually being selected for improved hardiness and quality; seeded varieties, in particular, show the potential for improved winter survival. Both seeded and vegetative types need regular evaluation to determine their long-range suitability for use in Kansas.

MATERIALS AND METHODS:

In June 2002, three replications each of 42 bermudagrass cultivars and experimental numbers were planted in a randomized complete block design at the John C. Pair Horticultural Center in Haysville, Kan. Twenty-nine entries were seeded; thirteen vegetative entries were plugged with 12-inch spacing. Starter fertilizer was incorporated into the study plots at planting time at a rate of 1.0 lb. N/1000 sq.ft. Plot fertility is maintained at 0.5 to 0.75 lb. N/1000 sq.ft. per growing month. Plots are mowed once a week during the growing season at 0.75 to 1.0 inch. Irrigation is done as necessary to prevent dormancy, and controls for weeds, insects, and diseases applied only to prevent severe stand loss. During the course of the study, information is being collected on spring green-up, genetic color, leaf texture, seed heads, quality, and other measures when appropriate. Rating is done on a scale of 0 = poorest, 6 = acceptable, and 9 = optimum measure.

RESULTS:

At the end of the 2002 growing season, the seeded Bermudagrass varieties/experimental numbers were by far the best established. Of these, FMC-6, Sunstar, SR 9554, Panama, B-14, and NuMex Sahara had achieved better than 90% cover (Table 1). The vegetative varieties/experimental numbers developed far more slowly, with the best – Patriot, Celebration, Midlawn, and Tift No. 3 – only attaining a bit more than 70% cover.

The next spring, the 2003 growing season began with a look at green-up. By May 12 the seeded varieties Yukon, SWI-1014, and Riviera, and vegetative varieties Midlawn and Patriot were the greenest. At that time, the seeded entries SWI-1003 and Tift No. 2 showed no signs of life; and SWI-1046 and Tift No. 1, only the barest trace of green. Turf quality is rated monthly from May through September. Quality ratings were influenced by degree of coverage and weed infestation as well as turf color, texture, and density. The best overall seeded performers were Yukon, SWI-1045, SR 9554 and Sunstar; and the best vegetative, Midlawn and Patriot. As clean looking turf with no seed heads is preferred, seed head density was rated in spring, summer, and fall. At the end of May few seed heads were visible in any of the turfgrass plots. In July, the seeded varieties SWI-1045, Princess 77, and SWI-1041 and vegetative variety Tift No. 4 had the fewest seed heads; in September, the seeded variety SRX 9500 and vegetative varieties MS-Choice, Midlawn, Patriot, and Tifway, had the fewest. Toward the end of the growing season, an evaluation of turf color and texture showed that seeded entries Tift No. 2 and Yukon and vegetative entries Celebration, Patriot, GN-1, and MS-Choice were the darkest green. Seeded entry Yukon and vegetative entries Ashmore, Midlawn, OR 2002, Tifway, and Tifsport had the finest texture.

Table 1. 2002–2003 performance of bermudagrass cultivars at Haysville, Kan.[1]

Cultivar/ Experimental Number	Seeded/ Vegetative	% Established Sept. 2002	Spring Green-up	Genetic Color	Texture	Seed Heads July	Seed Heads Sept.	Quality					
								May	Jun.	Jul.	Aug.	Sep.	Avg.
Midlawn*[2]	V	71.7	6.3	6.0	7.3	8.3	8.7	6.7	6.7	6.3	6.7	5.7	6.4
Yukon*	S	75.0	6.7	7.7	6.7	7.3	7.3	6.7	5.7	6.0	5.0	5.7	5.8
SWI-1045	S	88.7	4.7	7.3	5.3	6.7	7.3	6.0	6.0	5.0	5.7	6.0	5.7
SR 9554*	S	94.3	4.0	6.7	5.3	7.7	7.7	5.7	6.0	5.0	5.3	5.0	5.4
Sunstar*	S	95.0	3.7	6.7	4.7	7.7	7.7	6.0	5.3	5.0	5.3	5.3	5.4
Patriot*	V	73.3	5.3	8.0	5.7	8.3	8.3	5.7	5.0	5.3	5.7	5.0	5.3
Panama*	S	92.0	3.3	6.0	4.7	8.0	7.7	4.7	5.7	5.0	5.3	5.3	5.2
Riviera*	S	66.7	5.0	6.0	4.7	7.7	7.3	5.0	6.0	4.3	5.0	5.3	5.1
SWI-1012	S	78.3	4.3	6.7	6.0	6.7	7.0	5.3	5.0	5.7	5.0	4.7	5.1
CIS-CD5	S	82.7	3.0	7.0	4.7	7.3	7.0	4.7	5.0	4.7	5.3	5.7	5.1
FMC-6	S	95.0	3.3	6.0	4.7	8.3	7.7	4.7	5.7	4.7	5.7	4.7	5.1
SRX 9500	S	89.3	3.7	6.3	4.3	7.7	8.3	5.0	4.7	4.7	5.0	5.0	4.9
Mohawk*	S	87.7	3.0	6.3	4.3	8.0	8.0	4.3	5.0	4.0	5.7	5.0	4.8
SWI-1014	S	60.0	6.0	6.7	4.7	6.7	7.0	5.0	4.7	4.7	5.0	4.7	4.8
Southern Star*	S	85.0	3.7	6.7	4.3	7.0	7.3	4.7	5.0	4.7	5.0	4.7	4.8
Transcontinental*	S	86.7	3.7	6.3	4.3	7.3	7.3	4.7	4.7	4.3	4.7	5.3	4.7
CIS-CD7	S	89.3	2.7	6.7	4.0	6.7	7.3	4.0	4.7	4.0	5.0	5.0	4.5
NuMex Sahara*	S	91.0	2.7	6.0	4.3	7.7	8.0	3.7	4.7	4.7	5.0	4.7	4.5
CIS-CD6	S	80.0	3.3	6.3	4.7	7.3	7.0	4.3	4.3	4.3	5.0	4.7	4.5
SWI-1001	S	90.0	2.0	6.7	5.0	7.7	7.7	3.3	5.0	4.3	5.0	5.0	4.5
Aussie Green*	V	70.0	4.3	7.3	5.7	7.0	8.0	4.7	4.3	4.7	4.3	4.0	4.4
OR 2002	V	66.7	3.0	7.0	7.3	8.0	8.0	3.7	4.3	4.7	4.7	4.7	4.4
Sundevil II*	S	85.0	3.0	6.0	4.0	7.0	7.0	4.7	4.3	3.3	4.3	4.7	4.3
PST-R68A	S	70.0	3.0	6.0	4.7	6.7	7.0	3.7	4.0	3.7	4.7	5.0	4.2
SWI-1044	S	80.0	2.0	6.3	5.7	7.0	7.3	2.7	3.7	4.3	5.0	5.3	4.2
Ashmore*	V	50.0	4.3	5.0	7.7	8.3	7.7	4.3	4.3	4.0	4.0	4.0	4.1
B-14	S	91.0	2.7	6.3	4.3	7.3	7.7	4.0	3.7	3.3	4.7	4.7	4.1
MS-Choice*	V	66.7	3.7	7.7	4.7	8.7	8.7	4.0	4.3	3.3	3.7	5.0	4.1
SWI-1041	S	89.3	1.3	6.0	5.3	6.3	8.0	2.0	3.3	4.3	5.3	5.0	4.0
Celebration*	V	71.7	3.0	8.3	5.3	6.0	7.3	3.3	3.7	4.0	4.7	4.0	3.9
Arizona Common*	S	84.3	1.3	6.7	4.3	8.0	8.0	3.0	3.7	3.3	4.3	4.7	3.8
Princess 77*	S	88.7	1.0	7.0	5.7	6.3	6.7	2.0	3.0	3.3	5.0	4.7	3.6
OKC 70-18	V	53.3	4.0	6.3	6.3	7.3	6.7	2.7	2.3	3.0	4.0	4.7	3.3
Tifsport*	V	63.3	2.3	7.3	6.7	8.0	7.3	3.0	2.7	2.7	3.7	4.0	3.2

Cultivar/ Experimental Number	Seeded/ Vegetative	% Established Sept. 2002	Spring Green-up	Genetic Color	Texture	Seed Heads July	Seed Heads Sept.	Quality					
								May	Jun.	Jul.	Aug.	Sep.	Avg.
GN-1*	V	66.7	2.0	7.7	4.3	8.3	7.7	2.7	3.0	2.7	3.7	3.3	3.1
Tifway*	V	53.3	1.0	7.3	7.0	8.0	8.3	1.7	2.3	3.0	4.0	4.3	3.1
SWI-1046	S	78.3	0.7	7.0	5.0	7.7	7.0	1.3	2.7	2.7	3.7	4.7	3.0
Tift No. 3	V	71.0	1.3	6.7	5.0	7.7	7.3	1.7	2.3	2.7	3.7	4.7	3.0
Tift No. 4	V	61.7	2.3	7.0	6.3	6.7	7.3	2.3	2.7	2.7	3.0	3.7	2.9
SWI-1003	S	80.0	0.0	6.0	3.7	6.0	6.0	0.7	2.0	2.0	3.0	3.7	2.3
Tift No. 1	S	81.7	0.7	6.7	3.3	7.7	6.0	0.7	1.3	1.3	2.7	3.3	1.9
Tift No. 2	S	81.0	0.0	7.7	4.0	7.7	6.3	0.3	1.0	1.7	2.0	2.7	1.5
LSD [3]		*11.0*	*1.5*	*0.8*	*1.2*	*1.8*	*0.8*	*1.2*	*1.3*	*1.0*	*1.0*	*1.1*	*0.8*

[1]Ratings based on a scale of 0-9 with 9 = best measure.

[2]Cultivars marked with "*" will be commercially available in 2004.

[3]To determine statistical differences among entries, subtract one entry's mean from another's. A statistical difference occurs when the value is larger than the corresponding LSD value.

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500