Kansas State University Agricultural Experiment Station
and Cooperative Extension Service

K-STATE
TURFGRASS RESEARCH

2006

Report of Progress 962

FOREWORD

Turfgrass Research 2006 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 3, 2006. The enclosed articles present summaries of research projects that have been recently completed, or will be completed in the next year or two. This year's report presents summaries of research on environmental stresses, turfgrass establishment and culture, and cultivar evaluations.

As we enter the 2006 season, we at K-State are fortunate to have been joined this year by two new outstanding faculty. Dr. Megan Kennelly is the new horticultural pathologist (based in the Plant Pathology department); she will be involved in disease diagnosis, and is also initiating a research program. Dr. Rodney St. John is the new statewide turfgrass extension specialist; he is based at the Olathe research center, and will be expanding turf research at that center. It has been some time since we were at full staffing level and, as many of you know, filling such positions is not automatic, but is based upon priority and importance determined by faculty and administrators. Your support of the Kansas Turfgrass Foundation is well recognized and has contributed to the strength of our program.

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 of our extension publications on the web at www.ksuturf.com.

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This is Contribution no. 06-337-S from the Kansas Agricultural Experiment Station, Manhattan, Kansas.

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Drought, Heat, and Freezing Resistance

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TITLE: Performance in the Transition Zone of Two Hybrid Bluegrasses Compared with Kentucky Bluegrass and Tall Fescue

OBJECTIVES: Evaluate Kentucky bluegrass (KBG), tall fescue (TF), and two cultivars of hybrid bluegrasses (HBG) for: 1) canopy establishment rates after fall seeding; 2) visual quality and growth characteristics of canopies; and 3) drought resistances under various irrigation regimes and deficits.

PERSONNEL: Dale Bremer, Kemin Su, Steven 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 turfgrass species that is commonly used in lawns and golf courses in the United States. Tall fescue (*Festuca arundinacea* Schreb.), another cool-season species, is also popular for use in lawns and is sometimes used in golf course roughs. In some areas of the United States, these grasses are subjected to frequent drought, which results in heat- and drought-stress symptoms, and irrigation is required to maintain acceptable quality. Kentucky bluegrass commonly goes dormant during periods of high temperature and drought. Tall fescue has good drought avoidance because of its relatively deep rooting system, but some turfgrass managers prefer the finer texture and recuperative capacity that KBG offers.

New HBG, which are genetic crosses between KBG and native Texas bluegrass (*Poa arachnifera* Torr.), have the appearance of KBG but may be able to withstand higher temperatures and extended drought without going dormant. In warm climates such as the southern United States, HBG may stay green all year long. Furthermore, HBG may use less water than other cool-season species do, while maintaining their green color. This is especially important, given the increasing competition for water and the rising costs of irrigation. Despite the potential for using HBG in lawns and golf courses, there are little scientific data available about its performance relative to KBG and TF under the stresses of different climates or cultural practices. In this study, two HBG were compared with KBG and TF near Manhattan, Kansas, which is in the stressful climate of the transition zone in the United States, a difficult region in which to maintain turf quality because of hot summers and cold winters.

MATERIAL AND METHODS:

Two HBG cultivars (‘Thermal Blue’ [HBG1] and ‘Dura Blue’ [HBG2]), one KBG (‘Apollo’), and one TF (‘Dynasty’) were evaluated for two years for establishment rates after seeding, visual quality and growth characteristics, and drought resistance. Irrigation treatments included 100% and 60% ET replacement and a control receiving only natural precipitation.

RESULTS:

Tall fescue reached full cover 37, 52, and >73 days faster than HBG1, KBG, and HBG2, respectively. In both years, average quality over the growing season ranked: TF>KBG>HBG1>HBG2 (Figure 1); an infestation of bluegrass billbugs (*Sphenophorus parvulus*

Gyllenhal) in 2003 reduced quality among bluegrasses but not in TF. Canopy density was lower in HBG2 and higher in TF among treatments. Clipping biomass of TF was 42 to 73% higher than that of the bluegrasses. Vertical growth rates were highest in HBG1 and TF and lowest in KBG (Figure 2). Drought generally reduced quality among bluegrasses, but effects on TF were negligible (Figure 3). Results indicate that TF is better adapted than HBG where soils are deep in the transition zone. Further research is needed, using new cultivars of HBG and in areas with different soils.

ACKNOWLEDGEMENTS:

The authors appreciate the technical support of Angela Kopriva, Emily Lundberg, and Alan Zuk in data collection and plot maintenance during this study.

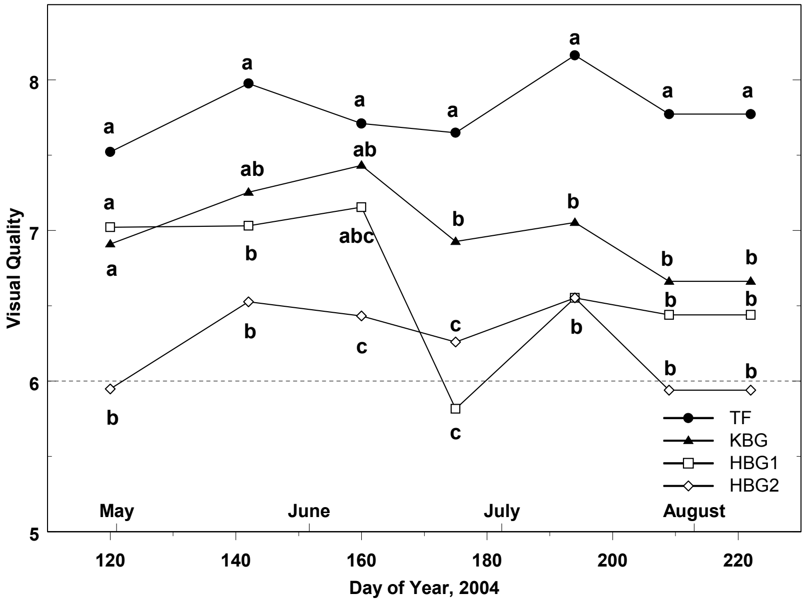

Figure 1. Visual quality ratings of tall fescue (TF), Kentucky bluegrass (KBG), and two hybrid bluegrasses (HBG1 and HBG2) during 2004. Ratings were on a scale from 1 (dead, brown turf) to 9 (optimum uniformity, density, and color). Dashed, horizontal line at 6 indicates acceptable quality for a home lawn. Means followed with the same letter within each respective day of year (vertical) are not significantly different (*P*<0.05).

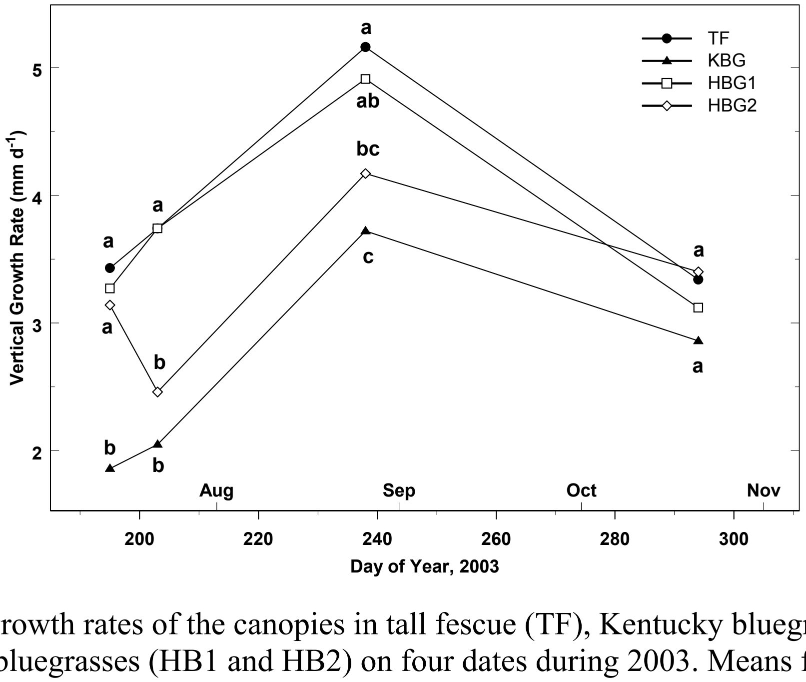

Figure 2. Vertical growth rates of the canopies in tall fescue (TF), Kentucky bluegrass (KBG), and two hybrid bluegrasses (HB1 and HB2) on four dates during 2003. Means followed with the same letter within each respective day of year (vertical) are not significantly different (*P*<0.05).

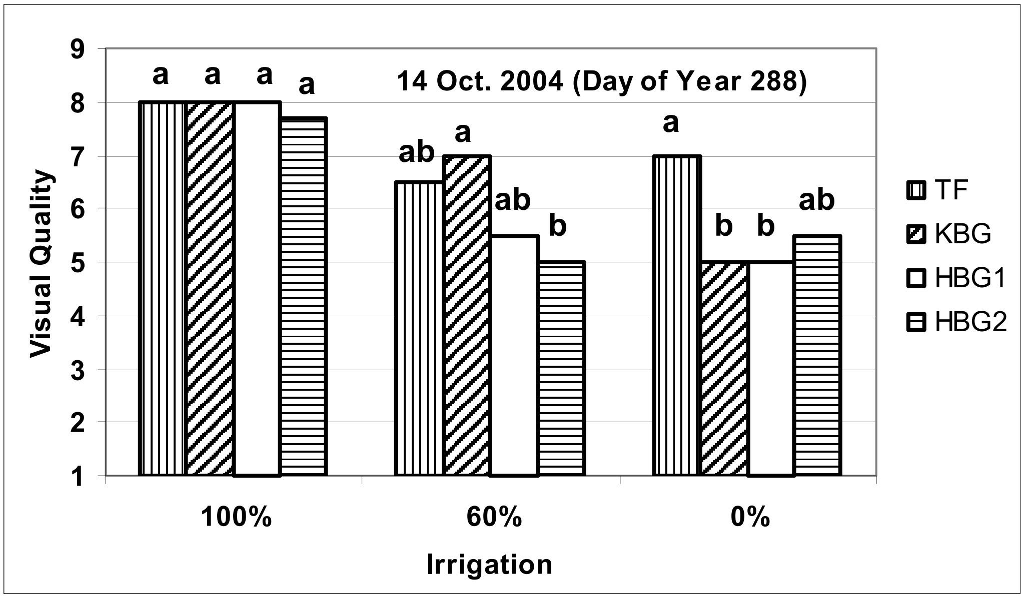

Figure 3. Comparisons of visual quality of tall fescue (TF), Kentucky bluegrass (KBG), and two hybrid bluegrasses (HBG1 and HBG2) within each irrigation treatment after a 52-d dry period (Aug 24 to Oct 14, 2004; day of year 237 to 288). Ratings were on a scale from 1 (dead, brown turf) to 9 (optimum uniformity, density, and color) and 6 indicates acceptable quality for a home lawn. Means with same letters within each irrigation group were not significantly different ($p<0.05$).

TITLE: Root Lengths of Two Hybrid Bluegrasses, Kentucky Bluegrass, and Tall Fescue: A Field Study

OBJECTIVES: Evaluate total root lengths in the 0- to 80-cm profile of Kentucky bluegrass (KBG), tall fescue (TF), and two cultivars of hybrid bluegrasses (HBG) under well-watered conditions.

PERSONNEL: Kemin Su, Dale Bremer, Steven Keeley, and Jack Fry

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

INTRODUCTION:

New HBG, genetic crosses between KBG (*Poa pratensis* L.) and native Texas bluegrass (*Poa arachnifera* Torr.), have the appearance of KBG, but may be able to withstand higher temperatures and extended drought without going dormant. Rooting depth may affect the ability of turfgrasses to maintain higher quality during hot and dry periods; turfgrasses with deeper roots can tap into soil water reservoirs lower in the profile. In this study, total root lengths of two HBG were compared with those of KBG and TF (*Festuca arundinacea* Schreb.) in plots under a large (12 by 12 m) rainout shelter near Manhattan, Kansas.

MATERIALS AND METHODS:

Total root length in the 0- to 80-cm profile was measured for two HBG cultivars (‘Thermal Blue’ and ‘Reveille’), one KBG (‘Apollo’), and one tall fescue (*Festuca arundinacea* Schreb.) (‘Dynasty’) after two years under well-watered conditions.

RESULTS:

Total root length in the 0- to 80-cm profile was greatest in Thermal Blue among turfgrasses (Figure 1). Total root length was greater in Apollo than in Reveille; Dynasty’s root length was between those of Apollo and Reveille, but not significantly different from either ($P<0.05$). Total root length in the lower profile (60 to 80 cm), however, was greatest in Dynasty among turfgrasses (Figure 2). Total root length was similar among bluegrasses in the lower profile. More roots at deeper depths may explain why the quality of TF was higher than the quality of bluegrasses in related water-deficit studies at Kansas State University (e.g., see article *Performance in the Transition Zone of Two Hybrid Bluegrasses Compared with Kentucky Bluegrass and Tall Fescue* in this year’s report). This study under the rainout shelter will continue during summer 2006. More results will be included in next year’s Turfgrass Research report.

ACKNOWLEDGEMENTS:

The authors appreciate the loan of a hydraulic soil probe, used for the collection of root cores in this study, from Dr. Jay Ham, Agronomy Department, K-State.

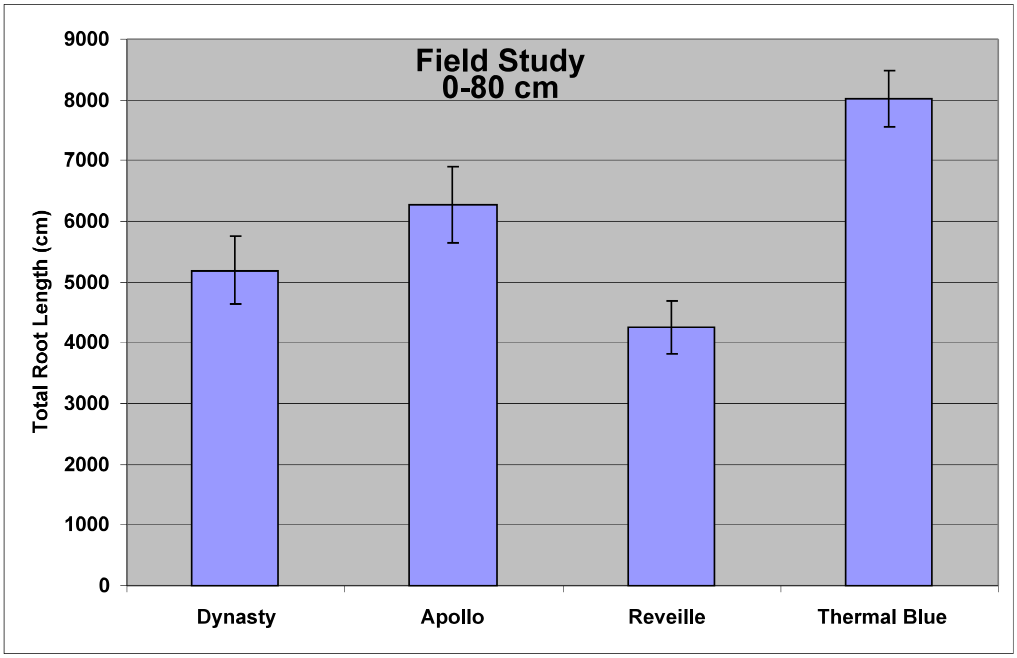

Figure 1. Total root length in the 0- to 80-cm profile of tall fescue (Dynasty), Kentucky bluegrass (Apollo), and two cultivars of hybrid bluegrasses (Reveille and Thermal Blue) under well-watered conditions.

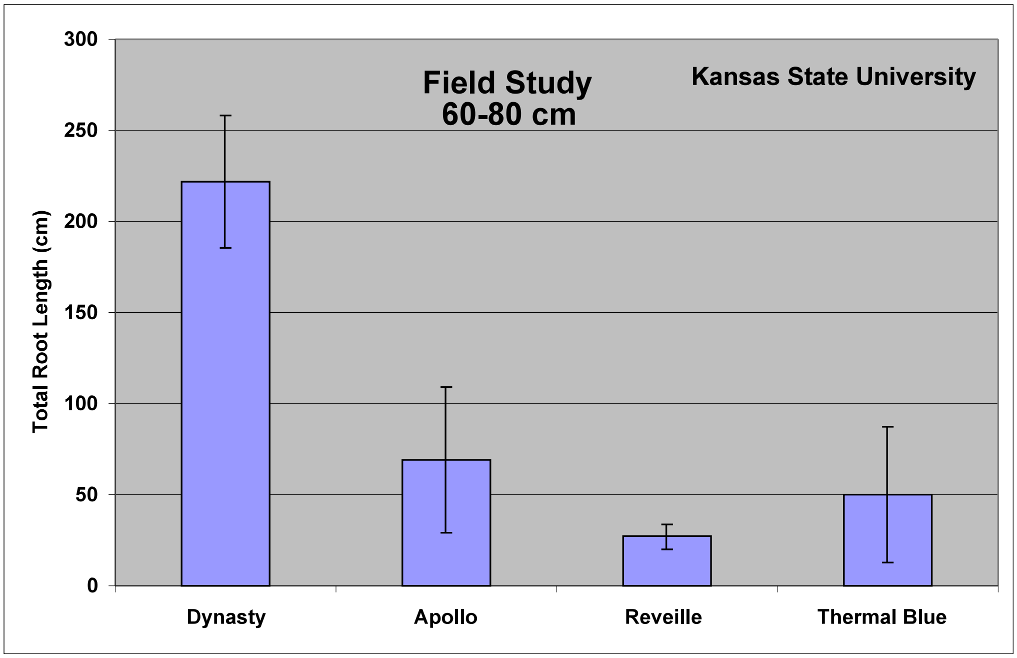

Figure 2. Total root length in the lower profile (60 to 80 cm) of tall fescue (Dynasty), Kentucky bluegrass (Apollo), and two cultivars of hybrid bluegrasses (Reveille and Thermal Blue) under well-watered conditions.

TITLE: Root Lengths of Two Hybrid Bluegrasses, Kentucky Bluegrass, and Tall Fescue: A Greenhouse Study

OBJECTIVES: Evaluate total root lengths in the 0- to 120-cm profile of Kentucky bluegrass (KBG), tall fescue (TF), and two cultivars of hybrid bluegrasses (HBG) under well-watered conditions.

PERSONNEL: Kemin Su, Dale Bremer, Steven Keeley, and Jack Fry

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

INTRODUCTION:

New HBG, genetic crosses between KBG (*Poa pratensis* L.) and native Texas bluegrass (*Poa arachnifera* Torr.), have the appearance of KBG, but may be able to withstand higher temperatures and extended drought without going dormant. Rooting depth may affect the ability of turfgrasses to maintain higher quality during hot and dry periods; turfgrasses with deeper roots can tap into soil water reservoirs lower in the profile. In this study, total root lengths of two HBG were compared with KBG and TF (*Festuca arundinacea* Schreb.) in a greenhouse study.

MATERIALS AND METHODS:

Total root length in the 0- to 120-cm profile was measured for two HBG cultivars (‘Thermal Blue’ and ‘Reveille’), one KBG (‘Apollo’), and one tall fescue (*Festuca arundinacea* Schreb.) (‘Dynasty’) under well-watered conditions. Turfgrass sods were transferred from the field onto clear polyethylene tubes filled with fritted clay in the greenhouse; polyethylene tubes were placed into opaque PVC tubes. Roots in all tubes were harvested when those in one tube were observed emerging from the bottom, and root length was measured.

RESULTS:

Total root length in the 0- to 120-cm profile was greatest in Thermal Blue and Apollo (Figure 1) and lowest in Dynasty and Reveille; no significant differences were observed between Thermal Blue and Apollo or between Dynasty and Reveille. In the 60- to 90-cm profile, total root length in Apollo was comparable to that of Dynasty and was longer than in Thermal Blue and Reveille (data not shown). Total root length in the lower profile (90 to 120 cm), however, was greatest in Dynasty and negligible, but similar, among bluegrasses (Figure 2). More roots at deeper depths may explain why the quality of TF was higher than the quality of bluegrasses in related water-deficit studies at Kansas State University (e.g., see article *Performance in the Transition Zone of Two Hybrid Bluegrasses Compared with Kentucky Bluegrass and Tall Fescue* in this year’s report).

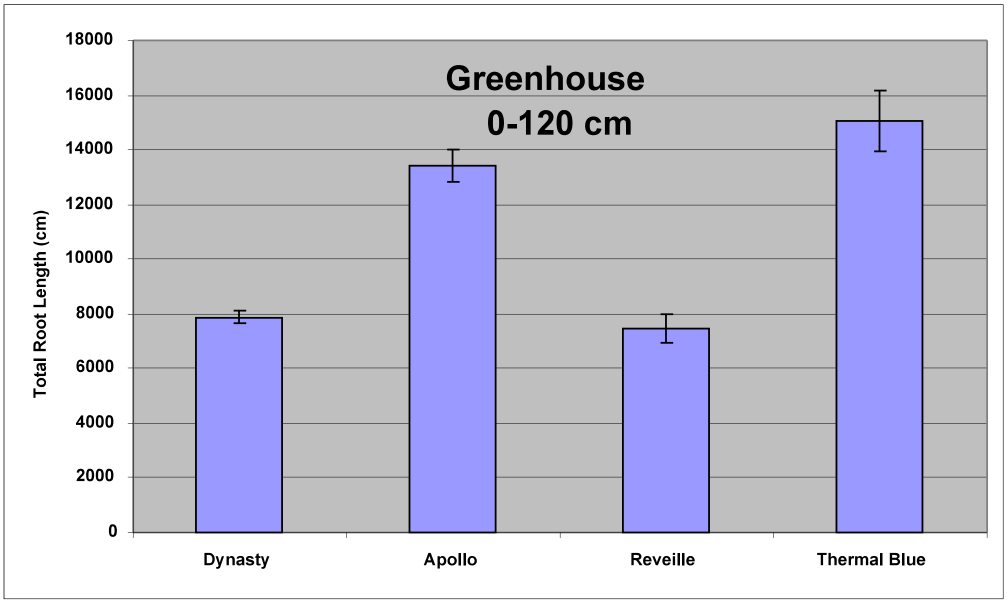

Figure 1. Total root length in the 0- to 120-cm profile of tall fescue (Dynasty), Kentucky bluegrass (Apollo), and two cultivars of hybrid bluegrasses (Reveille and Thermal Blue) under well-watered conditions.

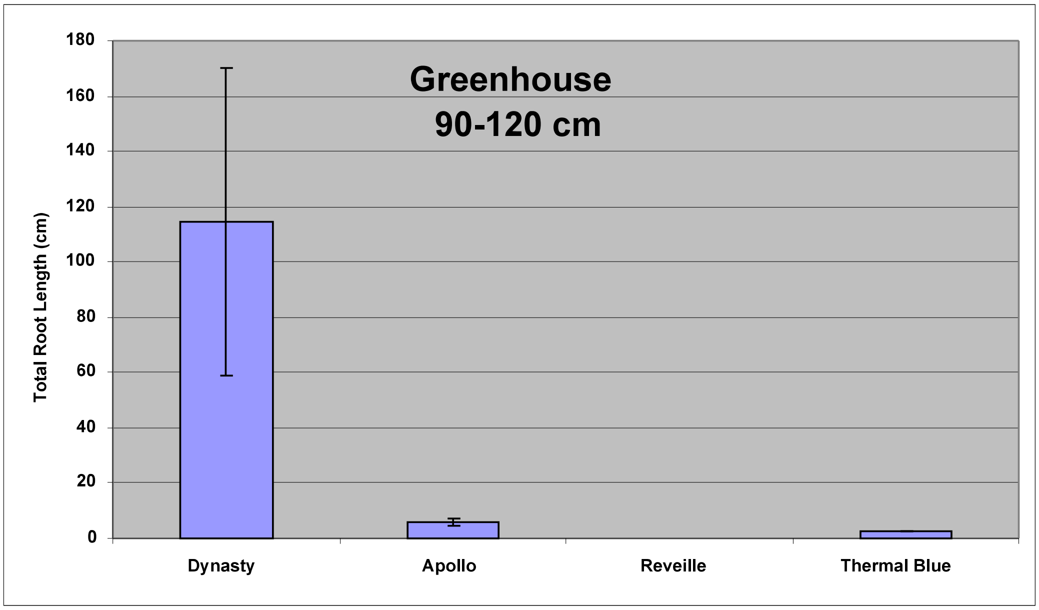

Figure 2. Total root length in the lower profile (90 to 120 cm) of tall fescue (Dynasty), Kentucky bluegrass (Apollo), and two cultivars of hybrid bluegrasses (Reveille and Thermal Blue) under well-watered conditions.

TITLE: Membrane Lipid Composition and Heat Tolerance in Kentucky Bluegrass, Tall Fescue, and a Hybrid Bluegrass

OBJECTIVES: 1) Investigate mechanisms at the cellular level that may explain differences in heat tolerance among three cool-season turfgrasses, Kentucky bluegrass (KBG), tall fescue (TF), and hybrid bluegrass (HBG); 2) identify and quantify specific lipid compositional changes under heat stress; and 3) discover relationships of specific lipid compositions (or ratios) under optimum and high temperatures.

PERSONNEL: Kemin Su, Dale Bremer, Richard Jeannotte, and Ruth Welti

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

INTRODUCTION:

New HBG, genetic crosses between KBG (*Poa pratensis* L.) and native Texas bluegrass (*Poa arachnifera* Torr.), have the appearance of KBG but may be able to withstand higher temperatures and extended drought without going dormant. Heat stress may damage cell membranes in cool-season turfgrasses, causing leakage of cytoplasm and consequently causing tissue damage or death. Lipid molecules are structural building blocks of cellular membranes that, among other things, modulate membrane trafficking of select chemicals, are precursors of intracellular signaling molecules, and participate in the regulation and control of cellular function and response to stresses or injury through signal transduction processes. In this study, lipids were profiled in HBG (‘Thermal Blue’), KBG (Apollo), and TF (*Festuca arundinacea* Schreb.) (Dynasty) in a growth chamber study.

MATERIALS AND METHODS:

Sods of each turfgrass were transferred from the field into containers, maintained in a greenhouse for three weeks, and then moved into a growth chamber for three months. Daily temperatures were maintained at 22°C for 14 h under lighted conditions and then at 15°C for 10 h in darkness. Turfgrasses were mowed once a week at 6.5 cm and were well watered (i.e., every 3 days to replace 100% of evapotranspiration, which was determined gravimetrically). Leaf tissue was sampled in each turfgrass for lipids profiling at the Kansas Lipidomics Research Center at Kansas State University at the end of the three-month period. Although the temperature was thereafter increased to induce heat stress for later lipids profiling, this report includes only results from the initial sampling. Results from the post-heat-treatment lipids profiling are not yet available, but will be included in next year’s report.

Data were analyzed by principle component (PC) analysis, which simplified an otherwise complex process by reducing 149 molecular species into 14 principal components. These 14 components were then evaluated to determine the amount of variance they accounted for in the data. The most significant PCs were then evaluated for their “loadings”, which refers to the individual lipids species within each PC group. Loadings of the most significant PC groups may indicate which individual lipid species determine heat tolerance in cool-season turfgrasses. These species may represent potential biomarkers for heat tolerance in turfgrasses.

RESULTS:

Two of the fourteen PCs explained more than 56% of the variance in the dataset (Figure 1). The biggest differences were between TF and the bluegrasses (i.e., HBG and KBG), which were separated along the PC1 axis; PC1 explained more than 41% of the variance of the dataset. Although HBG and KBG were the same on the PC1 axis, they clearly were separated along the PC2 axis (PC2 explained approximately 15% of the variance). Inspection of the loadings of PC1 and PC2 revealed 40 individual species that separated the more heat-tolerant bluegrasses from TF (Table 1; bluegrasses were more heat tolerant in a previous growth chamber study, see *Comparison of the Heat and Drought Tolerances of a Texas Bluegrass Hybrid Compared with Kentucky Bluegrass and Tall Fescue: A Growth Chamber Study*. p. 53 *in* K-State Turfgrass Research Report 2005, Report of Progress 946). Therefore, we concluded that there is a high probability that these 40 species are potential biomarkers for genetic modification, or enhancement of heat tolerance in turfgrasses. Further experiments are needed, however, particularly where these turfgrasses are exposed to higher temperatures, to determine whether these lipid species are actual physiological mechanisms for heat tolerance.

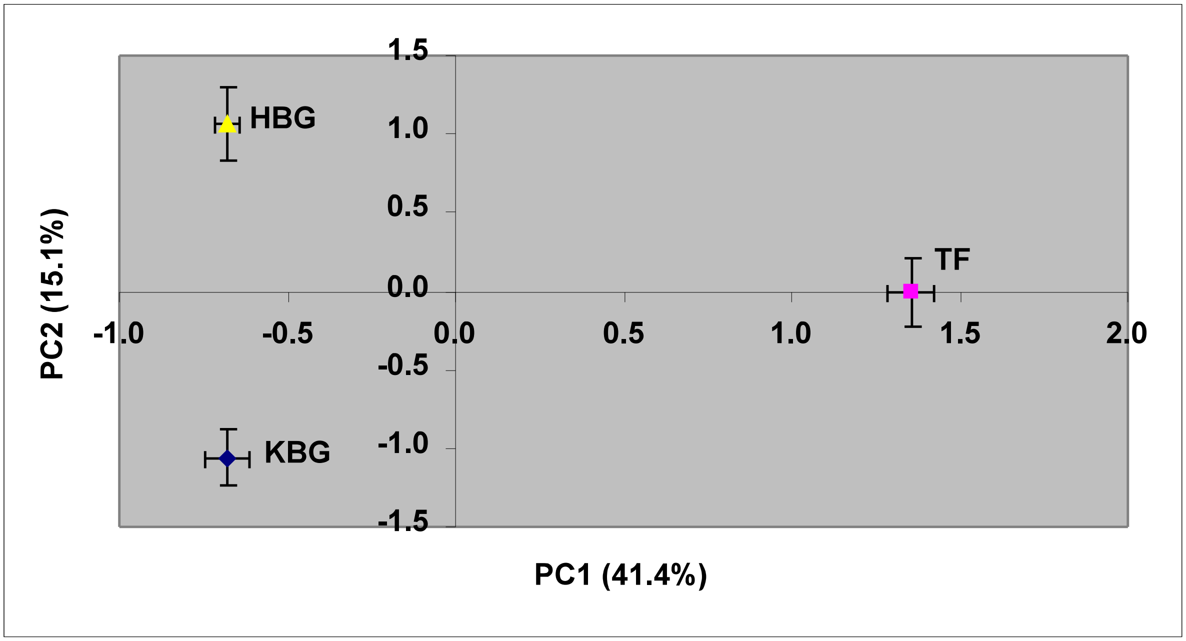

Figure 1. Principal component (PC) analysis of 149 lipid species in tall fescue (TF), hybrid bluegrass (HBG), and Kentucky bluegrass (KBG). PC1 and PC2 accounted for 41.4 and 15.1%, respectively, of the variance of the dataset, for a total of about 56%.

Table 1. Forty molecular species that were significantly different in the bluegrasses, compared with tall fescue. These lipids represent potential biomarkers for genetic modification or enhancement of heat-tolerance in bluegrasses.

High-lipid Species in Heat-tolerant Turfgrasses[†]			
DGDG 34:2	PE 34:2	PS 38:2	PG 34:4
MGDG 34:2	MGDG 36:5	PS 34:2	LysoPC 18:2
PE 38:2	PC 34:2	PC 38:2	MGDG 36:4
PE 36:4	DGDG 36:2	PS 36:2	PS 40:2
DGDG 36:5	PG 34:2	PI 34:2	PC 36:4
Low-lipid Species in Heat-tolerant Turfgrasses			
DGDG 36:3	P 42:4	PS 38:3	PC 36:6
PC 36:5	DGDG 36:6	PE 34:4	PE 34:3
PC 38:6	MGDG 34:4	PE 36:5	PS 42:3
PS 36:5	PC 34:4	PI 34:3	PS 40:3
DGDG 34:1	PC 34:3	DGDG 34:4	PE 36:6

[†] Hybrid and Kentucky bluegrasses were more heat tolerant than tall fescue in a previous growth chamber study at Kansas State University.

TITLE:	Preliminary Evaluation of Freezing Tolerance of New Zoysiagrass Progeny
OBJECTIVE:	Evaluate field performance of 381 zoysiagrass progeny and identify the potential cultivars that can be used in the transition zone with similar cold tolerance as ‘Meyer’.
PERSONNEL:	Qi Zhang, Jack Fry, Milt Engelke, Dennis Genovesi, and Dale Bremer
SPONSORS:	Heart of America Golf Course Superintendents Association, the Kansas Golf Course Superintendents Association, and the Kansas Turfgrass Foundation

INTRODUCTION:

Meyer’ zoysiagrass (*Zoysia japonica* Steud.) has been the predominant cultivar used in the transition zone since its release in 1952 because of its excellent freezing tolerance and good turf quality, but it is relatively slow to establish and is coarser in texture than cultivars of *Z. matrella.* Researchers at Texas A & M released several zoysiagrass cultivars, including ‘Crowne’, ‘Cavalier’, ‘Diamond’, and ‘Palisades’, that exhibited higher turf quality than ‘Meyer’ in southern evaluations, but they lacked freezing tolerance necessary in the transition zone. New progeny have been generated from crosses between freezing-tolerant cultivars and high-quality lines that may have desirable characteristics lacking in ‘Meyer’, but with a comparable level of freezing tolerance. This eventually may lead to the selection of one or more high-quality cultivars that are well adapted to the transition zone environment.

MATERIALS AND METHODS:

Three hundred seventy-eight genetically different zoysiagrass progeny resulting from crosses at Texas A & M were space-planted (3-ft centers) as 4 by 4 inch plugs at Manhattan, Kansas, on August 16, 2004, for field evaluation (Table 1). In most instances, 18 off-spring from a cross represented a “family” and were arranged in groups of six in a randomized complete-block design with three replicates. Meyer was replicated three times for purposes of comparison. The plugs were watered twice and mowed at 4 inches weekly during the growing season in 2005. Urea was applied at 1 lb/1,000 sq. ft on July 20, 2005.

Zoysiagrass progeny were evaluated visually for fall color, leaf texture, winter kill, and diameter (rate of growth). Leaf color was used as an indicator for the rate at which each selection enters autumn dormancy and was evaluated in October and November, 2004 and 2005, according to a 0-to-9 scale, where 0 = straw-brown and 9 = dark green. On May 15, 2005, winter kill was evaluated visually according to a 0-to-9 scale, where 0 = dead and 9 = no winter injury. Seventy-eight progeny with no severe winter damage and high quality were selected for further evaluation (Table 1). Lateral spread was determined by measuring the diameter of each selection on 18 May, 2005. Percentage surface coverage in a 30 x 30 inch square of each selected progeny was measured by using a First Growth digital camera monthly from June to October of 2005. Leaf texture of each selection was evaluated monthly on a 0-to-9 scale, where 0 = coarsest texture and 9= finest texture. Data were analyzed with PROC GLIMMIX procedure.

Air and soil surface temperatures were collected from a weather station located within 30 ft of the study area and dual probe sensors that were placed in contact with randomly selected crowns and connected to a CR-10 data collection unit.

RESULTS:

Soil temperature. Soil temperature was recorded from December 3, 2004, to April 30, 2005 (Figure 1). The lowest temperature at the soil surface was -15 C on day 359 (December 25) in 2004 and -7 C at a 2-cm depth on day 18 (January 18) of 2005.

Field performance. In fall 2004, Meyer, Meyer x BMZ230 (TAES #5322), Meyer x Anderson #2 (TAES #5323), and Companion x Diamond (TAES # 5332) had lower color ratings in November, indicating an earlier entry into dormancy (Table 2). Leaf texture ratings were variable, but some selections clearly had a finer texture than Meyer did. Texture is also being evaluated in the greenhouse, where duplicate samples of all progeny are being kept. A lower mowing height, which will be employed when a smaller group of progeny is selected, will better help separate the progeny on the basis of leaf texture.

Meyer had less winter damage, compared with averages of most of the other crosses, when rated on May 15, 2005. Progeny within another five crosses, Cavalier x Anderson #1 (TAES #5311), Cavalier x Anderson #2 (TAES #5312), Meyer x BMZ230 (TAES #5322), Meyer x Anderson #2 (TAES #5323), and Emerald x Zenith (TAES #5334), had winter damage ratings similar to those for Meyer.

Meyer exhibited a growth rate (diameter) that was as good as any of the averages of the families evaluated on May 15, 2005. By October, only two progeny from TAES 5330 (Crowne x Companion) had greater coverage than Meyer.

Seventy-eight progeny exhibiting good freezing tolerance and quality characteristics were identified for further evaluation in the field on May 15, 2005 (Table 2). Half of the selected progeny were from crosses of Cavalier x Anderson #1 (TAES #5311) and Meyer x Anderson #2 (TAES #5323) (Table 2). No progeny from crosses of Meyer x Cavalier (TAES #5282), Meyer x BMZ230 (TAES #5322), Meyer x Diamond (TAES #5327), or 8501x Zenith (TAES #5343) were selected, because they had severe winter damage or coarse leaf texture.

Additional field experiment. An additional 241 progeny from Texas A & M were planted in Manhattan, Kansas, in 2005, and will be evaluated by using the same techniques described herein.

Table 1. Zoysiagrass progeny generated from crosses between cold-tolerant and high-quality parental lines.

TAES (#)	Pedigree
5282	Meyer x Cavalier
5283	Cavalier x Meyer
5311	Cavalier x Anderson #1
5312	Cavalier x Anderson #2
5313	Zorro x Meyer
5320	Palisades x Meyer
5321	Emerald x Meyer
5322	Meyer x BMZ230
5323	Meyer x Anderson #2
5324	8501 x Meyer
5325	Meyer x 8508
5327	Meyer x Diamond
5330	Crowne x Companion
5331	Palisades x Companion
5332	Companion x Diamond
5334	Emerald x Zenith
5343	8501 x Zenith
Meyer	

Table 2. Field performance of zoysiagrass progeny from autumn 2004 to 2005 at the Rocky Ford Turfgrass Research Center, Manhattan, Kansas.

TAES #	# of Progeny to Start	2004			2005	# of Progeny after Selection[†]	2005[†]				
		Oct. 16		Nov. 11	May 15		May 18		Oct. 19		Nov. 12
		Color[‡]	Texture[‡]	Color[‡]	Winter kill[‡]		Color[‡]	Diameter (inch)	Color[‡]	Coverage (%)	Color
5282	8	5.50 g[*]	7.63 abcd	5.15 bcd	2.56 ef	0	------------	--------------	---------	--------------	------------
5283	10	5.10 gh	7.30 de	4.88 cd	2.26 ef	2	6.92 abc	7.56 bc	7.07 a	39.0 ab	1.84 abc
5311	36	6.33 de	7.19 e	5.28 bcd	7.39 ab	22	7.57 a	9.13 bc	6.23 a	28.3 bc	2.92 a
5312	36	6.28 e	7.44 cd	5.22 ab	6.31 b	10	7.59 a	8.23 bc	6.23 a	34.2 b	2.76 a
5313	36	6.64 abc	7.92 a	5.81 ab	1.89 f	2	7.04 abc	7.83 bc	7.00 a	31.0 bc	3.58 a
5320	18	6.41 bcde	6.77 ef	5.64 abc	2.28 ef	1	7.12 abc	8.11 bc	5.86 a	25.0 bc	1.03 bc
5321	18	6.61 abcd	7.72 abc	5.44 abc	4.11 cde	4	7.25 ab	6.65 c	5.82 a	27.0 bc	3.10 a
5322	18	6.18 ef	6.82 ef	3.83 ef	4.89 bc	0	------------	--------------	---------	--------------	------------
5323	36	6.00 f	6.58 fg	3.11 f	8.06 a	19	7.03 abc	11.30 ab	6.23 a	27.0 bc	1.20 bc
5324	36	6.72 ab	7.92 a	5.86 ab	3.33 de	6	7.13 abc	5.87 c	6.50 a	22.8 c	3.42 a
5325	18	6.67 abc	7.50 bcd	6.17 a	1.61 f	1	7.12 abc	9.29 abc	6.86 a	17.0 c	4.04 a
5327	18	6.88 a	7.75 ab	5.54 abc	1.06 f	0	------------	--------------	---------	--------------	------------
5330	18	6.33 cde	6.39 g	5.67 abc	3.67 cde	2	6.96 abc	16.18 a	7.14 a	49.0 a	3.63 a
5331	18	6.39 cde	6.06 h	5.72 abc	6.56 b	4	6.68 bc	9.29 bc	7.03 a	33.8 bc	2.91 a
5332	18	6.47 bcde	6.77 ef	4.54 de	3.72 cde	1	7.92 a	14.06 ab	6.00 a	42.0 ab	3.84 a
5334	18	6.22 ef	7.50 bcd	5.28 bcd	4.72 bcd	4	6.49 c	11.26 ab	6.53 a	28.0 bc	2.28 ab
5343	18	6.39cde	7.72 ab	5.67 abc	0.50 f	0	------------	--------------	---------	--------------	------------
Meyer	3	4.67 h	6.67 efg	4.00 def	7.67 ab	3	7.33 ab	12.28 ab	6.33 a	32.7 bc	1.00 c

[*] Means of each hybrid line, before and after selection. Numbers in a column followed by the same letter are not significantly different according to Tukey's LSD ($P \leq 0.05$).

[†] Zoysiagrasses with promising quality characteristics and freezing tolerance were selected on May 15, 2005. Selection was based upon performance of the group and individuals. Data were collected and analyzed only from selected individuals within each hybrid line after May 15, 2005.

[‡] Color, texture, and winter kill were rated with a 0 to 9 scale, where 0 = straw-brown color, coarsest texture, or winter-killed turf and 9 = dark green color, finest texture, and no winter damage. Color and texture were rated monthly and winter kill was rated on May 15, 2005.

TITLE: Preliminary Evaluation of Freezing Tolerance of Meyer and DALZ 0102 Zoysiagrass

OBJECTIVE: Compare freezing tolerance of ‘Meyer’ and DALZ 0102 zoysiagrass.

PERSONNEL: Qi Zhang and Jack Fry

SPONSORS: Kansas Turfgrass Foundation

INTRODUCTION:

Meyer has long been the standard zoysiagrass cultivar for use in Kansas and throughout the transition zone. DALZ 0102 is an experimental zoysiagrass selection that has performed well in the most recent NTEP evaluation in Manhattan. Temperatures over the past four winters have not been low enough to allow a good comparison of freezing tolerance between Meyer and DALZ 0102. This study was done in a controlled freezing chamber to determine relative freezing tolerance.

MATERIALS AND METHODS:

One hundred and ninety-two rhizomes from Meyer and from DALZ 0102 were sampled from Rocky Ford Turfgrass Research Center on February 24, 2006. Sixteen rhizomes of each (four replications and four subsamples) were exposed to temperatures ranging from control (no freezing) to -23 C. Rhizomes measured about 3 inches long and each had 4 nodes. Each group of four rhizomes was wrapped in a wet paper towel and then in aluminum foil. Rhizome bundles were put in a circulating ethylene glycol bath set at -3 C for 3 hours, and ice pieces were added to ensure ice formation. The temperature was decreased at 2 C/hour; one group of rhizomes was taken out at each interval. Rhizomes were slowly thawed in a growth chamber at 4 C overnight, planted in small pots containing a standard potting mixture, and placed in the greenhouse.

Data were collected on the number of living rhizomes and nodes, number of shoots, and leaf and root dry weights 8 weeks after exposure to the freezing temperatures. The minimum freezing temperature at which some recovery occurred was also recorded. Data were analyzed with PROC GLM procedure, and means were separated with Fisher’s protected LSD test.

The experiment was set up as a complete randomized design with four replications. A statistical test between the two experiments indicated a difference; therefore, results of the two studies are presented separately.

RESULTS:

This study was complicated by a relatively low percentage of surviving rhizomes in controls that were not exposed to freezing temperatures. When a rhizome is washed in the field after sampling, it is unknown if it is alive or dead. As such, Meyer had an average rhizome survival in the control of about 60%, and about 40% survival occurred with DALZ 0102.

The greatest decrease in rhizome survival occurred between -13 and -15 C in both Meyer and DALZ 0102 on the February 24 sampling date (Table 1). Meyer exhibited greater rhizome survival at -7 and -9 C, and had more living nodes than DALZ 0102 on this date. Meyer exhibited some rhizome survival to -17 C, whereas no survival occurred beyond -13 C in DALZ 0102.

Even though the second sampling was done on March 1, one week later, both cultivars seemed to have lost some hardiness (Table 2). No regrowth occurred below -15 C in either cultivar. Meyer was superior to DALZ 0102 for all measured variables except root weight at -7 C; otherwise, cultivars responded similarly.

Preliminary results indicate that DALZ 0102 is not hardier than Meyer, and results of the February sampling suggest that Meyer may be slightly hardier. The experiment will be repeated during cold acclimation (October to December) and de-acclimation (February and March) next year.

Table 1. Evaluation of Meyer and DALZ 0102 zoysiagrass regrowth 8 weeks after exposing rhizomes to freezing temperatures on 24 February, 2006.

Treatment	Living Rhizomes (%)		Living Nodes (%)		Shoots (no./pot)		Leaf Weight (mg/pot)		Root Weight (mg/pot)	
	Meyer	Dalze	Meyer	Dalze	Meyer	Dalze	Meyer	Dalze	Meyer	Dalze
Control	62.5 a[*]	43.8 a	28.0 a	26.3 a	5.0 a	6.8 a	19.6 a	34.1 a	11.6 a	19.8 a
-3 C	68.8 a	37.5 a	26.5 a	22.8 a	5.0 a	7.5 a	25.0 a	46.2 a	10.0 a	25.1 a
-5 C	87.5 a	37.5 a	35.8 a	16.5 a	8.0 a	6.3 a	50.7 a	35.7 a	20.1 a	16.3 a
-7 C	81.3 a	43.8 b	33.5 a	27.5 a	8.5 a	6.0 a	59.9 a	30.0 a	25.6 a	15.3 a
-9 C	56.3 a	18.8 b	35.0 a	14.3 b	6.8 a	2.8 a	42.2 a	17.8 a	33.4 a	22.5 a
-11 C	31.3 a	31.3 a	11.8 a	10.3 a	3.0 a	1.8 a	16.2 a	9.2 a	9.1 a	4.7 a
-13 C	50.0 a	31.3 a	19.8 a	10.8 a	4.5 a	3.0 a	18.0 a	16.2 a	10.8 a	5.1 a
-15 C	6.3 a	0 a	1.8 a	0 a	0.3 a	0 a	0.5 a	0 a	0.2 a	0 a
-17 C	12.5 a	0 a	3.8 a	0 a	0.5 a	0 a	2.1 a	0 a	0 a	0 a
-19 C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
-21 C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
-23 C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a

[*] Means followed by the same letter within a temperature are not significantly different at $P \leq 0.05$.

Table 2. Evaluation of Meyer and DALZ 0102 zoysiagrass 8 weeks after exposing rhizomes to freezing temperatures on March 1, 2006.

Treatment	Living Rhizomes (%)		Living Nodes (%)		Shoots (no./pot)		Leaf Weight (mg/pot)		Root Weight (mg/pot)	
	Meyer	Dalze	Meyer	Dalze	Meyer	Dalze	Meyer	Dalze	Meyer	Dalze
Control	60.0 a	37.5 a	41.5 a	24.5 a	8.5 a	8.3 a	49.0 a	42.7 a	25.2 a	19.8 a
-3 C	68.8 a	81.3 a	35.0 a	47.3 a	9.0 a	8.8 a	47.1 a	40.2 a	25.8 a	19.5 a
-5 C	68.8 a	50.0 a	45.3 a	34.8 a	8.8 a	5.8 a	29.4 a	21.5 a	19.1 a	9.8 a
-7 C	37.5 a	12.5 b	30.0 a	5.0 b	7.0 a	0.8 b	26.7 a	3.0 b	12.2 a	1.1 a
-9 C	81.3 a	41.7 a	38.5 a	19.3 a	8.0 a	4.7 a	40.5 a	19.0 a	20.4 a	13.3 a
-11 C	33.3 a	8.3 a	18.3 a	2.7 a	4.0 a	0.3 a	11.0 a	0.7 a	4.6 a	0.4 a
-13 C	50.0 a	8.3 b	23.3 a	4.3 a	4.7 a	0.7 a	15.8 a	0.7 a	4.9 a	0.4 a
-15 C	8.3 a	6.7 a	2.0 a	1.7 a	0.3 a	0.3 a	1.7 a	0.7 a	0 a	0.3 a
-17 C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
-19 C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
-21 C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a
-23 C	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a	0 a

[*] Means followed by the same letter treated within the same temperature are not significantly different at $P \leq 0.05$.

TITLE:	Membrane Lipid Changes in Meyer and Cavalier Zoysiagrass During Cold Acclimation
OBJECTIVE:	Identify the differences in lipid contents between Meyer and Cavalier during cold acclimation.
PERSONNEL:	Qi Zhang, Jack Fry, Channa Rajashekar
SPONSORS:	Kansas Turfgrass Foundation

INTRODUCTION:

We are interested in identifying new zoysiagrass (*Zoysia spp.*) cultivars with a level of freezing tolerance comparable to ‘Meyer’ (*Zoysia japonica* Steud.), but with better quality characteristics. New progeny have been generated from crosses between freezing-tolerant cultivars and high-quality lines. Our goal is to identify some of the physiological contributors to freezing tolerance in zoysiagrass. Membrane lipid species have been reported to serve a role in signaling pathways that are important in the acclimation process. The type of lipid in living membranes influences how it responds to freezing temperatures. Membranes that contain more unsaturated fatty acids (analogous to cooking oil at home) are more flexible and tolerate freezing stress better. Membranes composed more of saturated fatted acids (analogous to butter) are less flexible and may sustain more freezing injury. Changes in lipid composition in Meyer (cold tolerant) and Cavalier (cold sensitive) were evaluated during cold acclimation.

MATERIALS AND METHODS:

Meyer (sampled from Rocky Ford Turfgrass Research Center) and Cavalier (kindly provided by Dr. Milt Engelke from Texas A & M) were propagated in cone-containers (2 inch diameter, 10 inches deep) in a greenhouse in June 2005. Containers were moved into an 8 ft diameter storage tank, with sand filled around the containers for natural cold acclimation. Containers were sampled monthly from October to January. One set of the containers was brought to a greenhouse with 70/80 F (Control), and another set of containers was exposed to cold temperature in a freezing chamber. The freezing temperatures that Cavalier was subjected to were -3, -6, -9, and -12 C; Meyer was exposed to temperatures of -5, -9, -13, and -17 C. The experiment was arranged as a randomized complete-block design with four replications. Plant survival was estimated visually as percentage of regrowth 6 weeks after the freezing treatment. The lethal temperature that killed 50% of the grasses (LT_{50}) was calculated by using regression. The minimum freezing temperature from which some shoot recovery occurred was also recorded (T_{min}).

Rhizomes were sampled from another set of acclimated plants removed from the field at the same time other plants were subjected to freezing treatments. Rhizomes were sampled from ~1 inch below the soil surface, and roots and leaves were excised from rhizomes. Rhizomes were then immersed in liquid nitrogen and stored in a -80 C freezer. A profile of the polar complex lipids (membrane lipids) was generated by electrospray ionization tandem mass spectrometry (ESI-ES/MS) and recorded as the percentage in the total amount of the lipids. Each of the entries in Table 2 represents a group of fatty acids ranging in number from 5 to 64.

Data were analyzed with the PROC GLM procedure, and means were separated with Fisher's protected LSD test. LT_{50} was calculated with a regression model.

RESULTS:

Freezing tolerance. Freezing tolerance increased from October to December in both cultivars (Table 1). The LT_{50} and T_{min} were lower in Meyer than in Cavalier in all months. Cavalier reached its maximum cold tolerance in November (LT_{50} -8.3 C), but recovery growth from Cavalier treated at -12 C was only observed in December. The lowest LT_{50} in Meyer (-15.9 C) occurred in December, one month later than that in Cavalier. Recovery growth from exposure to -17 C was also observed in December in Meyer.

Changes in membrane fatty acid species. Most lipid classes were significantly correlated with freezing tolerance in both cultivars (Table 2), but their functions have not been well documented. Lipids in the phosphatidylglycerol group increased in both cultivars as T_{min} decreased; lipids in the phosphatidic acid group declined as freezing tolerance improved .

We will work to determine relationships between specific lipids and freezing tolerance as this research progresses.

ACKNOWLEDGEMENTS:

We appreciate the assistance of Dr. Ruth Welti, Richard Jeannotte, and Mary Roth with the Kansas Lipidomics Research Center.

Table 1. Recovery growth (%), LT_{50}[†], and $\mathrm{T}_{\mathrm{min}}$[†] of Meyer and Cavalier zoysiagrass six weeks after exposure to freezing temperatures.

	October 4		November 5		December 2	
	Cavalier	Meyer	Cavalier	Meyer	Cavalier	Meyer
Control	100.0 a[*]	100.0 a	100.0 a	100.0 a	23.3 a	95.0 ab
-3 C	50.0 b	-------------	100.0 a	------------	33.8 a	-------------
-5 C	----------[§]	100.0 a	--------------	100.0 a	--------------	97.5 a
-6 C	0.0 c	-------------	100.0 a	------------	35.0 a	-------------
-9 C	0.0 c	0.0 b	37.5 b	100.0 a	20.0 a	87.5 ab
-12 C	0.0 c	--------------	0.0 c	------------	3.8 a	-------------
-13 C	--------------	0.0 b	--------------	77.5 b	-------------	77.5 b
-17 C	--------------	0.0 b	--------------	0.0 c	--------------	35.0 c
-21 C[‡]	-------------	------------	-------------	-----------	-------------	-----------
LT_{50} (C)	N/A[¶]	-7.7	-8.3	-13.4	N/A	-15.9
$\mathrm{T}_{\mathrm{min}}$ (C)	-3.0	-5.0	- 9.0	-13.0	-12.0	-17.0

[*] Means with the same letter in each column in each month are not significantly different at $P \leq 0.05$. Means represent the average of four replications.

[†] LT_{50}, lethal temperature that results in 50% or less recovery growth; $\mathrm{T}_{\mathrm{min}}$, the lowest freezing temperature at which any recovery growth was observed.

[‡] This temperature (-21 C) was only tested on Meyer in January, 2006.

[§] Dashed lines indicate that this freezing temperature not tested.

[¶] N/A, no LT_{50} was calculated because recovery growth was out of range.

Table 2. Correlation coefficients (r) for changes in composition of lipid groups in Meyer and Cavalier zoysiagrass rhizomes with T_{min}.

	T_{min} (C)	
Fatty acid group	Meyer	Cavalier
Digalactosyldiacylglycerol	-0.107 NS	-0.193 NS
Monogalactosyldiacylglycerol	0.394 NS	0.855 *
Phosphatidylglycerol	0.752*	0.682*
Lysophosphatidylglycerol	-0.052 NS	0.216 NS
Lysophosphatidylcholine	0.638*	0.295 NS
Lysophosphatidylethanolamine	-0.409 NS	-0.461 NS
Phosphatidylcholine	0.543 NS	0.744*
Phosphatidylethanolamine	0.631 *	0.838*
Phosphatidylinositol	-0.86*	-0.796*
Phosphatidylserine	-0.219 NS	-0.471*
Phosphatidic acid	-0.935*	-0.835*

*, significant at $P \leq 0.05$. NS, not significant

TITLE: Evaluation of Turfgrass Quality with Multispectral Radiometry in a Rainout Shelter Study

OBJECTIVES: Evaluate the use of multispectral radiometry to rate the visual qualities of four cool-season turfgrasses. Multispectral radiometry data were compared with visual estimates of turfgrass quality in two hybrid bluegrasses (HBG), Kentucky bluegrass (KBG), and tall fescue (TF) under well-watered and water-deficit conditions and two mowing heights during the summer of 2005.

PERSONNEL: Hyeonju Lee, Dale Bremer, and Kemin Su

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

INTRODUCTION:

Turfgrass quality is typically estimated by visual observations of uniformity, color, and density. Because of this, quality ratings are subjective and may differ among evaluators or even with the same evaluator over time. Multispectral radiometry (MSR) measures plant light reflectance in the visible and near-infrared ranges, and may provide a more objective, quantitative method for estimating turfgrass quality. Previous research by others has determined that reflectance of radiation in the narrow wavelength ranges of 661 and 813 nm, and also ratios in different wavelengths or ranges of wavelengths (i.e., normalized difference vegetation index [NDVI] and infrared to red [IR/R]; specific calculations for each are described in the methods section below) as measured by MSR have been highly correlated with turfgrass quality in warm-season grasses. Data are limited on the use of MSR in evaluating turfgrass quality in cool-season grasses.

OBJECTIVES:

The objectives of this research were to compare MSR data with visual quality ratings in four cool-season turfgrasses to determine if correlations were significant enough to warrant the use of MSR in providing objective, quantitative estimates of turfgrass quality.

MATERIALS AND METHODS:

This research was conducted under a 12 x 12 m rainout shelter at the Rocky Ford Turfgrass Research Center in Manhattan, Kansas. The rainout shelter excludes rainfall by covering plots during precipitation. Therefore, water can be applied precisely to impose drought stress on some plots while maintaining well-watered conditions in others. In this study, plots were either well watered (100% ET replacement) or had a water-deficit irrigation regime imposed (only 60% ET replacement). In addition, some plots were mowed at 3.8 cm and others at 7.6 cm. The four cool-season turfgrasses were two hybrid bluegrasses (*Poa arachnifera* Torr.)(‘Thermal Blue’ and ‘Reveille’), Kentucky bluegrass (*Poa pratensis* L.)(‘Apollo’), and tall fescue (*Festuca arundinacea* Schreb.)(‘Dynasty’).

Turfgrasses were visually rated for quality and measured for reflectance with a Cropscan MSR. Visual quality was rated on a scale from 1 (dead, brown turf) to 9 (optimum uniformity, density, and color), with 6 considered acceptable quality for a home lawn; all quality evaluations in each year were conducted by the same person. Data among plots on all dates were pooled for comparisons of MSR data with visual ratings. Reflectance was measured at eight wavelengths, including 507, 559, 613, 661, 706, 760, 813, and 935 nm. Visual quality was compared with reflectance at each wavelength, as well as with the ratios *NDVI* (computed as $[R_{935} - R_{661}] / [R_{935} + R_{661}]$), *IR/R* (or LAI; R_{935}/R_{661}), *Stress1* (R_{706}/R_{760}), and *Stress2* (R_{706}/R_{813}).

RESULTS:

Correlation analyses indicated significant relationships between turfgrass quality and MSR data at some wavelengths and ratios (Table 1). Strongest correlations were with *NDVI* (r = 0.88), *Stress1* (r = -0.84), *IR/R* (r = 0.83), and R_{661} (r = -0.80); the weakest correlation was with R_{813} (r = 0.38). In a separate study at K-State in 2004, significant correlations were also found between visual quality and NDVI, IR/R, and R_{661} (p. 49-52 in K-State *Turfgrass Research 2005*, Report of Progress 946), suggesting that *NDVI*, *IR/R*, and R_{661} may be useful in estimating visual quality objectively in cool-season turfgrasses. Contrary to results from other researchers working with warm-season grasses, however, R_{813} was not as accurate in predicting quality in cool-season turfgrasses in this study (r = 0.38) or in our 2004 study.

Regression analyses revealed that the best fit describing the relationships between visual quality and reflectance data was with quadratic models for R_{661} and *IR/R* and linear models for *NDVI* and *Stress1* (Figures 1 to 4). The r^2 values indicated that the quadratic and linear models explained from 68 to 79% of the variability in the data in R_{661}, *IR/R*, *NDVI*, and *Stress1*. Thus, results are encouraging and indicate that reflectance measurements in these four wavelengths and ratios may be useful in providing objective, quantitative estimates of visual quality in turfgrass research and management. This study will continue for another summer, and complete results will be reported in next year's Turfgrass Report.

Table 1. Correlation coefficients for turfgrass reflectance versus visual quality in four cool-season turfgrasses (data for all four turfgrasses, treatments, and measurement dates pooled).

Wavelength or Ratio	Correlation
R_{507}	-0.48
R_{559}	-0.64
R_{613}	-0.74
R_{661}	-0.80
R_{706}	-0.54
R_{760}	0.76
R_{813}	0.38
R_{935}	0.40
NDVI	0.88
IR/R	0.83
Stress1	-0.84
Stress2	-0.7

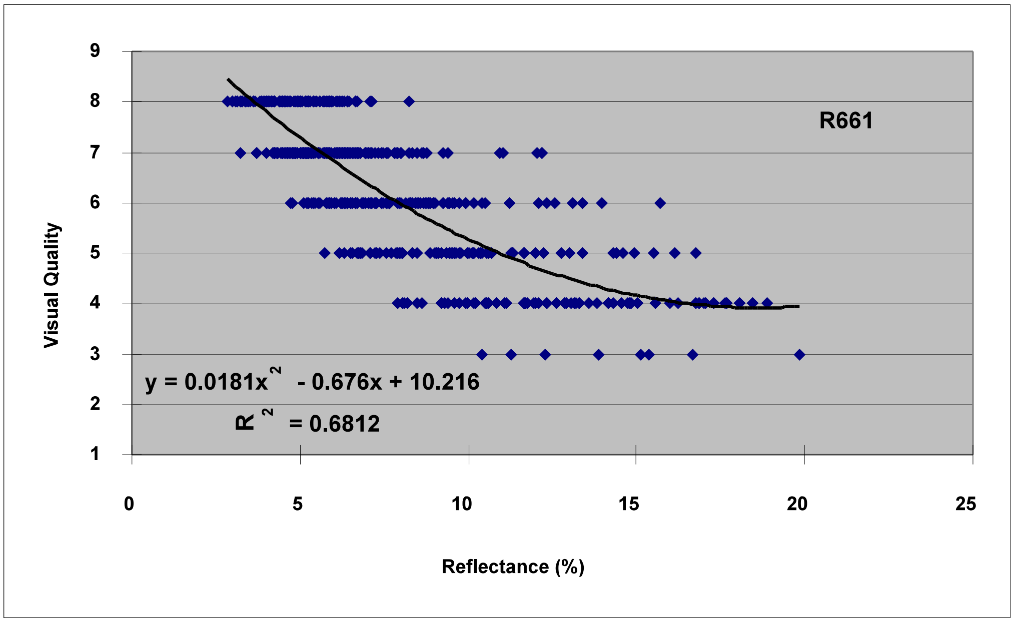

Figure 1. Relationship between visual quality ratings and percentage of reflectance at 661 nm in four cool-season turfgrasses.

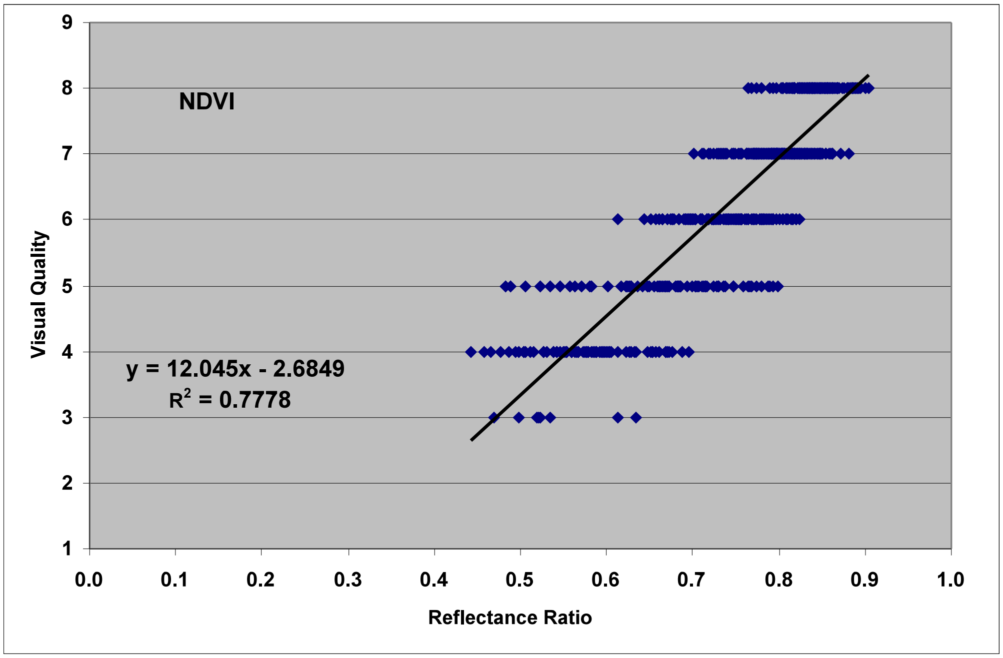

Figure 2. Relationship between visual quality ratings and reflectance ratios of the normalized difference vegetation index (*NDVI*; computed as (*R*935 - *R*661) / (*R*935 + *R*661)) in four cool-season turfgrasses.

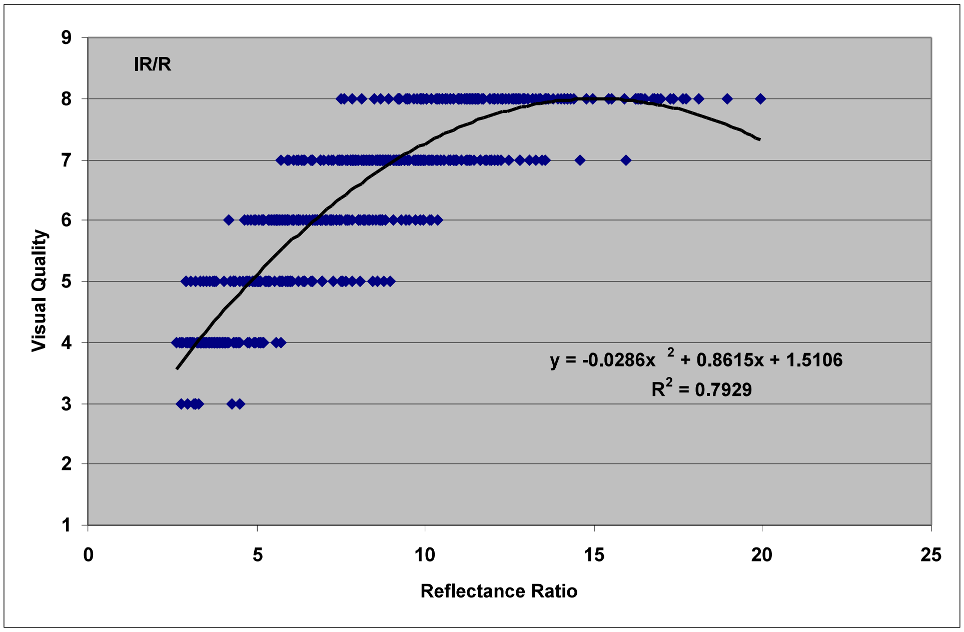

Figure 3. Relationship between visual quality ratings and reflectance ratios of the near infrared to red (*IR/R*; computed as *R*935 / *R*661) in four cool-season turfgrasses.

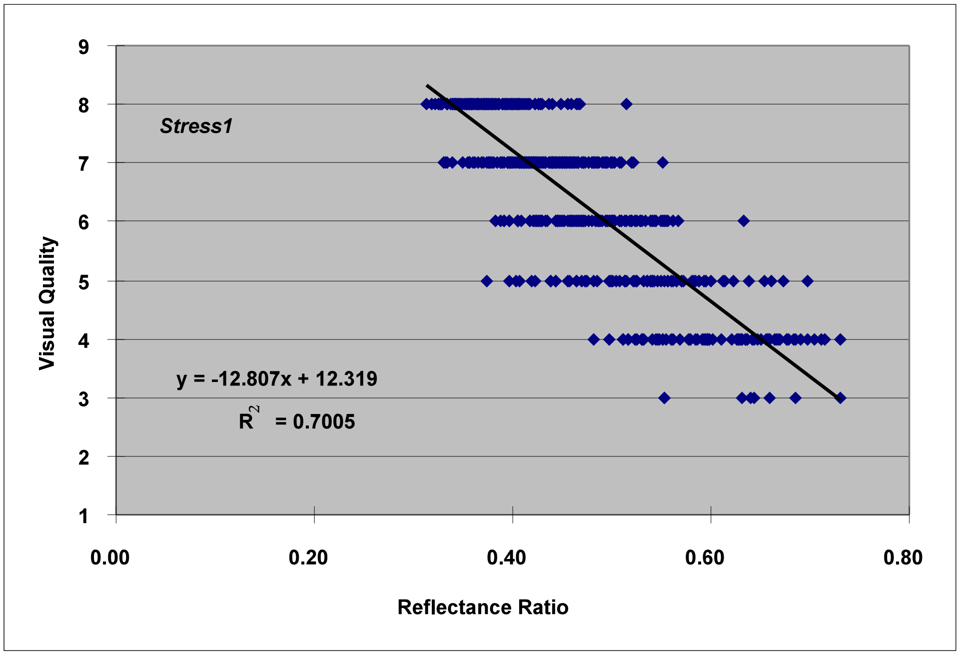

Figure 4. Relationship between visual quality ratings and reflectance ratios of the *Stress1* (computed as *R*935 / *R*661) in four cool-season turfgrasses.

TITLE: Effects of Nitrogen Fertilizer Types and Rates and Irrigation on Nitrous Oxide Fluxes in Turfgrass

OBJECTIVES: 1) Quantify the magnitude and patterns of nitrous oxide (N_2O) fluxes in turfgrass; and 2) determine how nitrogen (N)-fertilization rates, N-fertilizer types, and irrigation affect N_2O fluxes.

PERSONNEL: Dale Bremer

SPONSORS: Kansas National Science Foundation (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR) and the Kansas Turfgrass Foundation (KTF)

Note: This report is an abbreviated version of last year's report with the same name (in the 2005 K-State Turfgrass Research Report, Report of Progress 946). In that report, a calculation error resulted in the reporting of N_2O fluxes that were higher than they actually were. This report corrects those errors and adds data not included in last year's report.

INTRODUCTION:

Anthropogenic activities have contributed to an increase in concentrations of atmospheric nitrous oxide (N_2O), a greenhouse gas, and agriculture is considered a significant source. A number of studies have determined that N_2O fluxes into the atmosphere are high in croplands, which are fertilized with nitrogen (N) and irrigated (Figure 1). Urbanization in the United States and elsewhere, however, is replacing with turfgrass significant tracts of land that were once occupied by natural or agricultural ecosystems. Because turfgrass is often irrigated and fertilized with nitrogen (N), urban areas may represent an unappreciated, but increasingly significant, contributor to atmospheric N_2O. In this study, the impacts on N_2O fluxes of N (including fertilizer types and rates) and irrigation-management factors were quantified.

MATERIALS AND METHODS:

Thirty-six plots were arranged in a previously established sward of perennial ryegrass (*Lolium perenne* L.) (Figure 2). Two rates and two types of N fertilizers were applied to the plots: 1) urea, high rate (UH; 250 kg N ha^{-1} yr^{-1} [5 lb N 1,000 ft^{-2}]); 2) urea, low rate (UL; 50 kg N ha^{-1} yr^{-1} [1 lb N 1,000 ft^{-2}]); and 3) ammonium sulfate, high rate (AS; 250 kg N ha^{-1} y^{-1} [5 lb N 1,000 ft^{-2}]). Soil fluxes of N_2O were measured weekly for 1 year by using static surface chambers and analyzing N_2O by gas chromatography. After the 1-year study, irrigation was withheld from half of all plots for 1 month to investigate irrigation effects on N_2O emissions.

RESULTS:

Fluxes of N_2O ranged from -22 mg N_2O-N m^{-2} h^{-1} during winter to 407 mg N_2O-N m^{-2} h^{-1} after fall fertilization. Nitrogen fertilization increased N_2O emissions by up to 15 times within 3 days (Figure 3), although the amount of increase differed after each fertilization. Cumulative annual emissions of N_2O-N were 1.65 kg ha^{-1} (1.47 lb N acre^{-1}) in UH, 1.60 kg ha^{-1} (1.43 lb N acre^{-1}) in AS, and 1.01 kg ha^{-1} (1.31 lb N acre^{-1}) in UL (Figure 4). Thus, greater N fertilization increased annual N_2O emissions by 63%, but fertilizer type had no significant effect. The amount of N volatilized into the atmosphere as N_2O ranged from 0.6 to 2.6% of N-fertilizer applications.

Withholding irrigation reduced N_2O fluxes significantly in all N-fertility treatments (Figure 5). Cumulative N_2O fluxes were reduced 64 to 89% by drought (Table 1). The effects of drought were also evident in clippings biomass, which was 61 to 70% less in dry than in wet plots.

Recent research and surveys have indicated that as many as 50 million acres in the United States are covered with turfgrasses. These data suggest that emissions of N_2O from turfgrasses in the United States may be as much as 36,750 tons of N annually. Results indicated significant annual N_2O emissions from turfgrasses, similar to emissions from intensively managed croplands, and suggest that management practices such as irrigation and N fertilization may be adapted to mitigate N_2O emissions in turfgrass ecosystems.

ACKNOWLEDGEMENTS:

The author appreciates the advice of Drs. Jay Ham and Jack Fry in the planning and implementation of this study, as well as the technical support of Geoff Ponnath, Angela Kopriva, James (Ken) McCarron, Emily Lundberg, Daniel Hopper, and Alan Zuk in data collection and plot maintenance.

Table 1. Cumulative aboveground biomass (clippings from mowing) and N_2O-N emissions from perennial ryegrass during a 22-day period in which "dry" plots were not irrigated.

	Clippings			Cumulative N_2O-N Fluxes		
	Wet	Dry	% Reduction	Wet	Dry	% Reduction
	-------- $g\ m^{-2}$ --------			-------- $kg\ ha^{-1}$ --------		
UH	19.9a	6.2b	69	0.172a	0.019b	89
UL	10.1a	3.0a	70	0.121a	0.044b	64
AS	19.8a	7.6b	61	0.144a	0.025b	82

[1] Means followed with the same letter within a row are not significantly different ($P<0.05$).

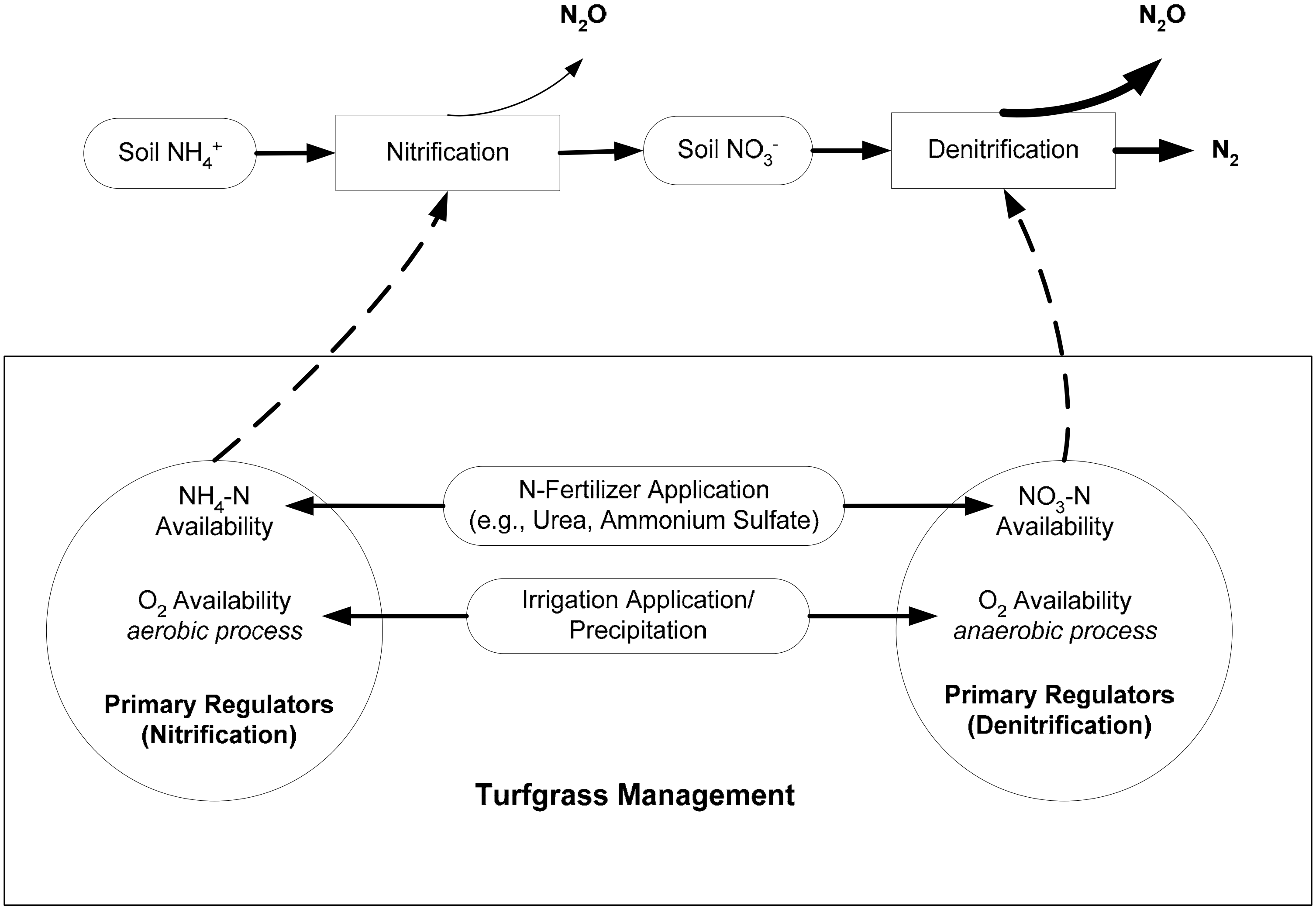

Figure 1. Simplified conceptual model illustrating the effect of fertilization and irrigation or precipitation on N_2O emissions from the soil.

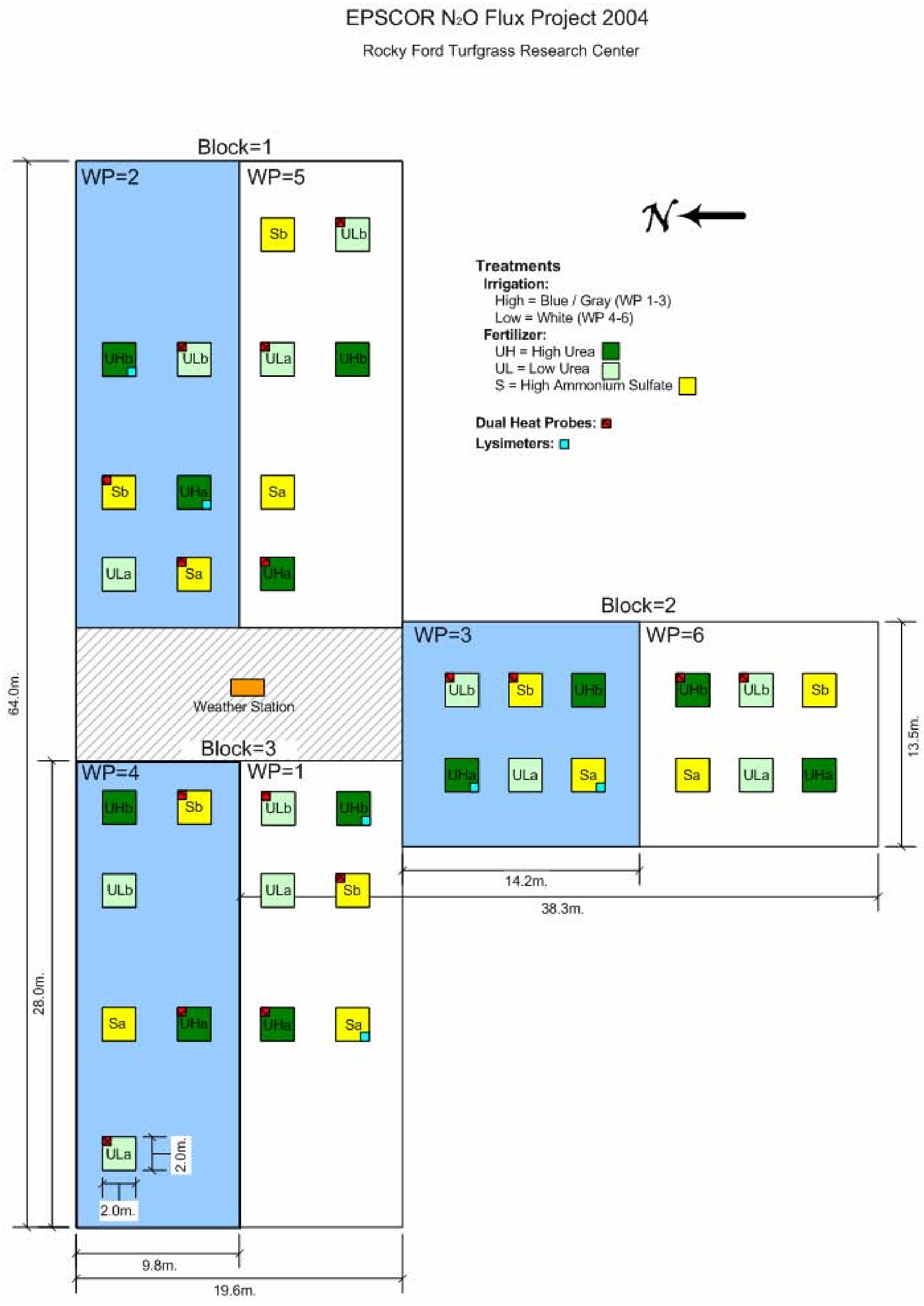

Figure 2. Schematic of plot layout in turfgrass nitrous oxide study.

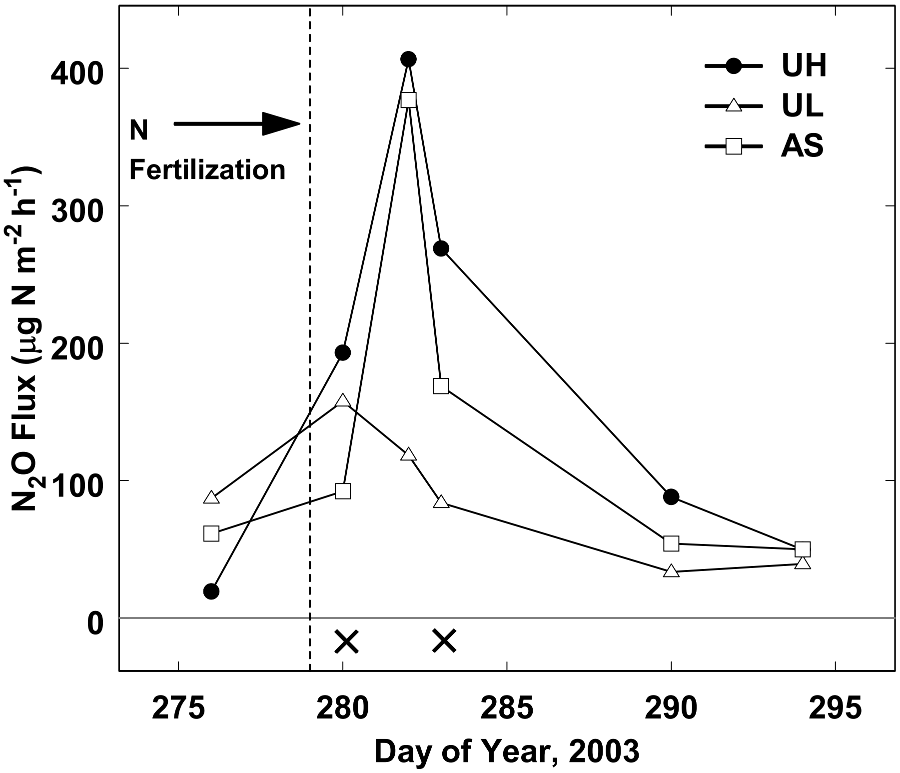

Figure 3. Fluxes of nitrogen (N_2O-N) from perennial ryegrass in fall of 2003. Vertical dashed lines represent N-fertilization date. Symbols (x) along the abscissa indicate significant differences between at least 2 treatments (*P*<0.05).

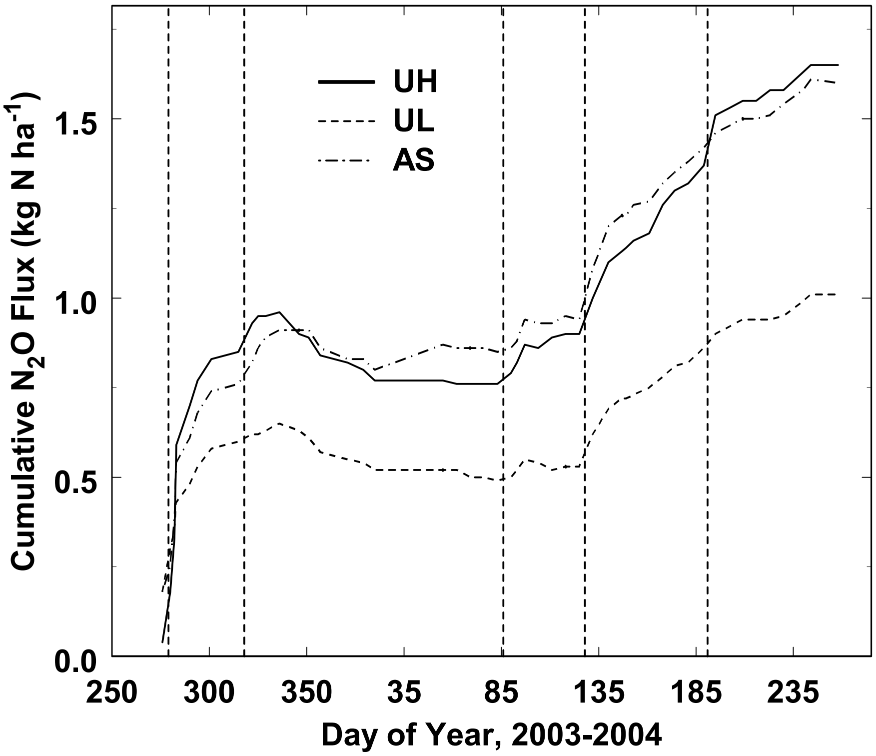

Figure 4. Cumulative fluxes of N_2O-N from plots treated with high rates of urea (UH), low rates of urea (UL), and high rates of ammonium sulfate high (AS). Vertical dashed lines represent fertilization dates.

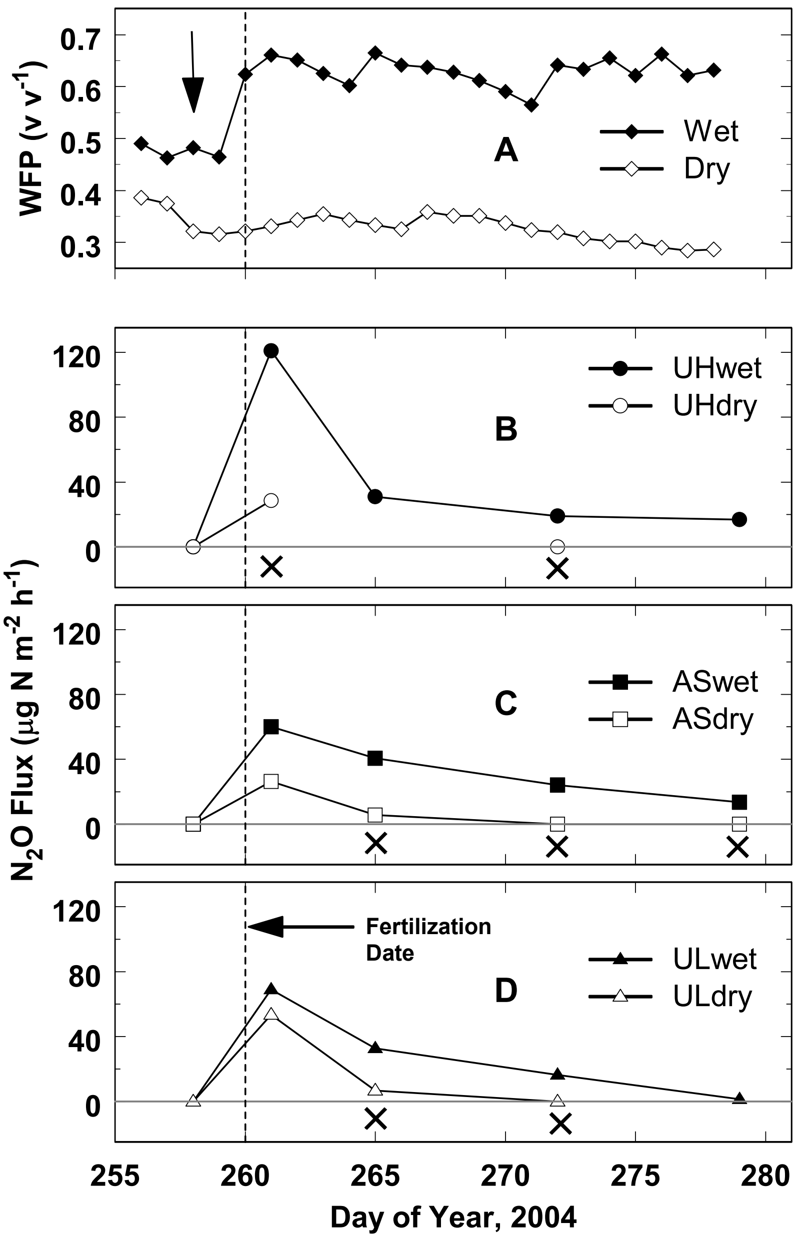

Figure 5. Average soil water-filled porosity (WFP) at 5 cm among irrigated (wet) and non-irrigated (dry) plots, respectively, of perennial ryegrass during irrigation study (A); and fluxes of N_2O from wet and dry plots treated with high rates of urea (UH)(B); high rates of ammonium sulfate (AS)(C); and low rates of urea (UL)(D). Arrow in A indicates beginning of period when differences in WFP were significant between irrigation treatments. Vertical line represents fertilization date.

TITLE: Effects of Turfgrass Species on Nitrous Oxide Fluxes Under Typical Nitrogen-management Regimes

OBJECTIVE: Investigate seasonal magnitude and patterns of nitrous oxide (N_2O) fluxes in one cool-season and two warm-season turfgrasses.

PERSONNEL: Dale Bremer

SPONSORS: Kansas Turfgrass Foundation (KTF)

INTRODUCTION:

Different species of turfgrasses (for example, warm- and cool-season turfgrasses) may be fertilized with N at different rates and frequencies and irrigated with different amounts of water, all of which may affect N_2O emissions. Thus, the selection of different species of turfgrasses may be a useful management tool in mitigating N_2O emissions from turfgrass ecosystems. This study investigated N_2O emissions from three species of turfgrasses during 7 months (i.e., May through November) of the growing season.

MATERIALS AND METHODS:

Thirty-two plots, or eight plots per species, were arranged in previously established swards of one cool-season (perennial ryegrass; *Lolium perenne* L.) and two warm-season turfgrasses (bermudagrass [*Cynodon dactylon*] and zoysiagrass [*Zoysia japonica*]) in May 2005. Urea N fertilizer was applied to turfgrasses according to the schedule presented in Table 1. Soil fluxes of N_2O were measured weekly to biweekly from May 2 to November 18, 2005, by using static surface chambers and analyzing N_2O by gas chromatography. Volumetric soil water content from 0 to 20 cm was measured with time-domain reflectometry on the same days that N_2O measurements were collected. Air temperature during N_2O measurements was obtained from a weather station located at the research center. Clippings were collected from plots on eight days during the summer (June 10, 22, and 29; July 7, 14, and 29; and August 8 and 16) with a walk-behind rotary mower equipped with a modified collection bag that allowed for complete capture of clippings from each plot. Clipped biomass was determined gravimetrically after samples had been dried in a forced-air oven for 48 h at 65 C. Turfgrasses' irrigation requirements were determined with the Penman-Monteith equation (FAO-56), and all plots were irrigated once or twice weekly as needed, by hand to ensure uniformity; all plots received the same amount of irrigation. Statistical analyses of treatment differences were conducted with the mixed linear model of SAS, and correlation analyses were conducted with the correlation procedure of SAS.

RESULTS:

Daily fluxes of N_2O ranged from -2.6 mg N_2O-N m^{-2} h^{-1} on October 28 to 245 mg N_2O-N m^{-2} h^{-1} after N fertilization on June 17. Nitrogen fertilization increased N_2O emissions by up to 17 times within 1 day (Figure 1A), although the amount of increase differed after each fertilization. Emissions of N_2O were weakly correlated with soil water content during the 7-month study ($r = 0.10$; $p<0.02$), and the highest N_2O fluxes occurred when volumetric soil water content was also highest (Figure 1B; June 17). Air temperature was also weakly correlated with

N_2O emissions ($r = 0.19$; $p<0.08$; Figure 1C), whereas correlations between clipping biomass and N_2O emissions were not significant (Figure 1D). Direct correlations between N_2O fluxes and any one of these variables are typically low in N_2O studies, however, because N_2O production is determined by complex interactions among soil water content, temperature, organic matter, soil N concentration, etc.

Cumulative emissions of N_2O-N during the study differed significantly among species (Figure 2). Cumulative fluxes were 1.10 kg ha^{-1} in bermudagrass, 0.57 kg ha^{-1} in perennial ryegrass, and 0.82 kg ha^{-1} in zoysiagrass. Thus, N_2O-N emissions averaged 68% higher in warm-season than in cool-season turfgrass species. Because cool-season turfgrasses may require more irrigation than warm-season species do, however, the cool-season turfgrass in this study may have been insufficiently irrigated during the warmest periods (i.e., ryegrass may have required more water, but received only the same amount as the warm-season species). Because less irrigation may reduce N_2O emissions in turfgrasses, the fluxes from perennial ryegrass in this study may have been suppressed. Furthermore, perennial ryegrass was actively growing earlier in the spring than warm-season grasses were (e.g., during March and April), before measurements were collected in this study, so N_2O emissions may have been greater from perennial ryegrass during that period, which would have reduced the *observable* impact of seasonal N_2O fluxes from perennial ryegrass reported in this study.

Between the two warm-season species, cumulative N_2O emissions in bermudagrass were 34% higher than in zoysiagrass. Higher emissions in bermudagrass were likely the result of greater N fertilization in bermudagrass than in zoysiagrass (Table 1). Soil water content was greater in bermudagrass, however, which also may have inflated N_2O emissions, compared with those for zoysiagrass (Figure 1B). Greater soil water content in bermudagrass probably resulted from it using less water than zoysiagrass used; bermudagrass received the same amount of irrigation as zoysiagrass in this study. Results from this preliminary study indicate that turfgrass species may have significant impacts on N_2O emissions into the atmosphere, and suggest that turf species selection may be a useful management tool to mitigate greenhouse gas emissions and the greenhouse effect.

ACKNOWLEDGEMENTS:

The author appreciates the technical support of Angela Kopriva, Erin Campbell, Hyeonju Lee, and Alan Zuk in data collection and plot maintenance during this study.

Table 1. Fertilization schedule for bermudagrass, perennial ryegrass, and zoysiagrass in 2005.

	Bermudagrass	Perennial Ryegrass	Zoysiagrass
	lb N/1,000 ft^{-2}		
May 5	1.0	1.0	1.0
June 16	1.0	--	--
July 21	1.0	0.5	1.0
August 11	1.0	--	--
September 19	--	1.5	–

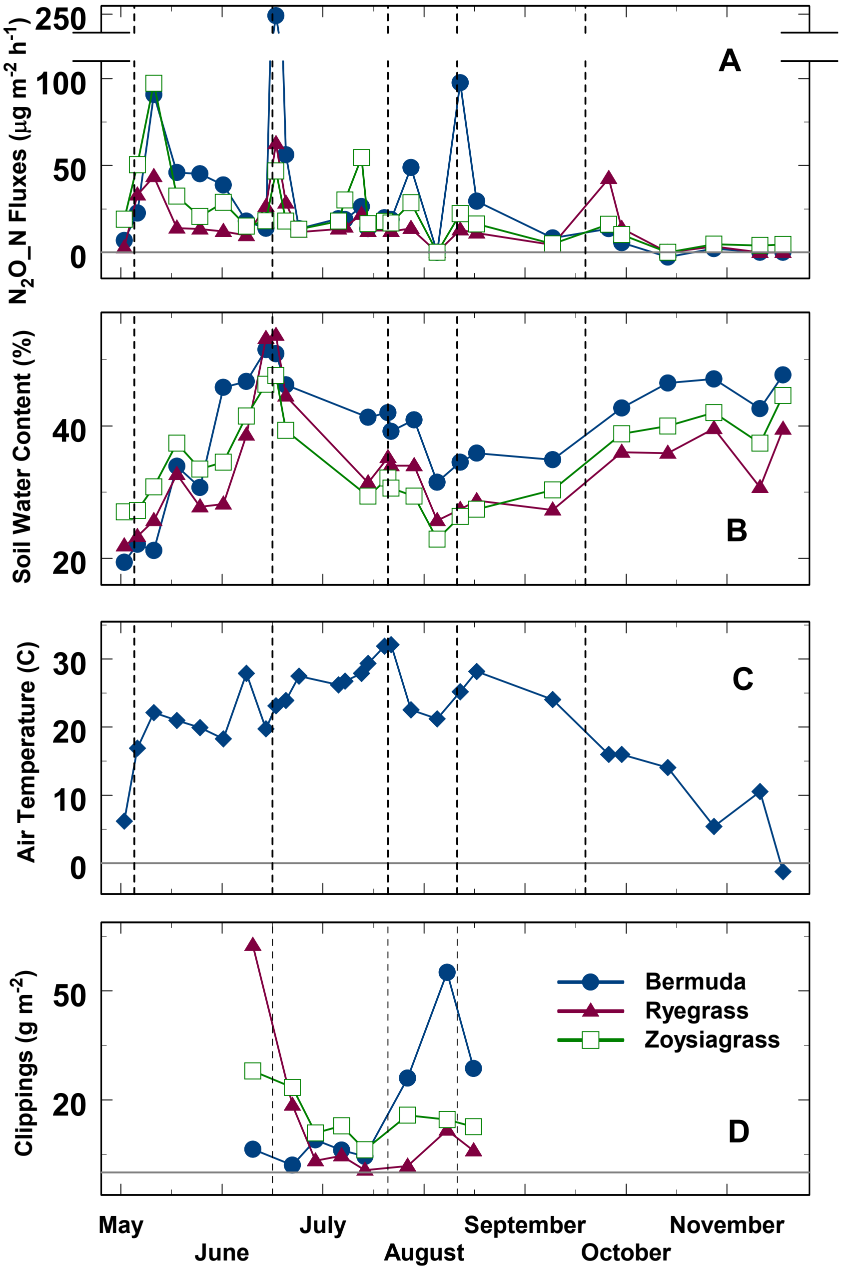

Figure 1. Patterns among turfgrass species of nitrous oxide nitrogen (N_2O-N; A) fluxes; volumetric soil water content in the 0- to 20-cm profile (B); average air temperature at 1.5 m above ground level (C); and clippings collected during mowing (D); from May 2 to November 18, 2005. Vertical dashed lines represent N-fertilization dates.

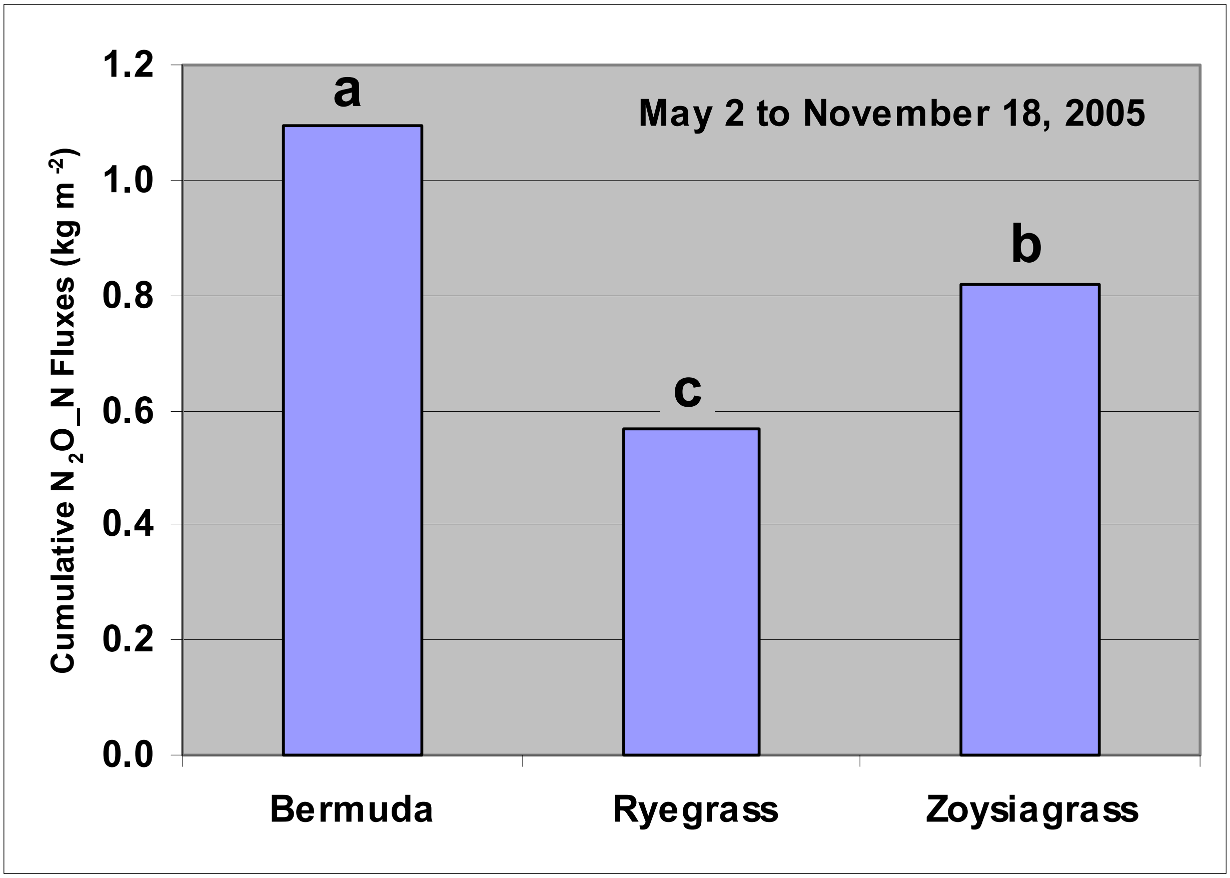

Figure 2. Cumulative emissions of of nitrogen (N_2O-N) from three species of turfgrasses during the summer and fall of 2005.

TITLE: Diurnal Trends in, and Transient Effects of Nitrogen Fertilization and Irrigation on, Nitrous Oxide Fluxes in Turfgrasses

OBJECTIVE: Investigate in turfgrasses: 1) diurnal fluxes of nitrous oxide (N_2O); and 2) transient patterns of N_2O emissions in the 2 to 3 days after irrigation or nitrogen (N) fertilization.

PERSONNEL: Dale Bremer

SPONSORS: Kansas Turfgrass Foundation (KTF)

INTRODUCTION:

Fluxes of N_2O may differ by time of day (diurnally) and, perhaps even more significantly, in the hours and days after substantial rainfall or irrigation and N fertilization. This confounds attempts to calculate cumulative fluxes of N_2O based on infrequent (e.g., weekly or biweekly) measurements. Cumulative sums are important when estimating the contribution of seasonal or annual fluxes of N_2O, a greenhouse gas, from turfgrass ecosystems to regional and global atmospheric N_2O budgets.

MATERIALS AND METHODS:

Transient fluxes of N_2O were measured in a cool-season (perennial ryegrass; *Lolium perenne* L.) and warm-season turfgrass (bermudagrass; *Cynodon dactylon*) by using static surface chambers and analyzing N_2O by gas chromatography.

On July 14, 2004, diurnal measurements of N_2O-N fluxes were collected from six plots of perennial ryegrass at 5:00 a.m., 8:00 am, 10:00 a.m., 1:00 p.m., 4:00 p.m., and 7:00 p.m. (CST). The plots had been fertilized 5 days earlier with 0.5 lb per 1,000 ft^{-2} (25 kg ha^{-1}) of urea N on July 9, and had been well watered. On the day of these diurnal measurements (July 14), irrigation was inadvertently applied to two plots late in the day, at 5:00 p.m., which was 2 hours before the final N_2O measurement of the day. Therefore, average (diurnal) fluxes from the four unaffected plots are presented, as well as fluxes from the two plots that were accidentally irrigated; data from the latter are presented only from 4:00 p.m. (pre-irrigation) and 7:00 p.m. (post-irrigation) to illustrate transient effects of irrigation on N_2O emissions in turfgrasses.

On August 9 to 11, 2005, N_2O emissions were measured for 2 days after irrigation was applied to three of six plots of bermudagrass. Initial N_2O fluxes were measured from the six (dry) plots at 6:30 a.m. (CST) on August 9, immediately before irrigation was applied at 8:00 a.m. with 25 mm of water in three of the plots. Thereafter, fluxes were measured at 9:00 a.m., 1:00 p.m., 4:00 p.m., and 7:00 p.m. on August 9; at 6:30 a.m., 9:00 a.m., 1:00 p.m., 4:00 p.m., and 7:00 p.m. on August 10; and at 7:00 a.m. on August 11. All plots were extremely dry before irrigation, and “dry” plots received no irrigation during the 3-day study; no precipitation occurred, nor was any additional irrigation applied to plots during the 2-day period. Diurnal emissions of N_2O were thus measured from both irrigated and dry plots on 2 complete days.

On August 15 to 18, 2005, N_2O emissions were measured for 3 days after a N-fertilizer application, from the same six bermudagrass plots just described. All plots had been well watered in the 3 days before N fertilization. Initial measurements of N_2O fluxes were collected at

7:00 a.m. CST on August 15, immediately before N fertilization with 1.0 lb per 1,000 ft^{-2} (50 kg N ha^{-1} yr^{-1}) of urea nitrogen. After fertilization, all plots (including unfertilized plots) received about 9 mm of irrigation to minimize N losses due to ammonia volatilization. Thereafter, N_2O fluxes were measured at 1:30 p.m. and 6:00 p.m. on August 15, at 7:00 a.m. on August 16, and at 7:00 a.m. on August 18.

RESULTS:

With the notable exception of 5:00 a.m., fluxes of N_2O showed a clear diurnal trend in perennial ryegrass, with fluxes increasing between 8:00 a.m. and 1:00 p.m., and then decreasing to their lowest values of the day by 7:00 p.m. (Figure 1). Fluxes at midday were 20% higher than at 8:00 a.m. and 42% higher than at 7:00 p.m. The highest values of the day, however, were at 5:00 a.m., and were 16% higher than at midday. The reason for the higher fluxes at 5:00 a.m. is uncertain, given that N_2O fluxes generally increase with temperature, which also increased substantially during the day (Figure 1). Nitrous oxide emissions in biological ecosystems are affected by a number of variables that were not measured in this 1-day study (e.g., soil water content, soil N concentration, microbial activity, organic matter, pH) and could have impacted N_2O fluxes. The error bars indicate some uncertainty in the measurements as well, which was a result of high spatial variability that is typical in N_2O measurements. Measurements with more chambers would likely have reduced the inherent error resulting from spatial variability.

Irrigation increased N_2O emissions from perennial ryegrass and bermudagrass by 2 to 2.5 times within 1 to 2 hours (Figures 2 and 3). In bermudagrass, fluxes generally remained higher during the 2 days after irrigation (Figure 3). Diurnal trends in N_2O emissions were more evident in irrigated plots, and were amplified, compared with emissions from dry plots. This resulted in significantly higher fluxes in irrigated than in dry plots during midday, but not early and late in the day. Cumulative fluxes during the 2-day period were 1.5 times higher in irrigated (5.2 g ha^{-1}) than in non-irrigated (3.5 g ha^{-1}) bermudagrass.

Nitrogen fertilization in bermudagrass caused a 63-fold increase in N_2O emissions (i.e., from 9.4 to 588.1 ug m^{-2} h^{-1}) within 4 hours (Figure 4). Fluxes in non-fertilized plots also increased by 2.7 times (i.e., from 9.4 to 25.4 ug m^{-2} h^{-1}) during the 4-hour period, because of the post-fertilization irrigation applied to all plots. Emissions of N_2O remained significantly higher in fertilized than in unfertilized plots during the following 3 days. Cumulative fluxes during the 3-day period were more than 46 times higher in fertilized (157.9 g ha^{-1}) than in unfertilized (3.4 g ha^{-1}) plots.

Results indicated rapid responses of N_2O emissions to irrigation and N fertilization in cool- and warm-season turfgrasses. Irrigation increased N_2O fluxes by 2 to 2.7 times within 1 to 4 hours, and N fertilization increased N_2O emissions by up to 63 times within 4 hours. Diurnal patterns of N_2O fluxes were evident, although they did not always follow daily patterns of solar radiation and temperature. Further research is required to determine causes of differences in fluxes according to time of day.

ACKNOWLEDGEMENTS:

The author appreciates the technical support of Angela Kopriva, Erin Campbell, and Alan Zuk in data collection and plot maintenance during this study.

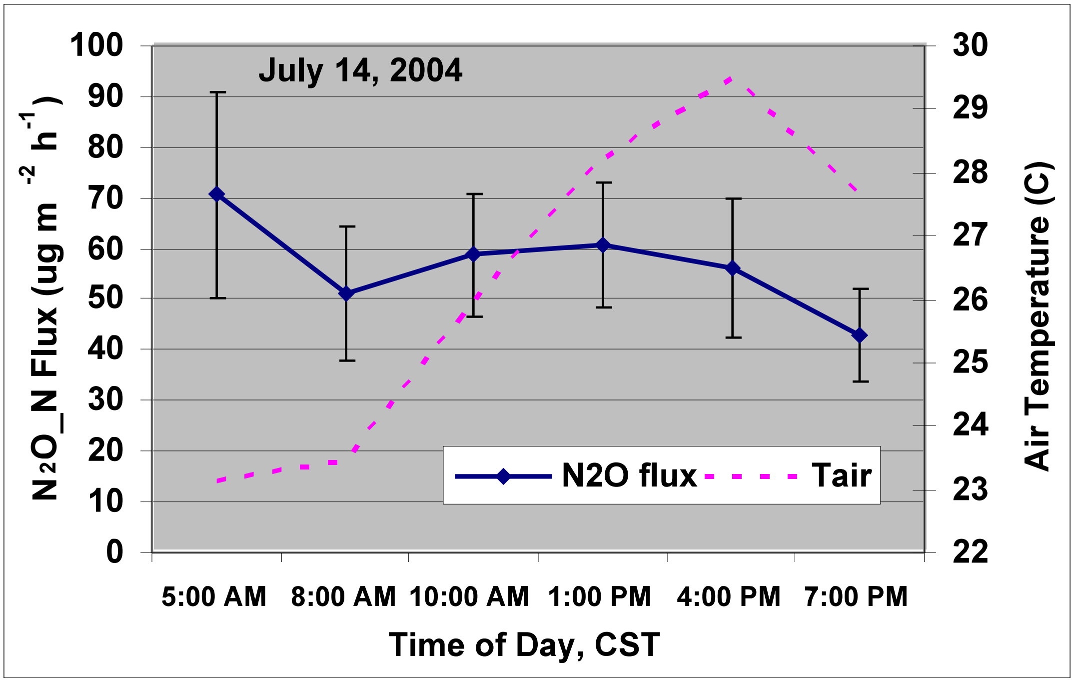

Figure 1. Diurnal pattern of nitrous oxide (N_2O-N) fluxes in perennial ryegrass and air temperature at 1.5 m between 5:00 am and 7:00 pm, CST.

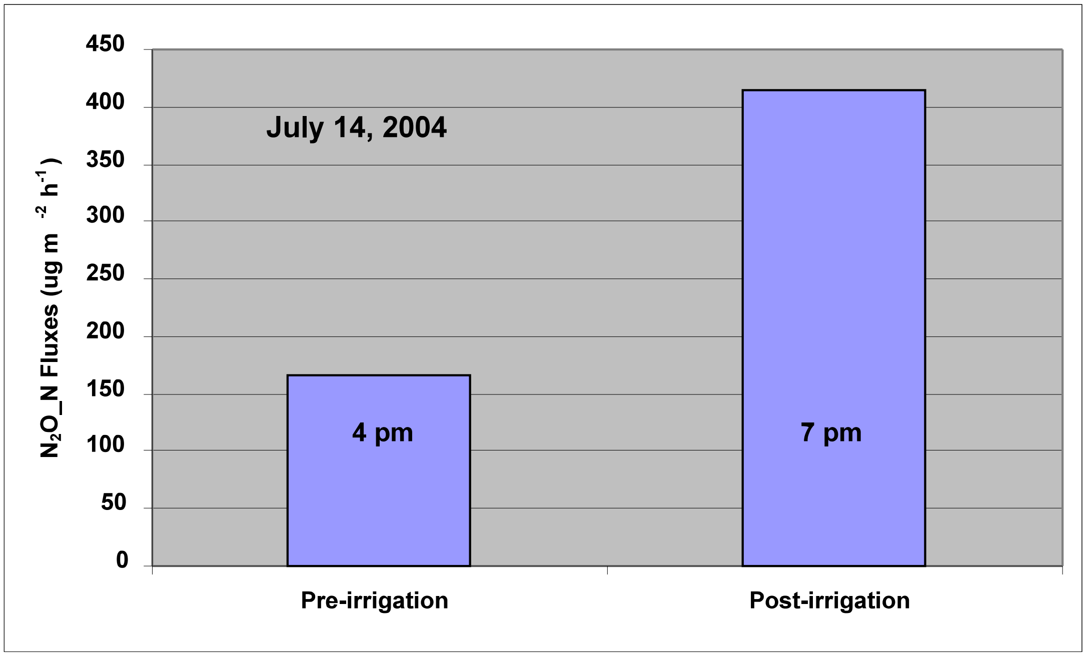

Figure 2. Fluxes of nitrous oxide (N_2O-N) at 4:00 p.m. (pre-irrigation) and 7:00 p.m. (post-irrigation) in perennial ryegrass plots; about 15 mm (0.60 inch) of irrigation was applied at 5 p.m. (CST).

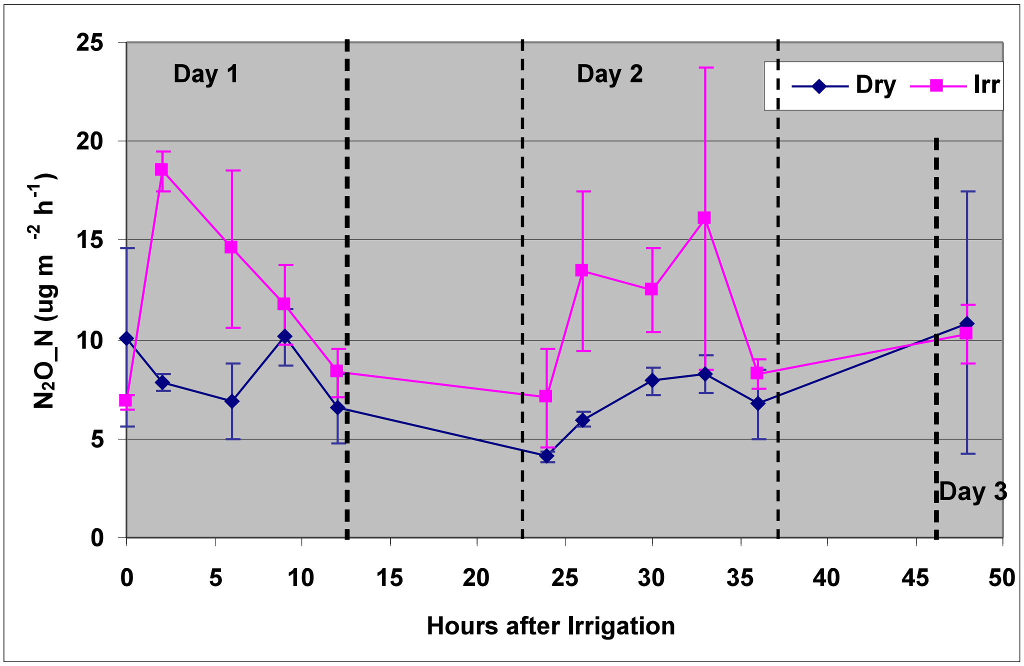

Figure 3. Fluxes of nitrous oxide (N_2O-N) in dry and wet plots of bermudagrass during a 48-hour period after irrigation (August 9 to 11, 2005). Vertical, dashed lines are placed at about 4:00 a.m. and 8:00 p.m. on each day to identify approximate time of day when measurements were collected.

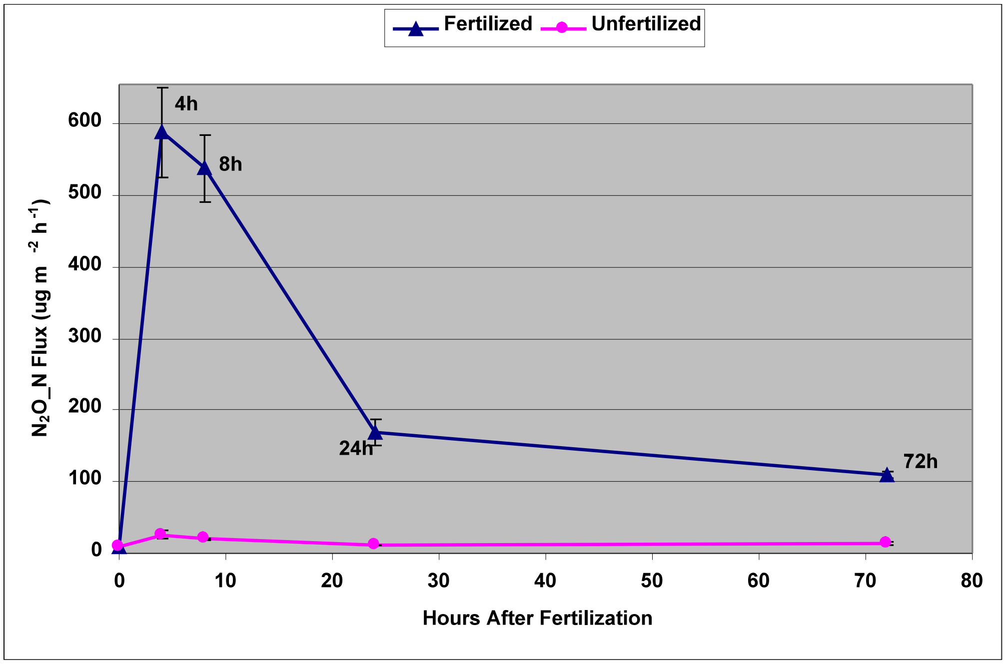

Figure 4. Fluxes of nitrous oxide (N_2O-N) in bermudagrass during a 72-hour period after fertilization with urea nitrogen (August 15 to 18, 2005). Initial measurements (0 h) were collected immediately before fertilization.

TITLE: Tall Fescue NTEP Evaluation

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, 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 incorporation of 13-13-13 at a rate of 1 lb N-P-K per 1,000 sq. ft into 480 5 ×5 ft study plots at the John C. Pair Horticultural Center in Wichita, Kansas, the area was seeded on September 28, 2001, with 160 tall fescue cultivars and experimental numbers in a randomized complete-block design at a rate of 4.4 lb of seed per 1,000 sq. ft. Fertility of the plots was maintained at 0.25 to 0.5 lb N/1,000 sq. ft per growing month. The plots were mowed weekly during the growing season at 2.5 inches, and clippings were removed. Plots were irrigated as necessary to prevent stress and control weeds, insects, and diseases, only when they presented a threat to the trial.

During the course of the study, information will be collected on spring green-up, genetic color, leaf texture, quality, and other measures when appropriate. Rating is done on a scale of 1=poorest, 6=acceptable, and 9=optimum measure.

RESULTS:

During the summer of 2005, data were collected on turf green-up, quality, color, and texture. By April 4, the cultivars/experimental numbers Blackwatch (Pick-OD3-01), Guardian-21 (Roberts DOL), Justice (RB2-01), and BE1 were among the greenest (Table 1). The 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 Justice (RB2-01), Apache III (PST-5A1), Wolfpack, and BE1. At the end of the summer, MRF 28, MRF 702, MRF 211, and NA-TDD were the darkest green, and Avenger (L1Z), CIS-TF-64, Finelawn Elite (DLSD), Inferno (JT-99), and JT-15 had the finest texture. More information on the National Turfgrass Evaluation Program and nationwide 2001 National Tall Fescue Test results can be found at http://www.ntep.org.

Table 1. 2005 performance of tall fescue cultivars at Wichita, Kansas[1].

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Justice (RB2-01)*[2]	5.3	6.0	6.3	4.7	4.7	5.7	5.7	6.3	5.3	6.0	5.5
ApacheIII (PST-5A1)*	4.3	6.5	6.0	5.0	4.3	5.0	5.3	6.0	5.7	6.0	5.3
Wolfpack*	4.7	5.5	5.7	5.0	4.7	5.0	5.3	5.7	5.7	6.0	5.3
BE1	5.3	6.0	6.0	4.0	4.7	4.7	5.3	6.7	5.7	6.0	5.3
FinelawnElite (DLSD)*	5.0	5.5	7.0	5.3	4.3	5.3	5.3	5.0	4.7	6.7	5.2
RegimentII (SRX805)*	4.3	7.5	6.3	5.3	4.3	4.7	5.3	5.0	5.7	6.3	5.2
Plantation*	5.0	6.0	5.7	4.7	4.7	4.7	5.7	5.3	5.7	6.0	5.2
CAS-ED	5.3	6.5	5.7	4.7	4.7	4.7	5.3	6.0	5.3	5.7	5.2
PST-5S12	4.7	6.0	5.0	4.3	4.7	4.3	5.3	6.3	5.3	6.0	5.2
Padre (NJ4)*	4.3	6.0	6.0	4.3	4.3	5.0	5.3	6.3	5.3	5.7	5.2
CochiseIII (018)*	4.7	6.0	6.3	5.3	4.7	5.0	5.7	5.0	5.0	5.3	5.1
MatadorGT (PST-5TUO)*	4.7	6.5	5.7	4.7	4.0	5.0	5.0	5.7	5.7	6.0	5.1
PST-5LO	5.0	5.5	5.7	5.0	4.0	4.7	5.3	6.3	5.3	5.3	5.1
Avenger (L1Z)*	5.3	7.0	7.0	4.0	4.3	4.7	4.7	7.0	5.3	6.0	5.1
Inferno (JT-99)*	5.0	6.0	7.0	5.0	4.3	5.3	5.3	5.7	4.7	5.7	5.1
Riverside (ProSeeds5301)*	5.0	6.0	5.7	4.7	4.0	5.3	5.7	5.3	5.3	5.3	5.1
ATF799	4.3	6.5	6.3	4.7	5.0	4.7	5.0	5.3	5.3	5.7	5.1
Focus*	4.3	6.0	5.3	5.0	5.0	4.7	4.7	5.3	5.3	5.7	5.1
Gremlin (P-58)*	5.0	5.5	6.3	4.0	4.7	4.7	5.3	5.7	5.3	6.0	5.1
JT-12	4.0	6.0	6.7	4.3	4.7	4.3	5.7	5.7	5.0	6.0	5.1
Millennium*	4.3	6.0	6.3	4.3	4.7	5.3	5.3	5.3	5.0	5.7	5.1
SR8550 (SRX8BE4)*	3.7	7.0	6.0	4.3	5.3	5.0	5.0	5.3	5.3	5.3	5.1
Trooper (T1-TFOR3)*	5.0	6.0	6.0	5.3	4.7	4.7	5.0	5.0	5.0	6.0	5.1
2ndMillennium*	5.0	6.0	6.7	4.7	3.7	4.7	5.7	5.3	5.0	6.3	5.0
MRF25	4.7	7.0	5.3	4.3	5.0	4.7	5.0	5.7	5.0	5.7	5.0
Scorpion*	5.0	6.0	6.3	4.0	4.3	5.0	5.3	6.0	5.0	5.7	5.0
ATF702	4.7	8.0	5.3	4.3	5.0	5.3	5.3	4.7	5.0	5.7	5.0
EA163	4.7	6.0	5.7	5.0	4.0	5.0	4.7	5.0	5.3	6.3	5.0
Expedetion (ATF-803)*	5.0	6.0	6.7	4.7	4.3	4.7	5.3	5.3	5.3	5.7	5.0
JT-15	4.0	6.0	7.0	4.7	4.0	5.3	5.0	5.7	4.7	6.0	5.0

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
MA127	4.7	6.5	5.7	5.3	5.3	5.3	5.0	4.0	5.0	5.3	5.0
Masterpiece*	5.0	5.5	6.0	4.7	4.3	4.3	5.3	6.3	5.3	5.0	5.0
Serengeti (GO-OD2)*	5.3	6.0	6.0	5.3	4.0	4.7	5.3	5.3	5.3	5.3	5.0
Ultimate (01-RUTOR2)*	5.3	6.5	6.3	4.7	4.7	4.0	5.7	6.0	5.0	5.3	5.0
Dynasty*	5.0	5.5	6.7	4.3	4.7	5.7	5.0	5.7	4.0	5.7	5.0
PST-5BAB	4.7	6.0	5.7	4.3	4.0	4.3	5.3	6.3	5.0	5.7	5.0
Picasso*	4.7	6.5	6.3	3.7	4.7	5.0	5.0	5.7	5.7	5.3	5.0
Titanium (SBM)*	4.7	6.0	6.3	4.3	3.7	4.7	5.0	6.3	5.3	5.7	5.0
BARFa1CR7	4.3	7.0	5.3	4.0	3.7	4.7	5.3	6.3	5.7	5.3	5.0
Constitution (ATF-593)*	4.3	7.0	5.3	4.0	4.3	5.0	5.3	5.7	4.7	5.7	5.0
DLF-J210	4.7	6.0	5.7	4.7	4.3	4.7	4.7	6.0	4.7	5.7	5.0
Fidelity (PST-5T1)*	5.0	5.5	6.0	4.3	4.0	4.7	5.0	6.0	4.7	6.0	5.0
Laramie*	4.3	6.0	6.0	4.3	4.0	5.0	5.3	5.0	5.3	5.7	5.0
Prospect*	4.3	6.5	6.0	4.7	4.3	4.3	4.7	5.7	5.3	5.7	5.0
Cayenne*	4.0	6.0	6.0	3.0	4.7	4.7	5.0	6.3	5.3	5.7	5.0
Firebird (CIS-TF-65)*	4.0	7.0	6.0	4.0	4.3	4.3	5.0	5.7	6.0	5.3	5.0
MRF26	4.7	7.0	5.3	4.7	4.7	5.7	5.0	4.7	5.0	5.0	5.0
Escalade (01-ORU1)*	5.3	6.0	6.3	4.7	4.7	4.3	5.0	6.0	4.0	5.7	4.9
FivePointMCN-RC*	5.0	6.5	5.7	4.0	4.3	5.0	5.3	5.3	5.3	5.0	4.9
Guardian-21 (RobertsDOL)*	5.7	6.0	5.7	5.0	3.7	5.0	5.7	5.0	4.3	5.7	4.9
Lexington (UT-RB3)*	4.3	7.5	5.7	4.7	4.3	4.7	5.0	4.3	5.7	5.7	4.9
MA138	4.3	6.5	5.7	5.0	4.0	5.0	5.0	5.0	5.0	5.3	4.9
MRF211	4.7	8.0	6.0	4.3	4.0	4.7	4.7	6.0	5.3	5.3	4.9
Magellan (OD-4)*	4.3	6.0	6.3	5.0	3.7	4.0	4.7	6.3	5.0	5.7	4.9
PST-53T	4.0	6.5	6.3	4.3	4.3	4.3	5.3	4.7	5.0	6.3	4.9
PST-5FZD	4.3	6.0	6.0	4.7	3.3	4.3	5.0	5.0	6.0	6.0	4.9
PST-5JM	4.0	6.5	6.3	4.7	4.7	4.7	5.3	5.0	5.0	5.0	4.9
R-4	5.0	7.5	6.3	4.7	4.0	4.0	5.0	6.0	5.0	5.7	4.9
Raptor (CIS-TF-33)*	3.7	6.0	6.3	4.3	4.3	4.7	5.0	5.0	5.0	6.0	4.9
Watchdog*	5.0	5.5	6.0	5.0	3.7	4.7	5.0	5.7	5.0	5.3	4.9
Biltmore*	4.3	6.5	6.3	4.3	3.7	5.0	5.3	5.7	5.0	5.3	4.9

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Bravo*	4.7	5.5	5.3	5.0	3.7	4.7	5.3	4.3	5.3	6.0	4.9
Endeavor*	4.3	5.5	5.7	3.7	4.3	4.3	5.0	5.3	5.7	5.7	4.9
FalconII*	4.7	5.5	6.3	4.3	3.7	4.7	5.0	5.7	5.3	5.3	4.9
MRF27	5.0	7.0	6.0	4.3	4.3	5.3	5.7	5.0	4.7	4.7	4.9
BARFa1005	4.7	7.0	5.7	4.0	4.3	4.0	4.7	5.7	5.3	6.0	4.9
Blackwatch (Pick-OD3-01)*	5.7	6.0	5.3	4.3	4.0	4.7	5.3	6.0	4.0	5.7	4.9
BladeRunner (RobertsSM4)*	4.7	6.5	5.7	4.7	3.3	4.3	5.0	5.7	5.3	5.7	4.9
MA158	4.3	6.0	6.3	4.0	4.3	4.7	5.3	5.7	4.7	5.3	4.9
MRF28	4.3	8.5	5.7	4.3	4.0	4.7	5.0	5.7	5.3	5.0	4.9
PST-5NAS	5.0	6.0	6.3	4.3	3.7	4.3	5.3	6.3	4.3	5.7	4.9
PureGold*	4.3	5.5	6.0	4.0	4.3	5.0	5.7	5.0	4.7	5.3	4.9
JT-9	5.0	6.0	6.3	3.7	4.0	4.7	5.0	6.0	4.7	5.7	4.8
PickTFH-97	3.7	6.0	6.7	4.0	4.0	4.7	5.7	4.3	5.7	5.3	4.8
Rembrandt*	5.0	6.0	6.0	4.3	4.0	4.3	5.3	5.3	4.7	5.7	4.8
SilveradoII (PST-578)*	4.7	6.0	5.3	3.7	4.0	4.3	5.0	5.7	5.0	6.0	4.8
Davinci (LTP-7801)*	4.3	6.0	6.3	4.3	3.3	4.0	5.7	5.7	5.3	5.3	4.8
FinesseII*	4.7	7.5	5.3	4.0	4.3	5.0	4.7	5.0	5.7	5.0	4.8
JT-13	4.0	6.5	6.3	4.0	4.3	5.0	5.7	4.0	4.3	6.3	4.8
SR8600*	4.7	6.0	6.3	4.0	4.7	5.0	5.0	5.0	4.7	5.3	4.8
Silverstar (PST-5ASR)*	4.3	6.0	5.7	4.7	3.0	3.7	5.0	5.7	6.0	5.7	4.8
TitanLtd.*	4.3	5.0	6.0	4.0	4.3	4.0	5.3	5.7	4.7	5.7	4.8
Quest*	4.0	6.0	6.3	3.7	4.3	4.7	5.3	5.0	5.5	5.3	4.8
Ninja2 (ATF-800)*	4.0	5.5	6.3	4.3	4.0	4.0	5.7	4.3	5.0	6.0	4.8
B-7001	4.7	7.0	5.7	4.3	4.3	3.7	5.0	5.0	5.3	5.7	4.8
BarlexasII*	4.3	6.0	6.0	4.7	4.3	4.0	5.0	4.7	5.0	5.7	4.8
CIS-TF-60	5.3	7.0	6.3	4.3	3.7	4.0	5.0	5.0	5.7	5.7	4.8
CIS-TF-77	4.7	6.5	6.0	4.3	2.7	4.7	5.0	5.7	5.3	5.7	4.8
Forte (BE-2)*	4.7	6.5	5.7	3.7	4.0	4.7	5.0	5.3	5.0	5.7	4.8
Legitimate*	4.7	5.5	5.3	4.7	4.7	4.0	5.3	5.0	4.3	5.3	4.8
PickZMG	5.0	5.5	6.0	3.7	3.7	5.0	5.3	5.0	4.7	6.0	4.8
Rendition*	4.3	6.5	6.0	4.7	5.0	4.7	5.3	4.7	3.7	5.3	4.8

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
Signia*	4.3	7.5	5.3	4.7	4.3	4.7	5.3	4.7	4.0	5.7	4.8
Stonewall (JT-18)*	4.3	6.5	5.7	4.3	4.3	4.3	5.0	5.7	4.3	5.3	4.8
Barrera*	4.3	6.0	5.7	4.3	4.0	4.0	5.0	6.0	4.7	5.0	4.7
Barrington*	4.0	6.0	6.7	4.0	3.7	4.3	5.0	5.3	4.7	6.0	4.7
CIS-TF-64	5.0	6.5	7.0	4.7	3.7	4.7	5.7	4.7	4.7	5.0	4.7
CIS-TF-67	4.0	6.0	6.0	4.0	5.0	4.7	5.7	4.0	3.7	6.0	4.7
FalconIV (F-4)*	5.0	6.0	6.0	4.3	4.0	4.0	5.3	4.7	4.7	6.0	4.7
JT-6	4.0	7.0	6.3	3.7	3.3	5.0	4.7	5.3	5.3	5.7	4.7
MRF29	4.7	7.0	5.7	5.0	3.0	4.3	5.0	5.7	4.7	5.3	4.7
Mustang3*	4.7	6.0	6.3	4.0	3.3	4.3	4.7	6.0	5.0	5.7	4.7
PST-5BZ	4.7	6.0	5.7	3.7	4.3	4.7	5.7	5.3	4.3	5.0	4.7
PST-5KU	4.0	6.5	5.7	3.7	4.7	4.3	5.0	4.3	5.3	5.7	4.7
RebelExeda*	4.7	6.0	5.7	4.7	3.0	4.0	4.7	5.7	5.0	6.0	4.7
SR8250*	5.0	6.5	6.0	4.3	3.3	4.0	5.0	5.0	5.7	5.7	4.7
TarHeel*	5.0	5.5	5.0	3.7	4.0	4.3	5.0	5.7	4.7	5.7	4.7
Turbo (CAS-MC1)*	4.7	7.5	5.3	4.0	3.7	5.0	5.0	5.7	4.0	5.7	4.7
ATF704	4.0	6.0	5.7	3.7	3.7	5.0	5.0	6.0	4.0	5.3	4.7
BARFa1003	4.0	7.0	5.7	4.0	4.7	4.3	5.3	5.0	5.0	4.3	4.7
Coyote*	4.3	6.0	5.7	4.3	4.0	4.7	5.7	5.0	4.0	5.0	4.7
Dominion*	4.0	5.0	5.3	4.3	3.7	4.3	5.0	5.0	4.7	5.7	4.7
TF66*	5.0	5.5	6.7	3.7	4.0	4.7	4.7	5.0	5.7	5.0	4.7
GrandeII*	5.0	6.0	6.0	4.3	4.0	4.3	4.7	4.7	5.0	5.7	4.7
MRF210	4.7	7.0	5.7	4.0	4.0	5.0	4.7	5.0	5.0	5.0	4.7
Dynamic (PST-57E)*	4.3	5.0	6.0	3.7	4.0	4.3	5.0	5.3	4.7	5.3	4.6
K01-E09	4.7	6.0	6.7	4.3	2.7	4.7	5.3	5.0	5.0	5.3	4.6
PST-DDL	4.7	6.0	6.3	5.0	3.7	4.7	4.7	4.7	4.0	5.7	4.6
K01-8015	3.7	6.5	6.3	3.3	4.7	3.7	4.7	5.7	4.7	5.7	4.6
Tahoe (CAS-157)*	4.3	6.0	5.3	4.7	4.3	4.7	5.3	3.0	4.7	5.7	4.6
Daytona (MRF23)*	4.3	7.0	5.3	4.0	4.3	4.3	5.0	5.0	5.0	4.3	4.6
Jaguar3*	4.3	5.5	5.3	4.7	4.0	4.0	5.3	4.3	4.7	5.0	4.6
OlympicGold*	4.7	5.0	5.3	4.0	3.7	4.7	4.7	5.3	4.3	5.3	4.6

Cultivar/	Spring	Genetic		Quality							
Experimental Number	Green-up	Color	Texture	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
RebelSentry*	4.3	6.0	5.7	4.0	4.3	4.3	4.7	4.7	5.0	5.0	4.6
SouthernChoiceII*	4.7	7.0	5.3	4.3	3.7	4.3	4.7	4.7	5.0	5.3	4.6
Tempest*	4.0	7.0	5.7	3.7	3.7	4.3	4.7	5.3	5.0	5.3	4.6
Tracer*	4.7	6.0	6.0	4.7	3.7	3.7	4.3	5.0	5.0	5.7	4.6
GO-RD4	4.7	6.0	6.0	4.3	3.7	3.7	5.0	5.0	5.3	5.0	4.6
ATF586	4.3	5.0	6.7	4.0	3.3	5.0	4.7	5.0	4.0	5.7	4.5
ATF707	4.0	5.5	6.3	4.0	4.0	4.3	5.0	4.0	5.0	5.3	4.5
DP50-9082	4.0	5.0	6.0	4.0	3.3	4.7	4.7	4.7	5.0	5.3	4.5
K01-8007	4.0	6.5	6.7	3.7	4.7	4.7	5.3	4.7	4.0	4.7	4.5
UT-155	4.3	6.0	5.7	4.3	3.3	4.0	4.3	4.3	5.7	5.3	4.5
Pick-00-AFA	4.3	5.0	6.7	4.0	4.3	3.7	4.7	5.3	4.0	5.3	4.5
SouthPaw (MRF24)*	4.7	6.5	5.0	4.3	3.7	4.0	4.3	5.3	4.7	5.0	4.5
Bingo*	5.0	7.5	6.0	4.3	3.7	4.3	4.7	5.0	5.0	4.3	4.5
Barlexas*	4.7	5.5	6.3	4.0	3.3	3.7	4.7	5.3	5.3	4.7	4.4
DP50-9226	4.3	5.0	5.7	4.3	3.3	4.3	5.0	4.3	4.3	5.3	4.4
JTTFF-2000	4.7	6.0	5.3	5.0	3.7	3.7	4.7	4.7	4.3	5.0	4.4
K01-WAF	4.0	5.0	5.7	4.0	4.3	3.3	4.3	5.0	4.3	5.7	4.4
TarHeelII (PST-5TR1)*	5.0	5.0	5.0	3.3	3.7	4.0	5.0	4.5	4.7	5.7	4.4
Kalahari*	4.7	6.0	6.3	4.7	3.0	4.7	5.3	4.0	4.0	5.0	4.4
PST-5KI	4.0	6.0	6.0	4.0	3.0	3.7	4.7	5.7	4.3	5.3	4.4
Stetson*	5.0	4.5	6.0	4.0	3.0	3.7	5.0	4.3	5.0	5.7	4.4
TulsaII (ATF706)*	4.7	5.0	5.7	4.0	3.7	3.7	4.3	5.0	4.7	5.0	4.3
K01-E03	4.3	6.0	6.7	3.7	3.7	4.3	5.0	4.0	4.0	5.7	4.3
T991	4.3	7.0	6.0	3.3	3.7	4.3	4.7	4.3	4.7	5.3	4.3
ATF806	4.3	6.0	6.3	3.7	3.7	5.0	4.3	3.7	4.7	5.0	4.3
Covenant (ATF802)*	4.3	6.0	6.0	3.7	3.7	3.7	4.7	4.0	4.7	5.7	4.3
NA-TDD	4.0	7.7	5.3	3.7	3.3	3.7	5.0	5.0	4.0	5.0	4.2
Wyatt*	4.0	5.0	5.7	3.7	3.3	4.0	4.7	4.7	3.7	5.7	4.2
Elisa*	5.0	4.0	5.7	4.0	3.3	4.0	4.3	4.0	4.3	5.3	4.2
GO-SIU2	5.0	4.5	5.3	3.7	4.0	3.3	4.3	3.7	4.7	5.3	4.1
KittyHawk2000*	3.7	6.0	5.3	4.0	3.3	3.3	5.3	4.0	4.0	5.0	4.1

Cultivar/ Experimental Number	Spring Green-up	Genetic Color	Texture	Quality							
				Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Avg.
TomahawkGT*	4.0	6.0	5.3	3.3	3.0	3.7	4.7	5.0	4.7	4.7	4.1
Floridian (GO-FL3)*	4.7	4.0	5.3	3.7	4.0	3.3	4.3	4.0	4.7	3.7	4.0
Lancer*	5.0	6.0	6.0	3.7	4.0	4.3	4.3	3.0	4.0	4.3	4.0
Matador*	5.0	6.5	5.7	4.0	3.7	4.0	4.3	3.0	3.3	4.7	3.9
Bonsai*	4.3	5.5	6.0	3.3	3.0	4.7	4.3	3.7	3.3	4.3	3.8
Ky-31E+*	5.0	3.3	4.0	2.7	3.0	3.0	3.0	3.0	3.0	3.0	3.0
LSD[3]	*1.9*	*1.8*	*1.4*	*1.9*	*3.6*	*2.7*	*1.8*	*3.0*	*3.0*	*1.8*	*0.8*

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

[2] Cultivars marked with “*” became commercially available in 2005.

[3] To determine statistical differences among entries, subtract one entry’s mean from another’s. If the result is larger than the corresponding LSD value, the two are statistically different.

TITLE: Bermudagrass NTEP Evaluation

OBJECTIVE: To evaluate bermudagrass 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:

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 region in the central United States where bermudagrass can be successfully grown as a perennial turfgrass. Few cultivars that have both acceptable quality and adequate cold tolerance historically 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 Wichita, Kansas. Twenty-nine entries were seeded; 13 vegetative entries were plugged with 12-inch spacings. Starter fertilizer was incorporated into the study plots at planting time at a rate of 1.0 lb N/1,000 sq. ft. Plot fertility was maintained at 0.5 to 0.75 lb N/1,000 sq. ft per growing month. Plots were mowed once a week during the growing season at 0.75 to 1.0 inch. Plots were irrigated as necessary to prevent dormancy and control weeds, insects, and diseases, only to prevent severe stand loss.

During the coarse of the study, information will be collected on spring green-up, genetic color, leaf texture, seed head density, quality, and other measures when appropriate. Rating is done on a scale of 1=poorest, 6=acceptable, and 9=optimum measure.

RESULTS:

By May 17, 2005, the vegetative varieties Ashmore, Midlawn, and OKC 70-18, and the seeded varieties Yukon and Riviera, were the greenest (Table 1). Turf quality was rated monthly from May through September. Quality ratings were influenced by degree of coverage and weed infestation, as well as turf color, texture, density, and the presence of seed heads. The best overall vegetative performers were OKC 70-18, Patriot, and Midlawn; the best seeded varieties were Yukon, SWI-1044, and SWI-1045. Because clean-looking turf with no seed heads is preferred, seed head density was rated in spring, summer, and fall. At the end of May, most of the turfgrass plots had few, if any, seed heads (Table 2). In July, vegetative varieties MS-Choice, Patriot, and OR 2002, and seeded varieties SWI-1046, Riviera, and Yukon, had the fewest seed heads; in September, the vegetative varieties Ashmore and Midlawn, and seeded varieties Yukon, SWI-1014, and SWI-1046, had the fewest. Mid-season, the turfgrass stands were rated for overall density, and the densest stands were vegetative varieties OR 2002, OKC 70-18, and Tifway, and seeded varieties SWI-1044 and SWI-1046. Toward the end of the growing season, vegetative entries MS-Choice, Celebration, and Patriot, and seeded entry SWI-102, were the darkest green. Vegetative entries Ashmore, OKC 70-18, Midlawn, and OR 2002, and seeded entries Yukon, SWI-1012, SWI-1044, and SWI-1046, had the finest texture. Just before first frost, the turf was rated for fall color retention; vegetative varieties MS-Choice, Tifway, and Tifsport, and seeded varieties Tift No. 2, SWI-1014, and Tift No. 1, were the greenest. More information on the National Turfgrass Evaluation Program and nationwide 2002 National Bermudagrass Test results can be found at http://www.ntep.org.

Table 1. 2005 performance of bermudagrass cultivars at Wichita, Kansas.[1]

Cultivar/ Experimental Number	S or V[2]	Spring Green-up	Quality					
			May	Jun.	Jul.	Aug.	Sep.	Avg.
OKC 70-18	V	6.0	5.3	5.3	6.0	5.7	5.3	5.5
Patriot*[3]	V	4.7	4.0	5.7	7.0	5.3	5.7	5.5
Yukon*	S	5.7	5.3	5.0	5.7	6.0	5.7	5.5
Midlawn*	V	6.0	5.3	5.0	6.3	6.0	4.7	5.5
SWI-1044	S	4.0	3.7	5.0	6.0	6.0	6.7	5.5
SWI-1045	S	4.0	4.3	5.0	5.7	6.3	5.7	5.4
OR 2002	V	5.3	4.7	5.0	6.7	4.7	6.0	5.4
Riviera*	S	5.0	4.3	5.3	5.7	5.7	5.7	5.3
SWI-1046	S	4.7	4.0	5.0	5.0	6.7	5.3	5.2
Tifsport*	V	4.3	4.3	5.3	5.7	5.3	4.7	5.1
Tifway*	V	4.3	4.3	5.3	5.7	5.0	4.7	5.0
SWI-1012	S	4.7	4.3	4.7	5.3	5.3	5.3	5.0
Celebration*	V	4.0	3.7	4.7	5.3	4.7	5.3	4.7
Aussie Green*	V	4.0	4.0	4.7	4.3	5.0	4.7	4.5
SWI-1041	S	3.3	2.7	4.0	4.7	5.0	5.7	4.4
CIS-CD5	S	3.7	2.7	4.3	4.7	5.0	5.0	4.3
MS-Choice*	V	2.0	2.0	4.0	4.7	5.7	5.3	4.3
Princess 77*	S	3.0	2.7	3.7	5.0	5.7	4.7	4.3
SWI-1014	S	4.7	3.3	4.0	5.0	5.0	4.3	4.3
Panama*	S	2.7	2.7	4.0	4.3	4.7	5.0	4.1
Sunbird (PST-R68A)*	S	3.7	3.0	4.3	4.3	4.3	4.7	4.1
Transcontinental*	S	3.3	3.0	4.3	4.3	4.0	4.7	4.1
Tift No. 4	V	3.7	3.7	4.0	4.3	3.7	4.3	4.0
CIS-CD6	S	4.0	3.3	4.7	3.7	4.3	4.0	4.0
CIS-CD7	S	3.7	3.0	4.0	4.7	4.3	4.0	4.0
FMC-6*	S	2.7	2.3	4.3	4.7	4.0	4.7	4.0
SR 9554*	S	3.7	2.7	4.0	4.3	4.3	4.7	4.0
Tift No. 3	V	3.3	2.3	3.7	4.7	4.3	5.0	4.0
Sunstar*	S	3.0	2.7	4.0	4.3	4.0	4.7	3.9
LaPaloma (SRX 9500)*	S	2.7	2.7	4.0	4.0	4.0	4.3	3.8
SWI-1001	S	3.0	2.7	4.0	3.7	4.3	4.3	3.8
Southern Star*	S	2.7	2.3	3.7	4.7	4.0	4.3	3.8
Ashmore*	V	6.7	5.3	4.3	2.7	3.0	3.3	3.7
B-14	S	3.0	2.7	3.7	3.7	4.0	4.0	3.6
GN-1*	V	2.7	2.3	3.7	4.0	4.0	4.0	3.6
SWI-1003	S	3.3	2.7	3.3	3.7	4.0	4.3	3.6
NuMex Sahara*	S	2.0	2.3	3.3	4.3	3.7	4.0	3.5
Mohawk*	S	3.0	2.3	3.7	3.7	3.7	4.0	3.5
Sundevil II*	S	3.3	2.3	3.3	3.7	3.7	3.7	3.3
Arizona Common*	S	2.0	2.0	3.0	3.3	3.7	4.0	3.2
Tift No. 1	S	2.3	2.0	2.0	3.0	3.3	3.7	2.8
Tift No. 2	S	1.0	0.7	1.3	1.3	1.7	1.7	1.3
LSD[4]		*0.9*	*0.8*	*0.9*	*1.2*	*1.0*	*1.3*	*0.7*

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

[2] Seeded or vegetative varieties.

[3] Cultivars marked with "*" all commercially available in 2005.

[4] To determine statistical differences among entries, subtract one entry's mean from another's. If the result is larger than the corresponding LSD value, the two are statistically different.

Table 2. 2005 Performance of Bermudagrass cultivars at Wichita, Kansas (continued).[1]

Cultivar/ Experimental Number	V or S[2]	Genetic Color	Texture	Summer Density	Fall Color	Seed Heads May	Seed Heads July	Seed Heads Sept.
OKC 70-18	V	6.0	8.3	7.7	5.0	9.0	6.7	7.3
Patriot*	V	7.7	5.0	7.3	4.0	9.0	8.0	8.7
Yukon*	S	6.7	6.3	7.0	5.0	9.0	5.3	7.7
Midlawn*	V	6.3	7.7	6.3	4.7	9.0	6.0	9.0
SWI-1044	S	6.0	6.0	7.3	3.7	8.7	5.0	6.7
SWI-1045	S	6.7	5.7	6.7	4.3	9.0	4.3	6.7
OR 2002	V	6.0	7.7	8.0	4.3	9.0	7.7	7.7
Riviera*	S	7.0	4.7	6.3	3.7	8.7	5.3	6.3
SWI-1046	S	7.0	6.0	7.3	4.3	9.0	6.0	7.0
Tifsport*	V	6.7	7.0	7.3	5.3	9.0	6.3	8.7
Tifway*	V	7.0	7.3	7.7	6.0	9.0	5.0	8.7
SWI-1012	S	7.3	6.0	7.0	5.0	9.0	5.0	6.7
Celebration*	V	7.7	5.7	7.0	4.0	9.0	4.3	7.7
Aussie Green*	V	6.7	6.0	6.7	3.3	9.0	6.3	8.0
SWI-1041	S	6.3	4.7	6.7	4.0	9.0	3.7	6.3
CIS-CD5	S	7.0	4.7	5.3	3.0	8.7	4.0	5.3
MS-Choice*	V	8.0	4.3	7.3	6.7	9.0	8.7	8.7
Princess 77*	S	7.0	5.3	5.3	3.7	9.0	3.7	5.7
SWI-1014	S	6.3	4.7	5.7	5.3	9.0	4.7	7.0
Panama*	S	6.3	5.0	4.7	2.7	8.7	4.3	5.3
Sunbird (PST-R68A)*	S	6.3	4.3	4.7	3.0	8.7	4.7	5.0
Transcontinental*	S	6.0	4.7	4.7	2.7	8.7	4.3	4.3
Tift No. 4	V	6.3	6.3	7.3	5.0	9.0	4.3	8.0
CIS-CD6	S	6.0	4.3	5.3	3.0	7.0	4.7	4.7
CIS-CD7	S	7.0	4.3	4.7	3.3	9.0	4.0	5.0
FMC-6*	S	6.0	4.3	4.7	2.7	8.7	4.7	5.3
SR 9554*	S	6.3	5.3	5.3	2.7	8.7	3.7	5.0
Tift No. 3	V	6.7	5.7	6.7	3.7	9.0	6.0	8.0
Sunstar*	S	6.3	4.3	4.0	2.7	9.0	5.0	5.7
LaPaloma (SRX 9500)*	S	6.3	4.7	5.0	3.0	9.0	4.3	5.3
SWI-1001	S	6.3	4.7	5.0	3.0	8.7	4.7	5.3
Southern Star*	S	6.7	4.0	4.7	2.3	9.0	3.7	4.7
Ashmore*	V	5.0	8.3	4.0	5.0	9.0	7.3	9.0
B-14	S	5.7	4.0	4.0	2.3	8.3	4.0	5.0
GN-1*	V	7.0	4.7	6.3	3.3	9.0	5.0	7.7
SWI-1003	S	6.3	5.0	5.7	3.7	8.3	2.7	4.7
NuMex Sahara*	S	6.0	4.3	4.0	3.0	9.0	5.0	5.7
Mohawk*	S	6.0	4.0	4.3	2.3	8.7	4.7	5.7
Sundevil II*	S	5.7	4.3	4.0	2.7	8.7	4.0	4.7
Arizona Common*	S	6.3	4.0	3.3	3.0	8.3	4.3	5.7
Tift No. 1	S	7.0	4.3	5.3	5.3	9.0	3.7	5.0
Tift No. 2	S	6.5	4.5	4.5	5.5	9.0	5.0	6.0
LSD[3]		*0.7*	*1.1*	*1.2*	*1.3*	*0.8*	*1.1*	*0.9*

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

[2] Seeded or vegetative varieties.

[3] To determine statistical differences among entries, subtract one entry's mean from another's. If the result is larger than the corresponding LSD value, the two are statistically different.

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.

MATERIALS AND METHODS:

Seeded and vegetative zoysiagrass selections were planted on June 27, 2002. Turf was maintained at a 0.5 inches, and received 1 lb N per 1,000 sq. ft in June and July. Irrigation was applied to prevent drought stress. Data were collected on turf quality each month and on fall color. Plots were rated visually on a 0-to-9 scale, 9 = best. A quality rating of 7 was considered acceptable for a golf course fairway.

RESULTS:

Those interested can see results from this location, and others throughout the United States on the web at www.ntep.org. Zorro, which performed well in 2004, suffered some freezing injury and had lower quality ratings in 2005. Emerald, another cultivar known to lack hardiness, did not suffer freezing injury, and had good quality in both July and August. DALZ 0102 is a cultivar that has a medium texture, but excellent density. We are presently evaluating its hardiness relative to Meyer zoysiagrass in controlled freezing evaluations in the laboratory. In addition to good quality in July and August, DALZ 0102 also exhibited good fall color when rated in October. Unlike seeded bermudagrasses, most seeded zoysias have very good winter hardiness. Hardiness of some of the vegetative cultivars in this evaluation is still suspect, however, because we have not had a terribly cold winter since the study was established.

Table 1. Summer quality and fall color of zoysiagrass cultivars at Manhattan, Kansas, in 2005.

	Seeded (S) or	Color[1]	Quality		
Name	vegetative (V)	Oct.	July	August	Mean
DALZ 0102	V	6.0	8.0	7.7	7.8
Emerald*	V	7.0	7.3	7.7	7.5
BMZ 230	V	4.0	6.0	6.7	6.3
DALZ 0101	V	7.0	6.0	6.7	6.3
Himeno	V	3.3	5.7	6.0	5.8
Chinese Common*	S	3.3	4.7	5.7	5.2
PZA 32	S	2.7	4.7	5.7	5.2
Zorro*	V	5.3	4.3	6.0	5.2
PZB 33	S	4.0	4.7	5.3	5.0
Companion*	S	2.3	4.7	5.0	4.8
J-37	S	3.3	4.7	5.0	4.8
PST-R7MA	S	2.7	4.7	5.0	4.8
Zenith*	S	3.3	4.7	5.0	4.8
DALZ 0104	V	1.7	5.0	4.3	4.7
GN-Z	V	3.0	5.0	4.3	4.7
DALZ 0105	V	2.3	4.7	4.3	4.5
DALZ 9604	V	2.0	4.7	4.0	4.3
Meyer*	V	2.0	4.3	4.3	4.3
6186	V	1.7	4.0	4.0	4.0
PST-R7ZM	V	2.0	3.7	4.0	3.8
LSD**		1.3	1.2	1.9	1.5

[1] Ratings done visually on a 0-to-9 scale; 9 = best.

[*] Commercially available in the United States in 2006.

[**] To determine statistical differences among entries, subtract the mean of one entry from that of another. A statistical difference occurs when the value is larger than the corresponding Least Significant Difference (LSD) value.

TITLE: Fine Fescue NTEP Evaluation

OBJECTIVES: Evaluate performance of fine fescue species and cultivars for adaptation in Kansas.

PERSONNEL: Jack Fry

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION:

Fine fescues are commonly used in mixtures for shady lawns in Kansas. Due to the fine texture and good drought resistance in these species, however, there is interest in identifying potential fine fescues for use in full sun as monostands.

MATERIALS AND METHODS:

Fine fescue species and cultivars were seeded in autumn 2003 in a full-sun location at the Olathe Research Center. Plots were mowed at 3 inches, received no irrigation, and receive 3 lb N/1,000 ft^2 per year. Species included strong creeping, hard, chewings, slender creeping, and sheep fescues.

Data were collected on turf quality each month from May through August. Quality was rated visually on a 0-to-9 scale, 9 = best. A quality rating of 6 was considered acceptable for a home lawn.

RESULTS:

Those interested can see results from this location, and others throughout the United States on the web at www.ntep.org. Commercially available cultivars and selections that had a mean quality rating greater than 6 were Predator (hard), SPM (hard), Berkshire (hard), Oxford (hard), Quatro (Sheep), SR 3000 (hard). Although some of these fine fescues have performed exceptionally well with no irrigation and in full sun, caution should still be taken before using these as monostands in full-sun locations. Fine fescue often declines in quality when soil conditions are wet and temperatures are high. We did not experience prolonged, saturated soil conditions at Olathe in 2005.

Table 1. Quality of hard, sheep, chewings, strong creeping, and slender creeping fescues at Olathe, Kansas, in 2005.

		Quality[1]		
Name	Type	June	July	Mean
IS-FL 28	Hard	7.0	7.0	7.0
Pick HF #2	Hard	7.0	7.0	7.0
Predator*	Hard	7.0	7.0	7.0
SPM	Hard	7.0	6.7	6.8
Berkshire*Hard	Hard	6.3	6.7	6.5
Oxford*Hard	Hard	6.7	6.3	6.5
Quatro*	Sheep	6.3	6.7	6.5
SR 3000*	Hard	6.0	7.0	6.5
DP 77-9985	Chewings	7.0	5.7	6.3
IS-FRR 23	Strong creeping	6.7	6.0	6.3
PST-4TZ	Chewings	6.7	6.0	6.3
Compass (ACF 188)	Chewings	6.7	5.7	6.2
Reliant IV (A01630REL)	Hard	6.0	6.3	6.2
Culumbra II (ACF 174)	Chewings	6.7	5.3	6.0
DLF-RCM	Strong creeping	6.7	5.3	6.0
PST-8000	Strong creeping	5.7	6.3	6.0
SRX 3K	Hard	6.0	6.0	6.0
SRX 51G	Chewings	6.3	5.7	6.0
7 Seas*	Chewings	6.3	5.3	5.8
IS-FRC 17	Chewings	6.0	5.7	5.8
Longfellow II*	Chewings	6.3	5.3	5.8
Scaldis*	Hard	5.7	6.0	5.8
SRX 55R	Slender creeping	6.0	5.7	5.8
Zodiac (Bur 4601)	Chewings	6.3	5.3	5.8
Celestial*	Strong creeping	6.3	5.0	5.7
DP 77-9360	Strong creeping	6.0	5.3	5.7
TL1	Strong creeping	6.3	5.0	5.7
5001	Strong creeping	6.0	5.0	5.5
C-SMX	Strong creeping	6.3	4.7	5.5
C03-RCE*	Strong creeping	6.0	5.0	5.5
Dawson E*	Slender creeping	5.3	5.7	5.5
DP 77-9578	Strong creeping	5.7	5.3	5.5
DP 77-9579	Strong creeping	5.7	5.3	5.5
IS-FRR 29	Strong creeping	5.3	5.7	5.5
IS-FRR 30	Strong creeping	5.7	5.3	5.5
J-5 (Jamestown 5)*	Chewings	6.0	5.0	5.5
Razor*	Strong creeping	5.7	5.3	5.5
Seabreeze	Slender creeping	6.0	5.0	5.5

Table 1. (cont.) Quality of hard, sheep, chewings, strong creeping, and slender creeping fescues at Olathe, Kansas, in 2005.

		Quality[1]		
Name	Type	June	July	Mean
TL 53	Strong creeping	6.3	4.7	5.5
Ambassador*	Chewings	5.7	5.0	5.3
Cascade*	Chewings	6.0	4.7	5.3
Jasper II*	Strong creeping	5.7	5.0	5.3
Musica*	Strong creeping	5.7	5.0	5.3
Pick CRS 1-03	Strong creeping	6.0	4.7	5.3
BMXC-S02	Strong creeping	5.3	5.0	5.2
CO3-4676	Strong creeping	4.7	5.3	5.0
Oracle*	Strong creeping	5.3	4.7	5.0
ASC 245	Strong creeping	5.0	4.7	4.8
Pathfinder*	Strong creeping	4.7	5.0	4.8
Audubon*	Strong creeping	5.0	4.3	4.7
DP 77-9886	Chewings	5.0	4.3	4.7
Shademaster*	Strong creeping	4.7	4.7	4.7
Boreal*	Strong creeping	5.0	3.7	4.3
LSD**		1.5	1.3	1.0

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[1] Ratings done visually on a 0-to-9 scale; 9 = best.

[*] Commercially available in the United States in 2006.

[**] To determine statistical differences among entries, subtract the mean of one entry from that of another. A statistical difference occurs when the value is larger than the corresponding Least Significant Difference (LSD) value.

TITLE: Creeping Bentgrass Fairway NTEP Evaluation

OBJECTIVES: Evaluate performance of creeping bentgrass cultivars under golf course fairway management conditions.

PERSONNEL: Jack Fry

SPONSOR: National Turfgrass Evaluation Program

INTRODUCTION:

Creeping bentgrass is used for putting greens in Kansas, but several courses are using it on fairways. In the eastern half of the United States, creeping bentgrass fairways are commonplace. Information is needed on which creeping bentgrass cultivars are best suited to use under golf course fairway conditions.

MATERIALS AND METHODS:

Creeping bentgrass was seeded on September 24, 2004, in plots measuring 6 by 6 ft. In 2005, the study area received 3 lb N/1,000 ft^2. Turf was mowed at 0.5 inches; no aerification or topdressing was employed. Irrigation was applied to prevent drought stress. An insecticide was applied in July for white grub control; no other pesticides were applied.

Data were collected on turfgrass quality each month from July to September. Ratings were done visually on a 0-to-9 scale, 9 = best; a quality rating of 7 was considered acceptable for a golf course fairway.

RESULTS:

Those interested can see results from this location, and others throughout the United States on the web at www.ntep.org. In general, creeping bentgrasses performed better than colonial bentgrasses. Quality of cultivars was below an acceptable level, except for the variety 13-M in July. Commercially available cultivars that were statistically similar to 13-M in mean quality were Penneagle II, Pennlinks II, L-93, Alpha, Bengal, Penncross, and SR 1119.

Table 1. Quality of creeping and colonial bentgrass cultivars maintained at fairway height at Manhattan, Kansas, in 2005.

		Quality[1]				
Name	Type	July	August	Sept.	Oct.	Mean
13-M	Creeping	7.3	6.3	6.3	5.3	6.3
Penneagle II*	Creeping	6.0	5.7	6.0	5.3	5.8
Pennlinks II*	Creeping	6.7	5.3	5.3	5.7	5.8
L-93*	Creeping	6.0	5.0	6.0	5.0	5.5
Alpha*	Creeping	5.0	5.3	5.3	5.3	5.3
Penncross*	Creeping	5.7	4.7	4.7	6.0	5.3
Bengal*	Creeping	5.3	5.3	5.3	5.0	5.3
PST-OEB	Creeping	5.0	5.0	5.3	6.0	5.3
SR 1119*	Creeping	5.3	5.0	5.3	5.7	5.3
LS-44*	Creeping	5.7	5.3	5.3	4.3	5.2
Princeville*	Creeping	5.3	4.3	5.3	5.7	5.2
Independence*	Creeping	5.0	5.0	5.0	5.0	5.0
IS-AP 14	Creeping	4.7	4.7	5.0	5.7	5.0
T-1*	Creeping	5.0	4.3	5.7	5.0	5.0
235050	Creeping	5.3	4.7	5.0	4.3	4.8
PST-9NBC	Colonial	5.0	4.7	4.0	5.3	4.8
Shark (23R)	Creeping	5.3	4.3	5.3	4.0	4.8
SR 1150 (SRX 1PDH)	Creeping	4.0	4.7	5.7	5.0	4.8
EWTR	Colonial	5.0	4.7	4.0	5.0	4.7
IS-AT 7	Colonial	5.3	4.3	4.3	4.7	4.7
PST-9VN	Colonial	4.7	5.0	4.0	5.0	4.7
Seaside*	Creeping	5.0	4.0	4.0	5.3	4.6
Kingpin (9200)	Creeping	5.0	4.3	5.0	3.7	4.5
Mackenzie (SRX 1GPD)	Creeping	4.7	4.3	5.0	4.0	4.5
Tiger II*	Colonial	4.3	4.0	4.0	5.7	4.5
Bardot*	Colonial	5.0	3.7	4.0	5.0	4.4
Declaration*	Creeping	4.7	3.7	4.3	4.7	4.3
SR 7150*	Colonial	4.0	3.7	3.7	5.3	4.2
LSD**		1.4	1.3	1.0	3.0	1.0

[1] Ratings done visually on a 0-to-9 scale; 9 = best.

* Commercially available in the United States in 2006.

** To determine statistical differences among entries, subtract the mean of one entry from that of another. A statistical difference occurs when the value is larger than the corresponding Least Significant Difference (LSD) value.

TITLE: Fairy Ring/Localized Dry Spot Complex Reduction with Fungicides and a Wetting Agent

OBJECTIVE: Evaluate preventive applications of Bayleton® and curative applications of Prostar® for reduction of a fairy ring/localized dry spot complex on creeping bentgrass.

PERSONNEL: Jack Fry and Qi Zhang

SPONSOR: Bayer

MATERIALS AND METHODS:

Treatments are indicated in the tables. Initial treatments were applied on April 15, 2005, on an L-93 practice putting green maintained according to standard maintenance practices at the Colbert Hills golf course in Manhattan, Kansas. The green was constructed by using a California-style method, and 5 to 10% by volume organic matter was used with sand during construction in 1999. No aerification had been done since construction. All treatments were initially applied on April 15. On this date, a Bayleton® 25 W fungicide was used, so the active ingredient applied was half of what was desired. The second application (all but Prostar®) was made on May 5, 2005. On this date, Bayleton® 50 W was used, so the level of active ingredient was as originally intended. The last applications of Bayleton® + Lescoflo® and Lescoflo® alone were made on May 31. On July 22, a curative treatment of Prostar® + wetting agent was applied (no other treatments). Plots measured 5 by 5 ft, and were arranged in a randomized complete-block design with four replications. Fungicides were applied in 10 gallons of water per 1,000 ft^2. All treatments were watered in immediately with 0.25 inches of water after application.

Both fairy ring (FR) and localized dry spot (LDS) were commonly present in the same plot. Therefore, plots were rated for percentage of FR/LDS complex and turfgrass quality. Data on individual rating dates, and as a season summary (AUDPC; Area Under the Disease Progress Curve), were subjected to analysis of variance. Percentage of FR/LDS complex on April 15 was used as covariate for the measurements after April 15. Means were separated by using an F-LSD procedure ($P < 0.05$).

RESULTS:

Treatment differences in extent of the FR/LDS complex were observed on 7 of 11 rating dates (Table 1). On all but one rating date, Lescoflo® alone provided a reduction in the FR/LDS complex equivalent to that provided by the fungicide + Lescoflo® combinations. On June 6, plots that had been treated with Bayleton® at 2 oz/1,000 ft^2 had less FR/LDS than all treatments except plots receiving Bayleton® at 1.5 oz/1,000 ft^2. Analysis of AUDPC indicated that all treated plots had less of the FR/LDS complex than the untreated plots had.

Differences in turf quality were observed on 5 of 8 rating dates (Table 2). Quality in fungicide + Lescoflo® treatments was similar to quality in turf treated with the Lescoflo® alone on 3 of the 5 dates. On June 24, Bayleton® (2 oz) + Lescoflo® provided higher quality than all other treatments. On August 31, plots that had been treated with Prostar® + Lescoflo® on July 22 had higher quality than those receiving only Lescoflo®.

Table 1. Percentage fairy ring/localized dry spot complex on an L-93 creeping bentgrass putting green as affected by treatments at the Colbert Hills Golf Course at Manhattan, Kansas, in 2005.

Treatment[1]	April	May			June		July		Aug			Sep	AUDPC
	15	5	20	31	6	24	1	19	5	18	31	15	
Check	8.3	8.3	7.8 a	8.8	6.7 a	10.4 a	8.5	21.3	34.5 a	48.5 a	31.8 a	19.3 a	199.5 a
Bayleton® 50 W 1.5 oz/1,000 sq.ft + Lescoflo® 8.0 fl. oz/1,000 sq. ft	8.5	6.6	3.8 abc	4.4	2.1 bc	4.1 b	5.0	9.8	13.3 b	12.5 b	8.5 b	3.5 b	74.4 b
Bayleton® 50 W 2.0 oz/1,000 sq.ft + Lescoflo® 8.0 fl. oz/1,000 sq. ft	6.0	3.4	1.9 bc	0.9	0.0 c	1.9 b	8.0	8.3	11.0 b	7.3 b	5.3 b	4.3 b	56.6 b
Prostar® 70 W 4.5 oz/1,000 sq. ft + Lescoflo® 8.0 fl. oz/1,000 sq. ft	4.8	6.8	5.3 ab	3.7	4.0 ab	4.2 b	4.8	9.0	9.0 b	5.3 b	4.8 b	1.8 b	64.6 b
Lescoflo® 8.0 fl. oz/1,000 sq. ft	10.0	3.1	-0.1 c	3.5	4.8 ab	4.9 b	7.5	8.8	10.8 b	13.3 b	8.8 b	6.8 b	66.3 b
ANOVA	NS	NS	*	NS	*	*	NS	NS	*	*	*	*	*

*, NS, significant at $P \le 0.05$ and not significant, respectively. Means followed by the same letter in a column are not significantly different.

[1] Bayleton® was applied at one-half the listed rate (but with the listed rate of Lescoflo®) on April 15 and at the indicated rate on May 5 and 31. Prostar® + Lescoflo® was applied on April 15 and July 22. Lescoflo® alone was applied on April 15 and May 5 and 31.

Table 2. Creeping bentgrass visual quality as affected by treatments at Colbert Hills Golf Course at Manhattan, Kansas, in 2005.

Treatment[1]	Quality[2]							
	May	June		July	August			September
	31	6	24	19	5	18	31	15
Check	5.6	4.9	4.9 c	3.4 b	3.8	3.0 b	3.3 c	4.0 b
Bayleton® 50 W 1.5 oz/1,000 sq.ft + Lescoflo® 8.0 fl. oz/1,000 sq. ft	6.9	5.9	6.2 b	5.5 a	5.0	5.0 a	5.0 ab	6.5 a
Bayleton® 50 W 2.0 oz/1,000 sq.ft + Lescoflo® 8.0 fl. oz/1,000 sq. ft	7.5	7.2	7.5 a	6.0 a	5.3	5.5 a	5.5 ab	6.3 a
Prostar® 70 W 4.5 oz/1,000 sq. ft + Lescoflo® 8.0 fl. oz/1,000 sq. ft	6.5	6.0	6.0 b	5.5 a	5.0	5.8 a	6.0 a	6.5 a
Lescoflo® 8.0 fl. oz/1,000 sq. ft	7.2	6.4	5.7 b	5.5 a	4.8	4.8 a	4.5 bc	5.8 a
ANOVA	NS	NS	*	*	NS	*	*	*

*, NS, significant at $P \leq 0.05$ and not significant, respectively. Means followed by the same letter in a column are not significantly different.

[1] Bayleton® was applied at one-half the listed rate (but with the listed rate of Lescoflo®) on April 15 and at the indicated rate on May 5 and 31. Prostar® + Lescoflo® was applied on April 15 and July 22. Lescoflo® alone was applied on April 15 and May 5 and 31.

[2] Quality was rated visually on a 0-to-9 scale; 7 = acceptable quality for a putting green.

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