K-STATE TURFGRASS RESEARCH 2009

REPORT OF PROGRESS 1015

KANSAS STATE UNIVERSITY
AGRICULTURAL EXPERIMENT
STATION AND COOPERATIVE
EXTENSION SERVICE

Steve Keeley, associate professor of turfgrass science, will be leaving K-State in September.
Thanks, Steve, for your service to K-State and the Kansas turfgrass industry.

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2009

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Note: Photos by K-State turfgrass faculty, staff, and students unless otherwise noted.

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Foreword

Turfgrass Research 2009 contains results of projects conducted by K-State faculty and graduate students. Some of these results will be presented at the Kansas Turfgrass Field Day on August 6, 2009, at the John C. Pair Horticultural Center in Wichita, KS. Articles in this Report of Progress summarize research projects that were completed recently or will be completed in the next year or two. Specifically, this year's report presents summaries of research on environmental stresses and the environment, disease control, and cultivar evaluations.

What questions can we answer for you? The K-State turfgrass research team strives to be 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, reports from previous years, and all K-State Research and Extension publications relating to turfgrass online at:

www.ksuturf.com and *www.ksre.ksu.edu/library/*

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Nitrogen Source and Timing Effect on Low-Temperature Tolerance of Bermudagrass

Objectives: Evaluate the effect of applying the total annual nitrogen (N) as a polymer-coated N source in either spring or late summer on low-temperature tolerance of 'Midlawn' bermudagrass.

Compare the effect of polymer-coated N sources and urea on low-temperature tolerance of 'Midlawn' bermudagrass.

Investigators: Tony Goldsby and Steve Keeley

Introduction

Nonstructural carbohydrates (NSC) are the energy source for turfgrass growth and recovery; consequently, NSC levels have often been used as an indicator of the physiological health and stress tolerance of a turfgrass. Several research studies have shown that higher NSC levels in winter improve low-temperature survival of various turfgrass species. Spring regrowth after winter dormancy and turfgrass recovery from excessive traffic and other stresses are also dependent on an adequate supply of NSC.

In several published studies, researchers debate the effects of late-season applications of N to warm-season grasses. Some believe these late application timings affect not only the level of NSC in the plant, but also the color and quality of the stand late into the growing season and on greenup in the spring. Turfgrasses with high tissue N have been shown to be less resistant to winter injury. Likewise, previous research reported that late-season N applications have been linked to increased vulnerability to winterkill and disease infestation of 'Tifgreen' and 'Tifdwarf' bermudagrass.

In contrast, recent studies reported that late-season N applications had no effect on winter survival of bermudagrass. Some studies also showed that water-soluble N had little effect on NSC levels of 'Tiflawn' and 'Tifgreen' bermudagrass receiving late-season fertilization. Turfgrass stands receiving late-season N were found to have enhanced turf greening the following spring. The benefits attained from late-season N applications might outweigh the potential negative effects. Further investigation into the relationship between NSC and low-temperature tolerance may provide more insight into the effects of late-season N applications on low-temperature tolerance of bermudagrass.

Objectives of our study were to: (1) determine the effect of applying the total annual N as a polymer-coated N source in either spring or late summer on low-temperature tolerance of 'Midlawn' bermudagrass (*Cynodon dactylon* L. Pers. × *C. transvaalensis* Burtt-Davy) and (2) compare the effect of the polymer-coated N regimes with a traditional N fertilization regime using urea.

Methods

Low-temperature tolerance of 'Midlawn' bermudagrass, as affected by N source and timing, was evaluated during the winter of 2006-2007. Nitrogen sources included a polymer-coated urea (PCU) that had an analysis of 43-0-0 and urea. The PCU was applied in single, yearly applications at 4 lb N/1,000 ft^2 in either April or August. Urea was applied at 1 lb N/1,000 ft^2 in May, June, July, and August. Low-temperature tolerance was measured with the following method: 25 plugs (2 in. diameter × 2.5 in. deep) were extracted from each treatment plot in November 2006 and January and March 2007. Plugs were immediately placed in a growth chamber and allowed to acclimate at 37°F for a period of 12 hours. Following the 12-hour acclimation period, plugs were moved to a thermo-controlled freezing chamber at 26°F. The temperature was then decreased at a rate of 5°F/hour, and five plugs were removed at each respective temperature. For the November and March sampling periods, plugs were removed at -6, -11, -16, -21, and -26°F, and for the January sampling period, plugs were removed at -11, -16, -21, -26, and -31°F.

After the freezing regime, plugs were allowed to reacclimate at 37°F for 12 hours. Plugs were then transplanted into 4-in. pots in a medium containing three parts peat, two parts sand, and two parts vermiculite (by volume) and kept in a greenhouse at 77°F for observation. Plugs were observed weekly for 6 weeks on two parameters, survival and percent recovery. If any regrowth was observed, the plug was given a status score of 1. If no regrowth occurred, the plug was given a status score of 0. Additionally, plugs were given a percent recovery rating from 1% to 100% to further track recovery.

Results

Application timing of PCU did not have a significant effect on low-temperature survival of 'Midlawn' bermudagrass. The PCU applied in April or August resulted in similar survival. In contrast, N source had a significant effect on low-temperature tolerance. Compared with urea, PCU fertilizers showed higher percent recovery means for the November 2006 and March 2007 sampling periods (Table 1 and Figure 1). This difference was significant for both periods when April-applied PCU was compared with urea. Our research did not indicate that the improved low-temperature tolerance was related to NSC levels. Further research investigating individual water-soluble carbohydrates or other factors is needed to elucidate the mechanism of improved low-temperature tolerance.

Table 1. Percent recovery of 'Midlawn' bermudagrass fertilized with different nitrogen sources at different times and then subjected to low temperatures, Manhattan

		Recovery (%)[1]		
Nitrogen source[2]	Timing	Nov. 2006	Jan. 2007	Mar. 2007
PCU	April	88a	72	72a
PCU	August	76ab	72	68ab
Urea	May, June, July, August	68b	68	56b

[1] Means refer to recovery after exposure to low temperatures. Plugs received a rating from 1% to 100% (1% = little or no growth, 100% = complete growth).

[2] PCU = polymer-coated urea applied in single yearly applications at 4 lb N/1,000 ft^2. Urea was applied at 1 lb N/1,000 ft^2.

Within a column, means followed by the same letter are not significantly different at $P = 0.05$.

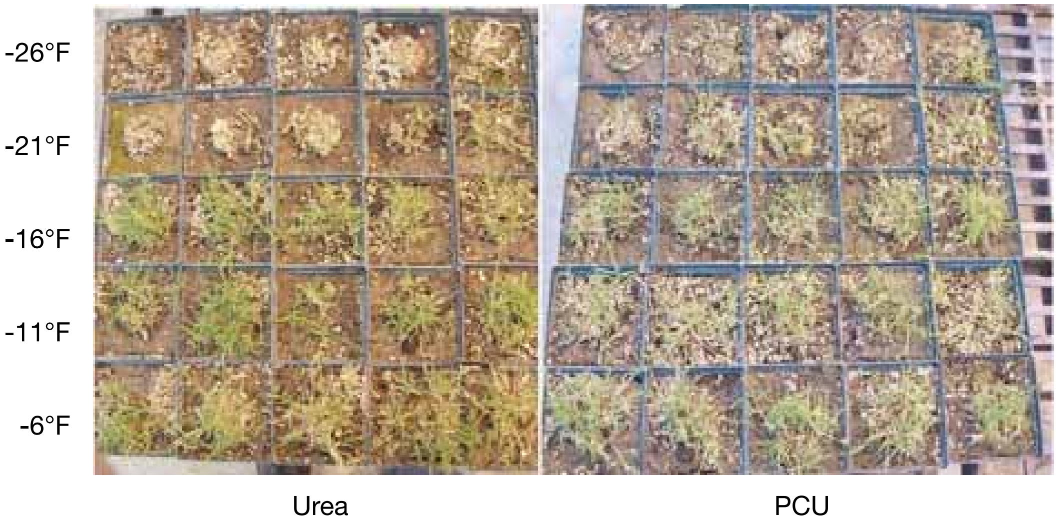

Figure 1. Regrowth of 'Midlawn' bermudagrass 6 weeks after being subjected to low temperatures (five replicates at each temperature).
Urea plugs received 1 lb N/1,000 ft^2 in May, June, July, and August. The PCU plugs received 4 lb N/1,000 ft^2 in April.

Nitrogen Source and Timing Effect on Carbohydrate Status of Bermudagrass

Objective: Compare the effects of applying coated nitrogen (N) sources at various timings and urea at traditional timings on nonstructural carbohydrate (NSC) status of bermudagrass.

Investigators: Tony Goldsby and Steve Keeley

Introduction

Nonstructural carbohydrates are the energy source for turfgrass growth and recovery; therefore, NSC levels have often been used as an indicator of the physiological health and stress tolerance of a turfgrass. Several research studies have shown that higher NSC levels in winter improve low-temperature survival of various turfgrass species. Spring regrowth after winter dormancy and turfgrass recovery from excessive traffic and other stresses are also dependent on an adequate supply of NSC. Turfgrass cultural practices can have a significant effect on plant health by altering NSC levels. Turfgrass fertilizer regimes can also play a role in NSC levels.

Nitrogen fertilizer is essential for high-quality turfgrass, but multiple studies have documented decreased NSC levels with higher N rates. This reduction in NSC likely occurs because N promotes vegetative growth, which has been shown to deplete NSC levels in turfgrass. Thus, turfgrass stands receiving high N may be less able to tolerate or recover from various stresses. Slow-release N fertilizers, which moderate turfgrass vegetative growth, offer a potential solution. Compared with fast-release sources, slow-release N sources may also require fewer applications, produce more uniformity, and have a lower burn hazard.

Many slow-release N sources are dependent on microbial activity for N release, which makes the timing and rate of release somewhat difficult to predict. Nitrogen release from natural organic N sources and urea formaldehyde is increased when conditions favor microbial decomposition. Consequently, most release occurs during periods of elevated temperatures and adequate moisture. Polymer-coated N fertilizers have been developed that are not dependent on microbial activity for N release. These should provide a more predictable and precise rate of N release.

The objective of our study was to evaluate the effect of spring and late-summer applications of polymer-coated N sources, in comparison to traditional N sources, on the NSC status, turf quality, color, and low-temperature survival of 'Midlawn' bermudagrass (*Cynodon dactylon* L. Pers. × *C. transvaalensis* Burtt-Davy).

Methods

This study was conducted on a 5-year-old stand of 'Midlawn' bermudagrass from August 2005 to September 2007 at the Rocky Ford Turfgrass Research Center near Manhattan, KS. Treatments consisting of various N sources applied in either spring or late summer were arranged in a completely randomized design with four replications. Plot size was 5 × 8 ft. Nitrogen sources included two polymer-coated ureas (PCU) that varied in coating thickness (the thicker-coated product had 41% N on a w/w basis, and the thinner-coated product had 43% N), sulfur-coated urea, and urea formaldehyde.

Each N source was applied in single, yearly applications at 4 lb/1,000 ft^2 in either April or August. Thus, August treatments were applied in 2005 and 2006, and April treatments were applied in 2006 and 2007. A check treatment consisted of urea applied at 1 lb/1,000 ft^2 in May, June, July, and August.

Nonstructural carbohydrate levels were evaluated by extracting two cores (4 in. diameter × 7 in. deep) from each plot every two weeks throughout the study, defoliating them, and placing them in a dark growth chamber at 75 °F. Etiolated regrowth was then measured over an 8-week regrowth period by excising shoot growth every two weeks, drying the clippings at 176 °F for 48 hours, and recording the dry weights. Because regrowth occurred in darkness, energy for regrowth necessarily came from NSC.

Turfgrass color and quality were recorded on a monthly basis during the growing season by the same researcher throughout the study. Color and visual quality were rated on scales of 1 to 9 (1 = brown, 9 = dark green; 1 = brown, dead turfgrass, 9 = highest quality, based on color, density, texture, and uniformity).

Results

Nitrogen source did not have a significant effect on bermudagrass NSC levels, turfgrass color, or visual quality (Table 1). In particular, polymer-coated N sources performed similarly to the other N sources.

In contrast, application timing had a significant effect (Figure 1). August-applied N resulted in higher NSC levels on several sampling dates and improved color in the late-season months. August-applied N resulted in similar turfgrass color in the spring, compared with April-applied treatments, and improved bermudagrass visual quality in May 2006. If turfgrass managers wish to save labor by making a once-per-year application of a controlled-release N source on bermudagrass, late-summer application is recommended.

Table 1. Etiolated regrowth (biomass) of 'Midlawn' bermudagrass as affected by nitrogen source and application timing, Manhattan

		Regrowth (g, dry weight)												
N source[1]	Timing	Sept. 2005	Nov. 2005	Jan. 2006	Mar. 2006	May 2006	July 2006	Sept. 2006	Nov. 2006	Jan. 2007	Mar. 2007	May 2007	July 2007	Total
PCU (43% N)	April	0.25	0.63	0.48b	0.21	0.36	0.30	0.25	0.31	0.29abc	0.16	0.03	0.07	3.34
	August	0.27	0.67	0.72a	0.23	0.27	0.37	0.23	0.39	0.32abc	0.24	0.02	0.12	3.85
PCU (41% N)	April	0.25	0.62	0.50ab	0.22	0.28	0.28	0.18	0.36	0.32abc	0.16	0.04	0.07	3.28
	August	0.28	0.74	0.59ab	0.38	0.26	0.29	0.27	0.42	0.19bc	0.17	0.05	0.22	3.87
SCU	April	0.33	0.49	0.44b	0.30	0.34	0.25	0.23	0.30	0.13c	0.22	0.05	0.08	3.14
	August	0.29	0.69	0.62ab	0.29	0.33	0.30	0.22	0.36	0.21bc	0.18	0.02	0.06	3.55
UF	April	0.36	0.57	0.62ab	0.27	0.28	0.33	0.22	0.29	0.50a	0.21	0.04	0.05	3.68
	August	0.30	0.70	0.60ab	0.31	0.28	0.33	0.24	0.36	0.33ab	0.18	0.04	0.07	3.80
Urea	Check	0.30	0.66	0.65ab	0.36	0.33	0.29	0.15	0.38	0.18bc	0.17	0.02	0.07	3.54
Contrast: August-applied vs. April-applied		NS	0.05	0.01	0.10	NS	NS	NS	0.10	NS	NS	NS	0.10	0.01

[1] PCU = polymer-coated urea, SCU = sulfur-coated urea, UF = urea formaldehyde. Each N source was applied in a single, yearly application at 4 lb N/1,000 ft^2 in either April or August, except for the urea check, which was applied at 1 lb N/1,000 ft^2 in May, June, July, and August.

Within a column, means followed by the same letter are not significantly different at $P = 0.05$. Columns with no letters indicate an insignificant F-test.

NS = nonsignificant.

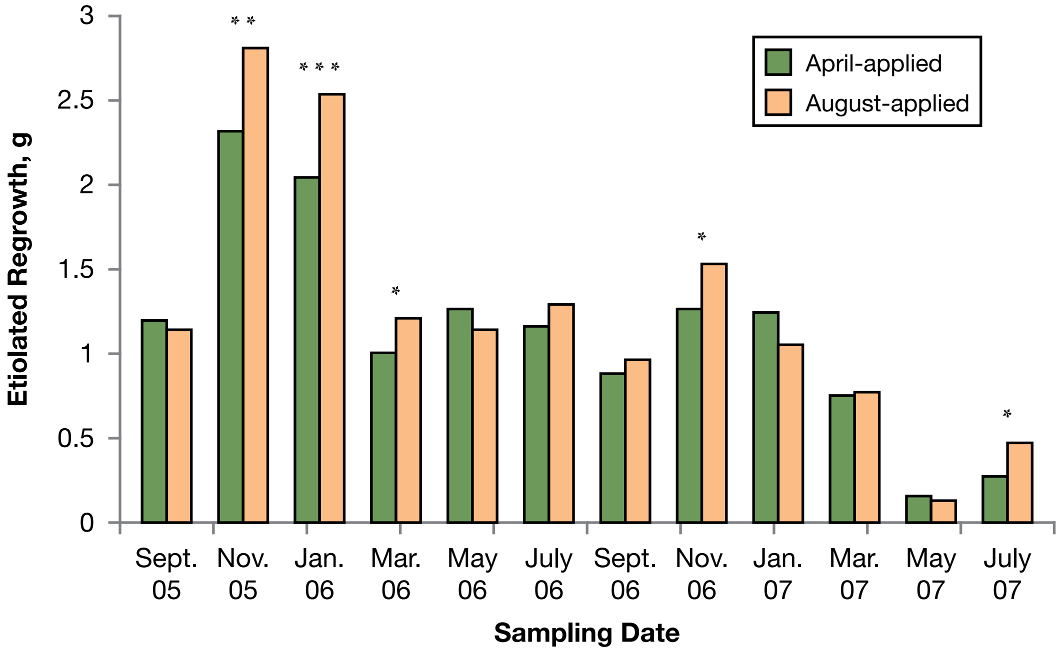

Figure 1. Cumulative etiolated regrowth (biomass) of all nitrogen sources as affected by application timing over the course of the 2-year study.
*P = 0.1, **P = 0.05, ***P = 0.01

Nitrogen Source and Timing Effect on Carbohydrate Status of Turf-Type Tall Fescue

Objectives:	Evaluate effects of polymer-coated nitrogen (N) sources at various timings and urea at traditional timings on nonstructural carbohydrate (NSC) status of tall fescue. Compare the effects of spring applications of a soluble N source and a polymer-coated N source on brown patch incidence in tall fescue.
Investigators:	Tony Goldsby and Steve Keeley

Introduction

Nonstructural carbohydrates are the energy source for turfgrass growth and recovery; therefore, NSC levels have often been used as an indicator of the physiological health and stress tolerance of a turfgrass. Several research studies have shown that higher NSC levels in winter improve low-temperature survival of various turfgrass species. Similarly, cool-season turfgrass quality during summer has been related to higher NSC content in shoots and roots.

Turfgrass cultural practices can have a significant effect on plant health by altering NSC levels. For example, lower mowing heights reduce leaf area for photosynthesis, which ultimately results in a reduction in rooting. Turfgrass fertilizer regimes can also play a role in NSC levels.

Nitrogen fertility has also been shown to have an effect on disease incidence in cool-season grasses. Grasses that have been overfertilized with N develop a thin cuticle. Cell walls become thinner, allowing for easier attack by disease-causing organisms. Increasing N levels in cool-season grasses has been shown to exacerbate brown patch (*Rhizoctonia solani* Kuhn) blighting. The brown patch fungus causes a foliar blight and crown rot that result in patches of necrotic turf up to a few meters in diameter. Spring applications of soluble N sources, as opposed to slow-release N sources, may affect development of brown patch during the summer. Evaluation of disease incidence in relation to N source will be useful in determining the N source and application timing combination that will maximize NSC levels while minimizing brown patch blighting during the growing season.

The objective of Study 1 was to evaluate the effect of spring and late-summer applications of polymer-coated urea (PCU) N sources, in comparison to traditional N sources, on the NSC status, turf quality, color, and brown patch incidence of tall fescue (*Festuca arundinacea* Schreb.). The objective of Study 2 was to evaluate the effect of spring applications of a soluble N source, in comparison to a PCU N source, on the NSC status, turf quality, color, and brown patch incidence of tall fescue.

Methods

Study 1 Site and Experimental Design

This study was conducted on a 3-year-old stand of tall fescue from August 2005 to September 2007 at the Rocky Ford Turfgrass Research Center near Manhattan, KS. Treatments consisting of various N sources applied in either September or September and March were arranged in a completely randomized design with four replications. Plot size was 5 × 10 ft. Nitrogen sources included two PCU that varied in coating thickness (the thicker-coated product had 41% N on a w/w basis, and the thinner-coated product had 43% N), sulfur-coated urea, and urea formaldehyde. Each N source was applied either in single, yearly applications at 3 lb N/1,000 ft^2 in September or two 1.5 lb N/1,000 ft^2 applications in September and March. A control treatment consisted of urea applied at 1 lb N/1,000 ft^2 in September, November, and May.

Study 2 Site and Experimental Design

This study was conducted on a 3-year-old stand of tall fescue from August 2005 to September 2007 at the Rocky Ford Turfgrass Research Center near Manhattan, KS. Treatments consisting of various combinations of PCU and urea were applied in September and May. Plots were arranged in a completely randomized design with four replications. Plot size was 2.5 × 5 ft. Each treatment received a total of 4 lb N/1,000 ft^2 in various combinations of PCU and urea. In September, plots received 2, 3, or 4 lb N/1,000 ft^2, all from PCU. The balance of the N was then applied in May with either PCU or urea as the N source (Table 1). The PCU used in the spring had a slightly thicker polymer coating than the coating used in September (41% N vs. 43% N) to provide a slower rate of N release during the spring and summer.

Study 1 and 2 Measurements

Nonstructural carbohydrate levels were evaluated by extracting two cores (4 in. diameter × 7 in. deep) from each plot every two weeks throughout the study, defoliating them, and placing them in a dark growth chamber at 75 °F. Etiolated regrowth was then measured over an 8-week regrowth period by excising shoot growth every two weeks, drying the clippings at 176 °F for 48 hours, and recording the dry weights. Because regrowth occurred in darkness, energy for regrowth necessarily came from NSC. Turfgrass color and quality were recorded on a monthly basis during the growing season by the same researcher throughout the study. Color and visual quality were rated on scales of 1 to 9 (1 = brown, 9 = dark green; 1 = brown, dead turfgrass, 9 = highest quality, based on color, density, texture, and uniformity). Brown patch visual ratings were recorded on tall fescue plots during summer to evaluate disease incidence. The Horsfall-Barrat scale (1 = 0% disease affected, 12 = 100% disease affected) was used for visual estimates.

Results

Study 1

Nitrogen source did not have a major effect on tall fescue NSC levels, turfgrass color, visual quality, or brown patch incidence. In particular, PCU N sources performed similarly to the other N sources. Application timing was significant; as a group, September/March applications yielded greater etiolated regrowth in January and March of 2007 than single September applications (Figure 1). For turfgrass managers who use a slow-release N source, a more balanced approach such as splitting the yearly N requirement between the spring and the fall might maximize NSC status in tall fescue. This would, however, negate the labor savings that may be attained from applying the total annual N in a single application.

Study 2

Nitrogen source did not have a significant effect on tall fescue NSC levels, turfgrass color, visual quality, or brown patch incidence. The PCU N sources performed similarly to urea. Application timing was significant; a single application of PCU N in September increased total NSC levels compared with split applications using a combination of PCU or PCU/urea in September and May (Table 2). Results of this study suggest turfgrass managers could make a single, yearly application of slow-release N in September without sacrificing NSC in the turfgrass. However, application rate and timing appear to be very important compared with the N source because similar results were not observed on tall fescue in the first study. Compared with PCU, spring applications of a soluble N source showed no significant effect on development of brown patch during the summer months (Table 3), but it is important to note that disease pressure was very low for both sampling periods.

Table 1. Treatment list for Study 2

	September[1]	May	
		PCU	Urea
	———lb nitrogen/1,000 ft^2———		
Treatment 1	2	2	–
Treatment 2	2	–	2
Treatment 3	3	1	–
Treatment 4	3	–	1
Treatment 5	4	–	–

[1] All nitrogen was from polymer-coated urea in September.

Table 2. Etiolated regrowth of tall fescue as affected by soluble vs. controlled-release nitrogen in spring, Manhattan

Nitrogen source[1], rate[2], and timing		Regrowth (g, dry weight)						
Sept.	May	June 2006	July 2006	Aug. 2006	June 2007	July 2007	Aug. 2007	Mean (study total)
PCU (2)	PCU (2)	0.20	0.36	0.24	0.10	0.06	0.04	0.71b
PCU (2)	Urea (2)	0.14	0.45	0.23	0.04	0.06	0.04	0.62b
PCU (3)	PCU (1)	0.20	0.36	0.31	0.06	0.05	0.03	0.75ab
PCU (3)	Urea (1)	0.16	0.44	0.26	0.07	0.08	0.03	0.75ab
PCU (4)	–	0.29	0.47	0.24	0.09	0.08	0.04	0.86a

[1] PCU = polymer-coated urea.

[2] Amount in parentheses indicate rate in lb N/1,000 ft^2.

Within a column, means followed by the same letter are not significantly different at $P = 0.05$. Columns with no letters indicate an insignificant F-test.

Table 3. Brown patch incidence on tall fescue as affected by nitrogen source and application timing, Manhattan

		Brown patch incidence[1]						
N source[2]	Timing	07/17/06	07/29/06	08/05/06	07/14/07	07/23/07	08/2/07	Total (mean)
PCU (43% N)	Sept.	3.7	3.5	3.2	2.5	2.5b	2.0	2.9
	Sept./Mar.	3.7	3.2	3.5	2.2	3.2ab	2.0	3.0
PCU (41% N)	Sept.	3.7	3.5	3.5	2.2	3.5a	2.0	3.0
	Sept./Mar.	3.5	3.2	3.5	1.7	2.7b	2.0	2.7
SCU	Sept.	3.5	3.2	3.2	2.2	3.5a	2.5	3.0
	Sept./Mar.	4.0	3.7	4.0	2.2	3.7a	2.0	3.2
UF	Sept.	3.5	3.2	3.2	2.2	2.7b	2.0	2.8
	Sept./Mar.	4.0	3.2	3.5	2.0	2.7b	2.0	2.9
Urea	check	3.7	3.2	3.5	2.7	3.2ab	2.0	3.0
Contrast: Sept. applied vs. Sept./Mar. applied		NS	NS	NS	NS	NS	NS	NS

[1] Visual estimates of Rhizoctonia blight were made using the Horsfall-Barratt rating scale (1 = 0% affected, 12 = 100% affected).

[2] PCU = polymer-coated urea, SCU = sulfur-coated urea, UF = urea formaldehyde. Each N source was applied in a single, yearly application at 3 lb N/1,000 ft^2; N sources with September/March timings were applied in two separate 1.5 lb N/1,000 ft^2 applications. The urea check was applied at 1 lb N/1,000 ft^2 in early September, November, and May.

Within a column, means followed by the same letter are not significantly different at $P = 0.05$. Columns with no letters indicate an insignificant F-test.

NS = nonsignificant.

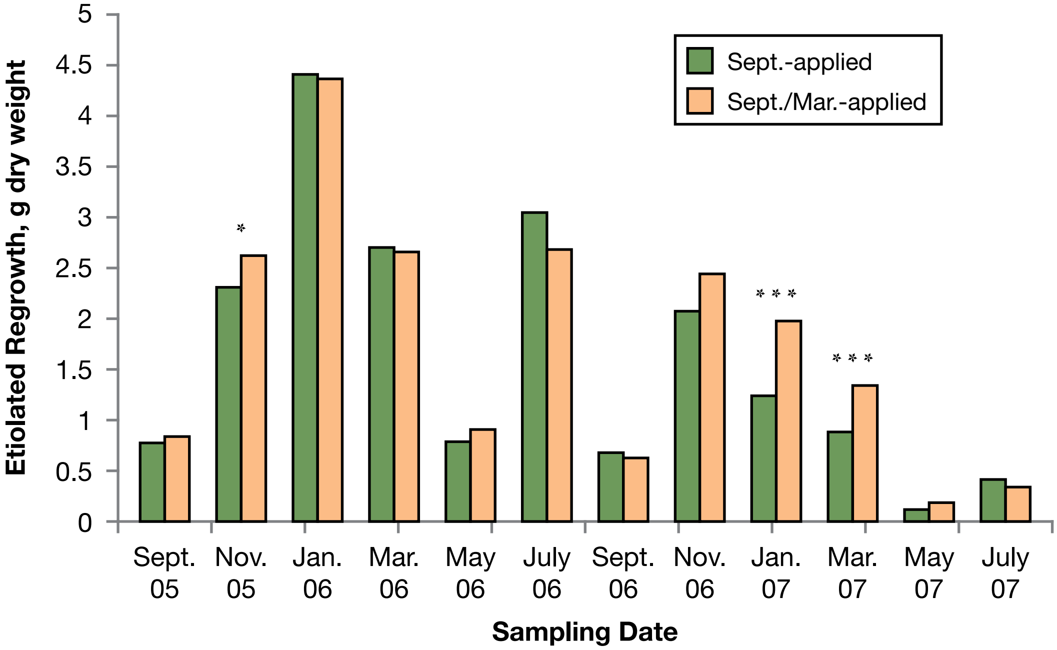

Figure 1. Cumulative etiolated regrowth of tall fescue (combined over all nitrogen sources) as affected by application timing over a 2-year period from 2005 to 2007.
**P* = 0.1, ***P* = 0.05, ****P* = 0.01

Spring Greenup, Fall Color Retention, and Freezing Tolerance of Experimental Zoysiagrass Progeny

Objectives:	Evaluate color of zoysiagrass progeny in spring and fall and determine potential relationships with freezing tolerance.
Investigators:	David Okeyo, Jack Fry, Dale Bremer, and Channa Rajashekar
Cooperators:	Milt Engelke and Dennis Genovesi, Texas A&M University
Sponsors:	Heart of America Golf Course Superintendents Association, Kansas Golf Course Superintendents Association, Kansas Turfgrass Foundation

Introduction

'Meyer' zoysiagrass usually loses its green color in mid to late October and greens up in mid to late April in Kansas. Ideally, a zoysiagrass that retains its color longer in the fall and greens up earlier is desirable. But extended autumn color might be a concern; it has been suggested that warm-season grasses that retain green color longer in autumn tend to be less tolerant of freezing. As part of our efforts to evaluate experimental zoysiagrasses for adaptation in the transition zone, we are interested in evaluating fall and spring color and their potential relationships with freezing tolerance.

Methods

Fully established plots of experimental zoysiagrass progeny growing at the Rocky Ford Turfgrass Research Center in Manhattan, KS, were used in the study (Figure 1). Plots were arranged in a randomized complete block with three replicates. Turf was mowed 3 days weekly at 0.5 in. and irrigated to receive 0.75 in. of water per week when needed. Fall color was evaluated once weekly between Oct. 19 and Nov. 19, 2007, and Oct. 8 and Dec. 2, 2008. Spring color was evaluated once weekly between Apr. 17 and May 6, 2007. To determine color, overhead photographs of each plot were taken with a Nikon D100 AF LR 28:105 mm camera mounted on a tripod at 4 ft above the plots. The digital images were analyzed with Sigma Scan Pro 5 under a color hue threshold of between 30 and 100 and saturation of between 0 and 100.

Ten of the progeny, together with 'Cavalier', DALZ 0102, and 'Meyer', were also subjected to freezing tolerance evaluation. Samples were collected on Oct. 15 and Dec. 15, 2008, and Feb. 15, 2009 (Figure 2). Each sampling included three replicates, and each replicate was run through a controlled freezing chamber separately. A thermocouple was installed at a 0.75-in. depth in two randomly selected plugs per replication to monitor temperature. Plugs were placed in a freezer at 27°F and covered lightly with crushed ice to prevent supercooling. The next day, the freezer was set to drop in temperature by 2°C (3.6°F)/hour. Temperature treatments were narrowed to 14°F, 10.4°F, 6.8°F, 3.2°F, and -0.4°F. At each sampling, one set of plugs was placed in a growth chamber at 39°F overnight and was not frozen (control). After freezing, plugs were returned to a growth chamber set at 39°F to thaw slowly overnight.

After thawing, grasses were planted in 8-cm-diameter containers and placed in a greenhouse maintained at a 86°F/77°F day/night temperature with a 14-hour photoperiod under supplemental lighting to provide 580 µmol/m^2 per second at canopy level. Recovery growth was evaluated after 6 weeks by counting the number of living tillers in each plug at each temperature. Number of surviving tillers for each plug at each temperature was converted to a percentage of surviving tillers and compared with the same progeny exposed only to the 27°F treatment. Percentage tiller survival data were subjected to analysis of variance. An LT$_{50}$ (temperature killing 50% of grass tillers compared with the nonfrozen control) was determined with regression analysis.

Data on turf color were subjected to analysis of variance, and means were separated by Fisher's protected LSD at $P \leq 0.05$. Correlation analysis was used to determine potential relationships between fall or spring color and LT$_{50}$.

Results

Substantial differences in spring greenup were evident across zoysiagrasses, particularly on April 17 and 22 (Table 1). On April 17, green color ranged from 8% (5311-8 and 5312-36) to 68% (5324-53), with 'Meyer' at 60%. On April 22, color ranged from 17% (5311-8) to 65% 5321-45), with 'Meyer' at 56%.

Green color was variable across progeny through the fall of 2007 (Table 2.) Highest color readings generally occurred in progeny from the cross of 8501 × Meyer. On November 27, the range in green color was 25% (Meyer) to 45% (5324-27).

In December 2007, February 2008, and December 2008, all grasses had LT$_{50}$ similar to 'Meyer', with the exception of 'Cavalier', a nonhardy *Zoysia matrella* (Table 3). The LT$_{50}$ were relatively high in October 2008 because grasses had not yet become hardy. Following sampling in December 2008, a period of temperatures well below 0°F apparently caused significant stress. In February 2009, only grasses sampled from the field and not exposed to controlled freezing exhibited regrowth. Exposure to the lowest temperature with the prescribed range (14°F) resulted in death of all grasses.

Significant correlation between turf color and LT$_{50}$ occurred only with the February 2008 evaluation of freezing tolerance (Table 4). Color in October 2007 was negatively correlated to LT$_{50}$ in February. In other words, grasses with a higher level of green color in October also had lower LT$_{50}$ in February. However, the range in color among grasses in October 2008 was relatively small, so it doesn't appear that this relationship is of much importance. Perhaps of greater importance, there was no relationship between color later in autumn and freezing tolerance. Grasses with higher levels of green color in November did not have higher LT$_{50}$. In the field, the only association between color evaluations was for October 2007 and Apr. 28, 2008 ($r = 0.72$). Grasses that tended to be greener in October were also greener in late April.

Table 1. Spring color of zoysiagrasses in 2008

	Green color in 2008 (%)[1]			
Progeny	Apr. 17	Apr. 22	Apr. 28	May 6
8507 × Meyer				
5283-27	40de	44de	69ab	70def
Cavalier × Chinese Common #2				
5311-3	13h	20e	51c	61f
5311-8	8h	17f	64abc	98a
5311-22	29efg	55abcde	73ab	67ef
5311-26	15gh	55abcde	66abc	81bcde
5311-27	13h	45cde	57abc	70cdef
5311-32	12h	41e	57abc	83abcd
Zorro × Chinese Common #2				
5312-36	8h	18f	64abc	70def
5312-49	21fgh	58abcd	69abc	97a
Emerald × Meyer				
5321-3	41cde	48bcde	70ab	98a
5321-24	36ef	58abcd	63abc	76bcdef
5321-45	41cde	65a	70ab	92ab
5321-48	58ab	52abcde	74a	71cdef
8501 × Meyer				
5324-18	11h	46cde	65abc	84abcd
5324-27	53abcd	60abc	64abc	77bcde
5324-52	57abc	62ab	65abc	98a
5324-53	68a	60abc	55bc	88ab
Meyer × Diamond				
5327-19	43bcde	58abcd	67abc	86abc
DALZ 0102	14gh	62ab	68abc	98a
Meyer	60a	56abcde	65abc	84abcd

[1] Percentage green cover was determined with digital pictures and the ratio of selected green pixels to the total pixels. Numbers are a mean of three digital images and three replicates.

Within a column, means followed by the same letter are not significantly different according to an LSD multiple comparison test at $P \leq 0.05$.

Table 2. Fall color of zoysiagrasses in 2007 and 2008

	Color in 2007 (%)[1]						Color in 2008 (%)					
Progeny	Oct. 19	Oct. 25	Nov. 1	Nov. 14	Nov. 20	Nov. 27	Oct. 8	Oct. 16	Oct. 28	Nov. 7	Nov. 19	Dec. 2
8507 × Meyer												
5283-27	93a	90a	86ab	55abc	46bc	34c	67abcde	55a	47abc	30bcd	15bcde	3ef
Cavalier × Chinese Common #2												
5311-3	91bcd	88abcd	83bcd	50cdef	42bcde	29efg	71abcd	43a	43abc	29bcd	16bcde	4bcdef
5311-8	92ab	89a	85abc	41hij	37fgh	30efg	74abc	51a	46abc	28bcd	9defg	2ef
5311-22	89cdef	85gh	80efg	40ij	32ij	29efg	79ab	47a	41bc	23bcd	8fg	2ef
5311-26	88efg	84gh	75i	38j	37gh	30def	46gf	53a	45abc	28bcd	5g	2f
5311-27	88fg	84gh	76hi	41hij	35hij	28fgh	45gf	53a	43abc	26bcd	4g	2f
5311-32	90bcde	86bcdefg	80efg	45ghij	40defg	29efg	59cdefg	39a	61ab	32abc	9def	3ef
Zorro × Chinese Common #2												
5312-36	92ab	88abcde	84bc	46ghij	38efgh	29efg	84a	35a	61ab	33abc	13cdef	3ef
5312-49	89cdef	86cdefg	78gh	44ghi	36ghi	30def	55defg	46a	37c	20d	9defg	2f
Emerald × Meyer												
5321-3	87g	85efgh	80efg	51cdef	44bcd	33cd	44g	49a	45abc	25bcd	21abc	6bcd
5321-24	90bcde	88abcde	82cde	48defg	41cdef	30ef	58cdefg	42a	46abc	22cd	8efg	2f
5321-45	88efg	85gh	78gh	52bcde	44bcd	32cde	48gf	53a	44abc	27bcd	14cdef	4cdef
5321-48	92ab	88abcd	87a	57ab	46bc	34c	60cdefg	54a	47abc	29abcd	20abc	4cdef
8501 × Meyer												
5324-18	91ab	88abcd	83bcd	46efgh	38fgh	28fgh	68abcde	41a	51abc	30bcd	15cdef	4cdef
5324-27	88efg	83h	81defg	59a	57a	45a	45gf	36a	67a	41a	18abc	6bcd
5324-52	89def	85fgh	81defg	55abc	53a	40b	46gf	57a	41bc	31bcd	24a	12a
5324-53	91abc	89ab	83bcd	53bcd	46b	35c	63bcdef	45a	42c	30bcd	21abc	6bc
Meyer × Diamond												
5327-19	90bcde	89abc	82cdef	46fghi	37gh	28fgh	50efg	46a	55abc	33abc	15bcde	5bcde
DALZ 0102	91abc	86bcdefg	80efg	41hij	35hij	26gh	59cdefg	49a	47abc	34ab	23ab	7b
Meyer	88efg	85defgh	79fg	38j	31j	25h	49efg	42a	45abc	27bcd	6g	2f

[1] Percentage green cover was determined with digital pictures and the ratio of selected green pixels to the total pixels. Numbers are a mean of three digital images and three replicates. Within a column, means followed by the same are not significantly different according to a LSD multiple comparison test at *P* ≤ 0 .05.

Table 3. Lethal temperatures (°F) that resulted in death of 50% of zoysiagrass tillers in 2007-2009 after sampling from the field at Manhattan

	LT_{50}[1]				
Progeny	Dec. 15, 2007[2]	Feb. 15, 2008	Oct. 15, 2008	Dec. 15, 2008	Feb. 15, 2009
8507 × Meyer					
5283-27	12.6	5.7	29.8	-0.4	29.8
Cavalier × Anderson #1					
5311-3	3.6	3.4	28.2	-4.7	29.8
5311-8	8.2	5.9	25.9	14.7	29.8
5311-22	4.1	3.9	16.3	7.7	29.8
5311-26	9.1	6.1	25.9	9.0	29.8
5311-27	5.4	3.0	29.8	13.8	29.8
5311-32	6.1	4.6	25.7	6.4	29.8
Emerald × Meyer					
5321-3	3.4	8.1	27.3	6.4	29.8
8501 × Meyer					
5324-18	9.7	4.5	29.8	-12.0	29.8
5324-53	8.2	1.9	29.8	4.1	29.8
Z. japonica					
Meyer	1.2	3.0	26.2	5.4	29.8
DALZ 0102	Not eval.	4.1	28.2	3.9	29.8
Z. matrella					
Cavalier	27.7	23.3	29.8	29.4	29.8

[1] LT_{50} were obtained from regressing percentage tiller recovery in relation to the control against temperature and determining the point of 50% recovery.

[2] Grasses were randomly sampled as 3-in.-diameter plugs on the dates shown before freezing.

Table 4. Correlation coefficients between fall and spring green color and LT_{50} of new zoysiagrass progeny

	Fall color (% green)				LT_{50}					Spring color (% green)	
	Oct. 07	Nov. 07	Oct. 08	Dec. 08	Dec. 07	Feb. 08	Oct. 08	Dec. 08	Feb. 09	4/17/08	4/28/08
Fall color (% green)											
Oct. 07	1.000	0.457	0.862**	0.035	-0.403	-0.886**	-0.074	-0.680	-0.292	-0.258	0.720*
Nov. 07	0.457	1.000	0.410	0.093	-0.339	-0.234	0.274	-0.645	-0.206	0.009	0.425
Oct. 08	0.862**	0.4098	1.000	-0.0968	-0.113	-0.639	0.143	-0.465	-0.549	-0.403	0.291
Dec. 08	0.035	0.093	-0.097	1.000	0.360	0.029	0.320	0.405	0.170	-0.400	0.230
LT_{50}											
Dec. 07	-0.403	-0.339	-0.113	0.360	1.000	0.674*	0.615	0.838**	0.289	-0.359	-0.514
Feb. 08	-0.888**	-0.234	-0.639	0.029	0.674*	1.000	0.412	0.705*	0.344	0.112	-0.723*
Oct. 08	-0.074	0.274	0.143	0.320	0.615	0.412	1.000	0.266	0.184	0.148	-0.272
Dec. 08	-0.680	-0.645	-0.465	0.405	0.838**	0.705*	0.266	1.000	0.213	-0.308	-0.643
Feb. 09	-0.292	-0.206	-0.550	0.170	0.289	0.344	0.184	0.213	1.000	0.354	0.261
Spring color (% green)											
4/17/08	-0.258	0.009	-0.403	-0.400	-0.359	0.112	0.148	-0.308	0.355	1.000	-0.047
4/28/08	0.720*	0.425	0.291	0.230	-0.514	-0.723*	-0.272	-0.643	0.261	-0.043	1.000

*$P < 0.1$, **$P < 0.05$.

Figure 1. Plots used for spring and fall color evaluation.

Figure 2. Snow removal from plots.
Grasses were sampled from the field and then subjected to a predetermined range of freezing temperatures in the lab to determine LT_{50}. In December 2008, snow had to be removed to sample the turf.

Measurements of Photosynthesis, Respiration, and Evapotranspiration in Turfgrass with a Custom Surface Chamber

Objectives: Fabricate a large surface chamber for measuring canopy-level CO_2 fluxes in turfgrass.

Measure photosynthesis in two cool-season and two warm-season turfgrasses during the seasonal transition from summer to fall.

Collect diurnal measurements in the same turfgrasses to evaluate seasonal responses of photosynthesis to light.

Estimate aerodynamic conductance to water vapor flux ($g_{a,v}$) from the surfaces of turfgrasses mowed at three different heights and killed with glyphosate.

Investigators: Dale Bremer, Jason Lewis, and Jay Ham

Sponsor: Kansas Turfgrass Foundation

Introduction

Field measurements of photosynthesis in turfgrass are often conducted with surface chambers that cover a small area of the canopy. Measurements with typical portable photosynthesis systems may take up to 4 minutes, during which time the conditions that affect photosynthesis (e.g., air temperature) may change significantly inside the chamber. We fabricated a large turfgrass chamber (Figures 1 and 2) that measured photosynthesis in about 30 to 40 seconds. Furthermore, we added an infrared thermometer inside the chamber to measure canopy surface temperature, which allowed for estimates of surface conductance to water vapor flux. Water vapor flux is a combination of canopy (stomatal) ($g_{c,v}$) and aerodynamic ($g_{a,v}$) conductances to water vapor fluxes. By measuring fluxes of water vapor from the surface of turfgrasses killed with glyphosate (i.e., $g_{c,v}$ is 0), we were able to estimate $g_{a,v}$ inside the chamber. This allows for more accurate estimates of $g_{c,v}$ (and thus, evapotranspiration [ET]) when measuring live turfgrass because $g_{a,v}$ is known (see detailed discussion in theory section). In this study, we collected measurements of photosynthesis and ET in two cool-season and two warm-season turfgrasses during the seasonal transition from summer to fall.

Theory

The nonsteady-state chamber estimates net CO_2 exchange (NCE) and water vapor flux (ET) from the surface by measuring the rate change of CO_2 and H_2O over a brief period (i.e., 30 to 40 seconds).

Estimating Gross Canopy Photosynthesis

NCE represents carbon assimilation by gross canopy photosynthesis (Pg) less respiration losses from the canopy (Rc) and soil (Rs):

$$\text{NCE} = \text{Pg} - (\text{Rc} + \text{Rs})$$

Instantaneous gross canopy photosynthesis (Pg) can be calculated as:

$$\text{Pg} = \text{NCE} + (\text{Rc} + \text{Rs})$$

where NCE and Rc + Rs are determined by paired sunlit and dark readings, respectively, on the same plot. Note that Rc will be slightly larger in darkness than in sunlight, which may lead to a small overestimation of Pg.

Estimating Canopy Conductance

ET is the water vapor loss from the canopy and the soil/thatch layer and can be modeled as:

$$ET = \frac{g_{a,v} g_{c,v}}{g_{a,v} + g_{c,v}} (\rho_{v,s} - \rho_{v,a})$$

where $g_{a,v}$ is the aerodynamic conductance, $g_{c,v}$ is canopy conductance (assuming negligible soil evaporation in thick turfgrass), $\rho_{v,s}$ is saturation vapor density at canopy temperature, and $\rho_{v,a}$ is vapor density of the air. ET, $\rho_{v,s}$, and $\rho_{v,a}$ are measured with the chamber, leaving $g_{a,v}$ and $g_{c,v}$ as unknowns. The magnitude of $g_{a,v}$ should be nearly constant inside the chamber for a given turfgrass type and height. and if it were known, it would be possible to solve for $g_{c,v}$ by rearranging the ET equation.

Methods

Chamber Fabrication and Operation

- Closed chamber design (nonsteady state); Dimensions: 19.3 × 19.3 × 11.4 in.
- Chamber sides constructed with clear polyvinyl chloride; top covered with heat-stretched Propafilm-C
- Fluxes were measured from rate change in CO_2 and H_2O over a 30- to 40-second period. Data were corrected for water vapor dilution and concentration vs. time curves fit with a quadratic model extrapolated to time zero. A linear model was used if the quadratic failed.

Measurements from Warm-Season and Cool-Season Turfgrasses During Seasonal Transition

- Chamber measurements were collected from two cool-season grasses, tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.), and two warm-season grasses, zoysiagrass (*Zoysia japonica* Steud.) and bermudagrass (*Cynodon dactylon* L.), at the Rocky Ford Turfgrass Research Center in Manhattan, KS; turf was mowed at 3 in., and chamber measurements were replicated three times in each turfgrass.
- Diurnal fluxes of CO_2 were measured every 2 to 3 hours between sunrise and solar noon on Aug. 3 and Sept. 18, 2008; fluxes were also measured at midday on August 4.
- Measurements were collected simultaneously with the chamber under full sunlight and shaded conditions, respectively.
- Soil moisture from 0 to 6 in. was measured with time-domain reflectometry on measurement days.

Estimates of Aerodynamic Conductance to Water Vapor Flux

- $g_{a,v}$ was estimated from dead turfgrass canopies, which were saturated with water mixed with surfactant immediately before measurements with the chamber.
- Turfgrasses included a creeping bentgrass (*Agrostis stolonifera* L.) green mowed at 5⁄32 in., a Kentucky bluegrass fairway mowed at ½ in., and Kentucky bluegrass and bermudagrass lawns mowed at 3 in.
- Measurements were collected on July 10, 2008.

Results

Measurements from Warm-Season and Cool-Season Turfgrasses During Seasonal Transition

- Diurnal measurements during midsummer (August 4) indicated stronger responses to light in the warm-season (zoysiagrass and bermudagrass) than in the cool-season grasses (tall fescue and Kentucky bluegrass) (Figure 3).
- Maximum photosynthesis was greater in warm-season than in cool-season grasses on August 4; maximum photosynthesis was lowest in Kentucky bluegrass (Figure 3).
- By September 18, responses to light had weakened in warm-season grasses, and maximum photosynthetic rates were lower than in the same grasses during August (Figures 3 and 4).
- Conversely, in cool-season grasses, responses to light and maximum photosynthetic rates were greater on September 18 than August 4 (Figures 3 and 4), indicating a favorable response to cooler temperatures.
- Maximum photosynthetic rates in warm-season grasses were lower in September than in August, although their maximum rates were similar to those in cool-season grasses in September (Figures 3 and 4).
- From August 4 to September 18, Pg increased in cool-season grasses, by 32% in tall fescue and 151% in Kentucky bluegrass, and decreased in warm-season grasses, by 64% in zoysiagrass and 45% in bermudagrass (Figure 5).

Estimates of Aerodynamic and Canopy Conductance to Water Vapor Flux

- $g_{a,v}$ was strongly affected by mowing height, with $g_{a,v}$ of 1.29 cm/second in a creeping bentgrass green, 1.65 cm/second in a Kentucky bluegrass fairway, and about 3.0 cm/second in Kentucky bluegrass and bermudagrass lawns (Figure 6).
- $g_{c,v}$ on August 4 and September 18 was 0.88 and 1.41 cm/second in tall fescue, 0.96 and 1.92 cm/second in Kentucky bluegrass, 0.99 and 1.87 cm/second in zoysiagrass, and 0.14 and 1.62 cm/second in bermudagrass, respectively.
- Soil moisture was similar on both dates in tall fescue (≈27%) but was greater on September 18 than August 4 in Kentucky bluegrass (27% and 24%, respectively), zoysiagrass (29% and 18%, respectively), and bermudagrass (32% and 27%, respectively). Greater soil moisture in the latter three grasses may have contributed to their increased canopy conductance from August 4 to September 18.

Summary

- Although warm-season grasses showed no visible signs of dormancy on September 18, measurements of Pg indicated a marked decrease in the photosynthetic capacities of their canopies compared with earlier in the summer (August 4). Diurnal measurements also indicated slower responses of photosynthesis to light in warm-season grasses by September 18.
- Average temperature rise inside the chamber during measurements was 1.33°F during midday, sunlit measurements on August 3 and 4 (i.e., with ambient air temperatures of 100°F and 104°F, respectively)
- Respiration rates, as indicated by CO_2 exchange at low (shaded) light levels, were as high as 37 μmol/m^2 per second, which is greater than in many native ecosystems and crops and suggests high heterotrophic respiration in the thatch and near-surface soil layer in turfgrass.

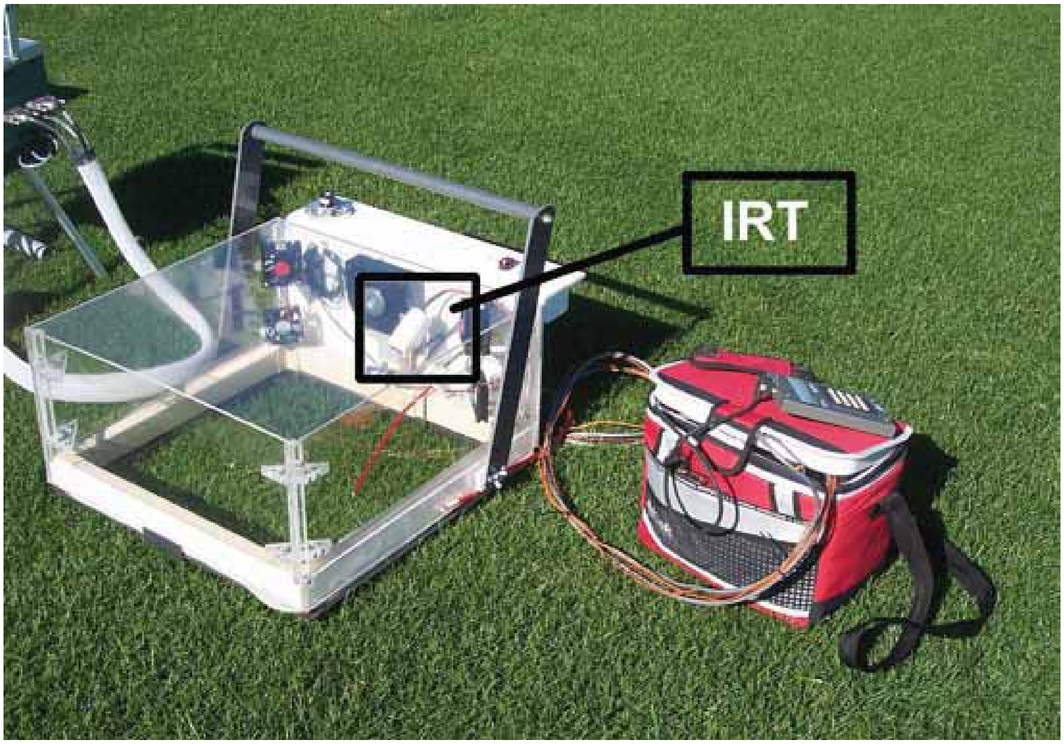

Figure 1. Large chamber fabricated to measure CO_2 fluxes in turfgrass.
The system was connected to and controlled by a datalogger in the red cooler. The chamber contained an infrared thermometer (IRT) to measure the temperature of the canopy surface.

Figure 2. The chamber console included a closed-path infrared gas analyzer (Licor 840, Licor Biosciences, Lincoln, NE) and a pressure differential transducer.

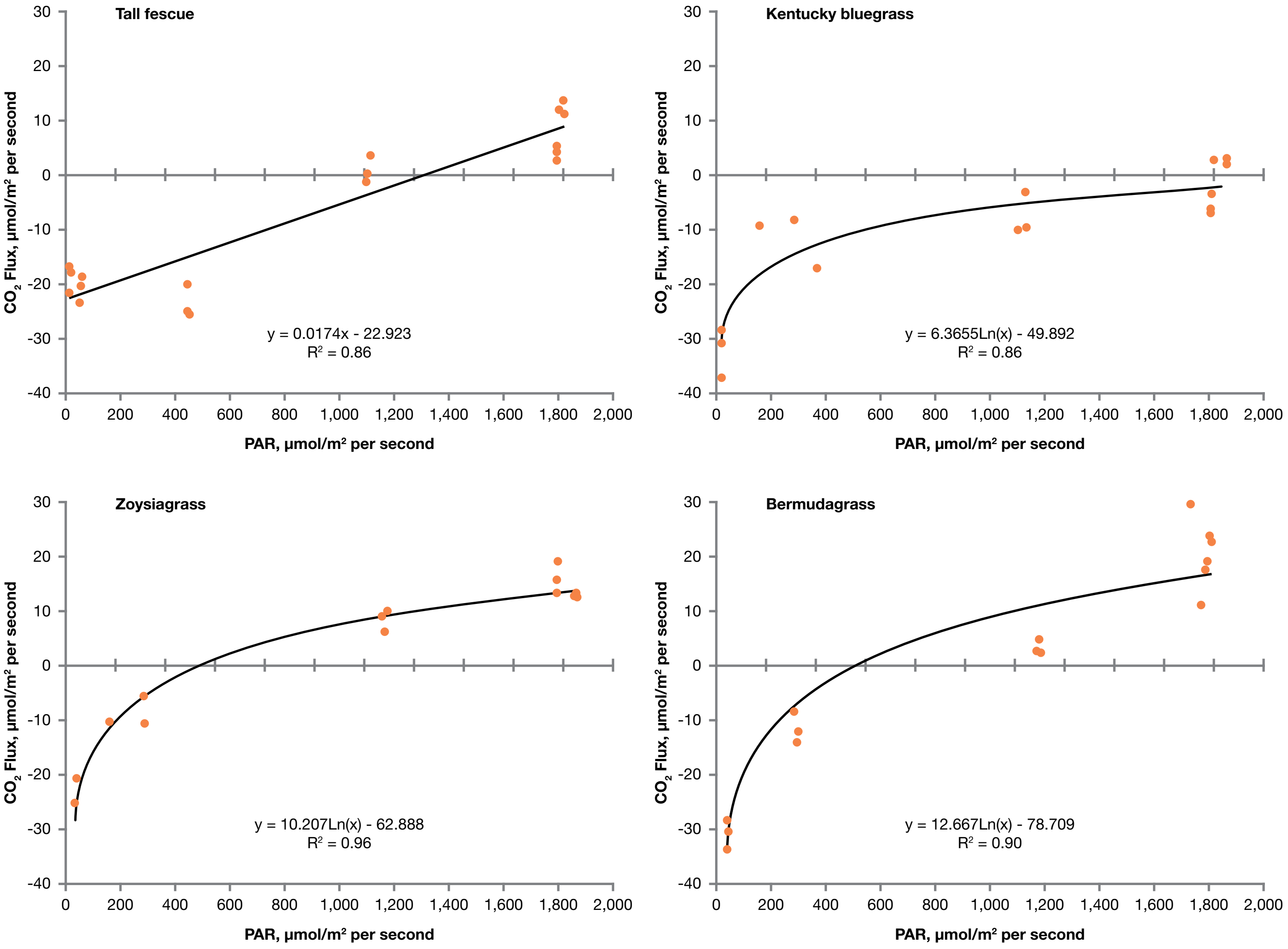

Figure 3. Responses of photosynthesis to photosynthetically active radiation (PAR) in two cool-season (tall fescue and Kentucky bluegrass) and two warm-season (zoysiagrass and bermudagrass) turfgrasses, Aug. 3, 2008.

Maximum air temperature on August 3 was 100 °F.

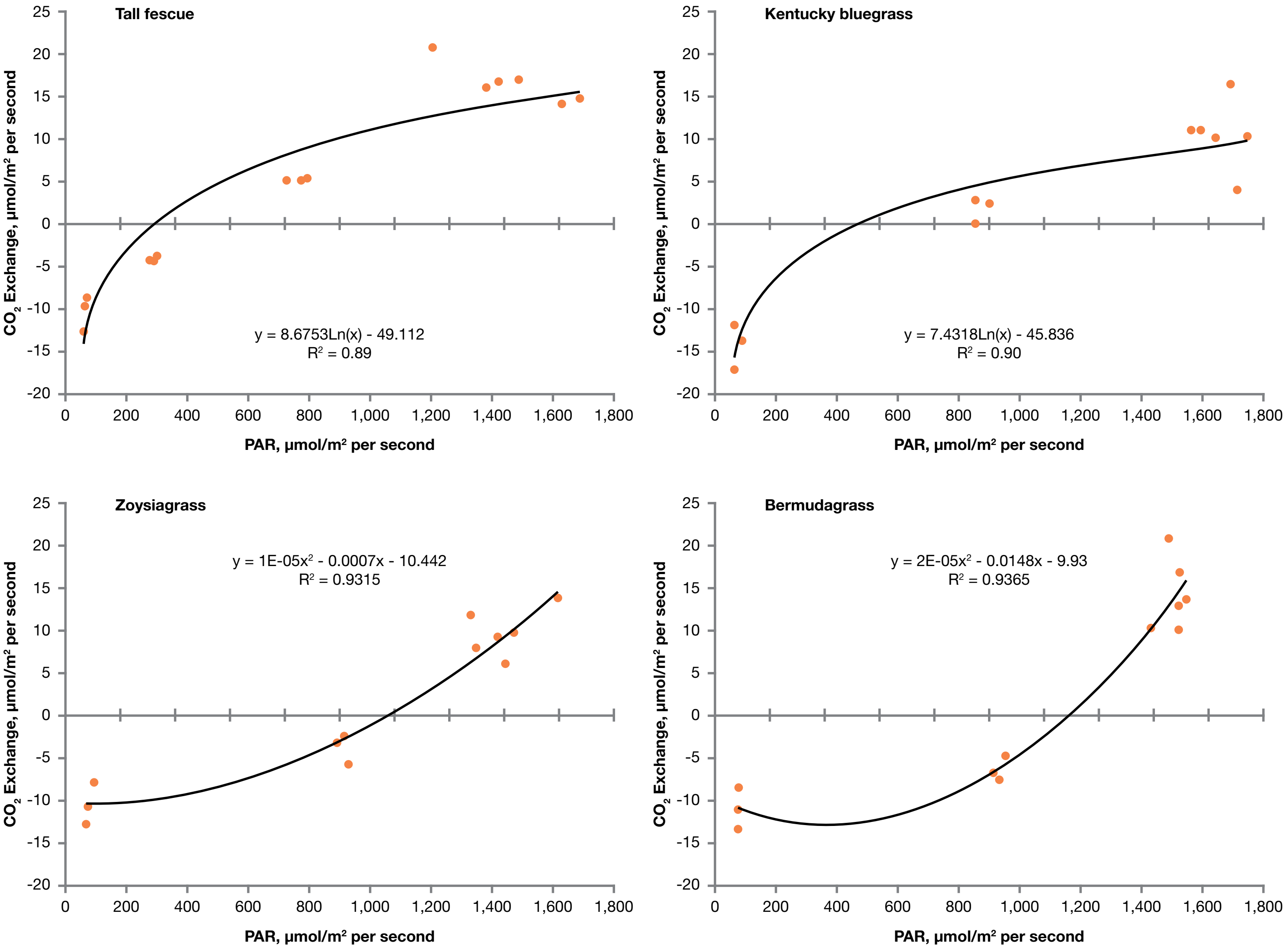

Figure 4. Responses of photosynthesis to photosynthetically active radiation (PAR) in two cool-season (tall fescue and Kentucky bluegrass) and two warm-season (zoysiagrass and bermudagrass) turfgrasses, Sept. 18, 2008.
Maximum temperature on September 18 was 79 ° F. Note different scales on the ordinate in Figures 3 and 4.

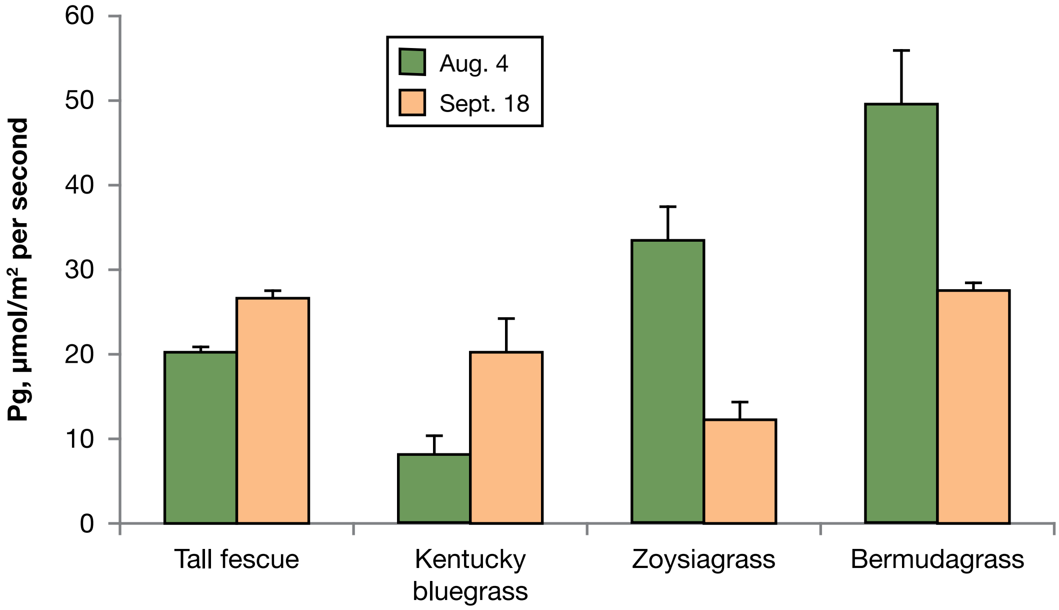

Figure 5. Estimates of gross photosynthesis (Pg) in two cool-season (tall fescue and Kentucky bluegrass) and two warm-season (zoysiagrass and bermudagrass) turfgrasses, Aug. 4 and Sept. 18, 2008.

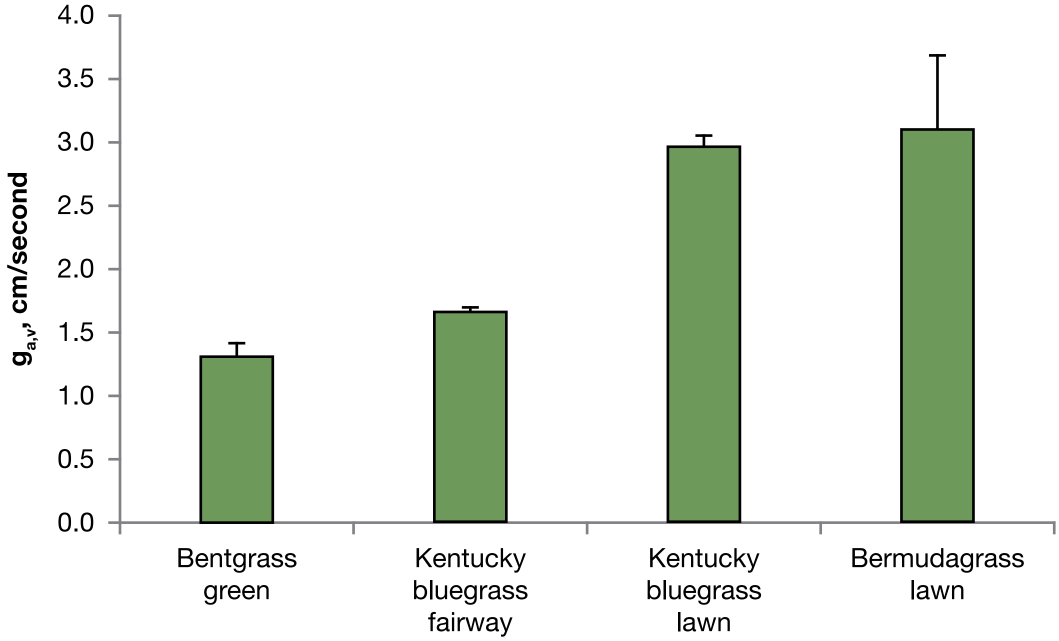

Figure 6. Estimates of aerodynamic conductance to water vapor flux ($g_{a,v}$) inside the chamber from dead turfgrasses mowed at 4 mm (bentgrass green), 14 mm (Kentucky bluegrass fairway), and 7.6 cm (Kentucky bluegrass and bermudagrass lawns), July 10, 2008.

Comparing Estimates of Turfgrass Quality Obtained using Normalized Difference Vegetation Index, Digital Imagery, and the Human Eye

Objective: Compare visual quality ratings of individual turfgrass plots with corresponding measurements of (1) spectral reflectance using multispectral radiometry and (2) percentage green cover from digital images.

Investigators: Hyeonju Lee, Dale Bremer, and Kemin Su

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

Introduction

Turfgrass quality is typically evaluated by visual observations of color, uniformity, density, and texture. Visual evaluations, however, are subjective and can vary among people. Multispectral radiometry and digital photography may provide quantitative, objective evaluations of turfgrass quality and responses to various stresses by measuring spectral reflectances of turfgrasses in the visible and near-infrared part of the spectrum (multispectral radiometry) or the percentage green cover (digital photography). This study investigated relationships among estimates of turfgrass quality obtained using visual observation, multispectral radiometry, and digital photography.

Methods

This research was conducted under an automated rainout shelter from June 20 to Sept. 30, 2005, at the Rocky Ford Turfgrass Research Center in Manhattan, KS. Visual ratings, reflectance measurements, and digital images were collected from turfgrass plots of Kentucky bluegrass (*Poa pratensis* L. 'Apollo'), tall fescue (*Festuca arundinacea* Schreb. 'Dynasty'), and two hybrid bluegrasses (HBG; 'Reveille' and 'Thermal Blue'); HBG are genetic crosses between Kentucky bluegrass and native Texas bluegrasses (*Poa arachnifera* Torr.). Two irrigation treatments were used to impose water stress: well watered (replacement of 100% of evapotranspiration [ET]) and irrigation deficit (60% ET replacement). Plots were mowed at 3 in. and arranged in a randomized complete block design with four replications.

Visual quality of each plot was rated on a scale from 1 to 9 (1 = brown and dead turf, 6 = minimally acceptable turf for use in home lawns, 9 = optimum turf) by the same person. Spectral reflectance of the canopy was measured with a handheld multispectral radiometer (MSR; model MSR16, CropScan, Inc. Rochester, MN), which provided estimates of the normalized difference vegetation index (NDVI; computed as R935 - R661/R935 + R661, where R = reflectance). Reflectance measurements were collected near the center of each plot with the MSR at 3.3 ft above ground level. To reduce variation, canopy reflectance was taken between 1200 and 1430 hours CST with no cloud cover during the whole season. All turfgrass plots were fully vegetated; thus, soil background effects were negligible. Estimates of percentage green cover were obtained from digital images taken with the First Growth Digital Canopy Camera (Version 1.1 Decagon Devices, Inc., Pullman, WA) on the same days as MSR measurements and visual estimates, also at 3.3 ft above ground level. Estimates of visual quality were then compared with NDVI and percentage green cover.

Results

When reflectance data from all turfgrass plots were pooled, visual quality was significantly correlated to NDVI ($r^2 = 0.78$; Figure 1). Similarly, estimates of percentage green cover from digital images were strongly correlated to visual quality ($r^2 = 0.79$; Figure 2). Nevertheless, disparities were observed in the relationships between visual quality and NDVI and percentage green cover. For example, at NDVI = 0.6, estimates of visual quality ranged from 3 to 6 (Figure 1). From Figure 2, it is evident that for each percentage green value on the abscissa, estimates of visual quality differed by two to four. For example, at 30% green cover, visual quality ranged from 4 to 7.

Digital images of plots clearly illustrated disparities in relationships among visual appearances, percentage of green cover, and NDVI (Figure 3). For example, three plots of a HBG (‘Thermal Blue’) with similar NDVI (i.e., 0.61 to 0.63) had subjective quality ratings that ranged from 4 to 6 and green cover that ranged from 31% to 61% (Figures 3A, 3B, and 3C). Similarly, photos of other HBG (‘Thermal Blue’) plots with similar NDVI (i.e., 0.70 to 0.71) had visual quality scores ranging from 5 to 7 and green cover ranging from 55% to 88% (Figures 3D, 3E, and 3F). Images of tall fescue plots with identical NDVI (i.e., 0.80) also exhibited wide ranges in visual quality score (i.e., from 5 to 8) and green cover (i.e., from 56% to 95%; Figures 3G, 3H, and 3I). Examples of disparities in the relationships between visual quality and percentage green cover are illustrated in two plots of a HBG (‘Thermal Blue’; Figures 3B and 3D). Both plots were rated with a visual quality of 5 but had 41% and 55%, respectively, green cover. Similarly, two other plots of ‘Thermal Blue’ with visual quality scores of 6 had green cover of 61% and 77% (Figures 3C and 3E).

The subjective nature of visual quality ratings undoubtedly contributed to variability in these relationships. The images presented in Figure 3, however, illustrate instances in which clear differences in visual quality were not detected with NDVI or percentage green cover.

Summary

Results from this study illustrate the complexity in estimating—subjectively or objectively—turfgrass quality. Each variable that can affect visual quality (e.g., canopy uniformity, texture, density, and color) may affect spectral reflectance and estimates of percentage green differently, which, in turn, may confound estimates of turfgrass quality obtained using reflectance data and digital imagery. Additional confounding effects of canopy architecture, soil background, solar elevation angles, atmospheric conditions, operator error, or turfgrass cultural practices (e.g., mowing height, turfgrass species) may exacerbate attempts to estimate visual quality with spectral reflectance data or digital photography. Because of the subjectivity and inherent error in human evaluation of turfgrass quality, measurements obtained using spectral reflectance and digital photography may be useful in providing more objective and accurate estimations of visual quality. Nevertheless, it may not be appropriate to totally discredit evaluations of turfgrass quality obtained with the human eye; ultimately, that is how turfgrass will be judged and evaluated, particularly for aesthetic purposes. In this study, we found important limitations in using reflectance data and digital imagery to estimate visual quality. Therefore, replacement of traditional visual assessments of turfgrass with reflectance measurements or digital imagery requires circumspection.

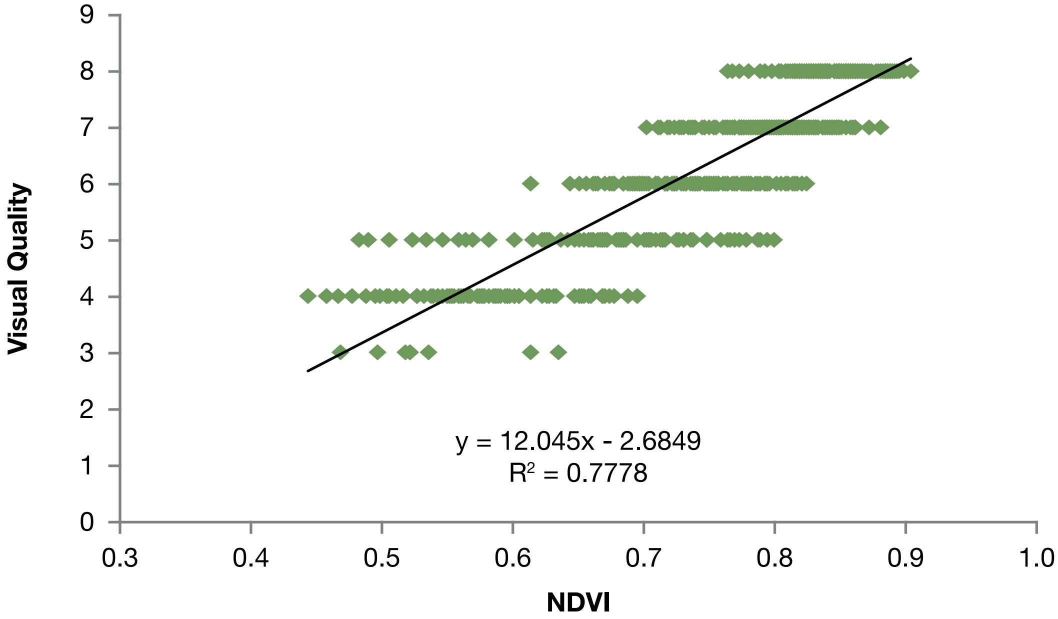

Figure 1. Relationship between visual quality ratings and normalized difference vegetation index (NDVI).

Data were regressed across the entire study period for four cool-season turfgrasses from well-watered and irrigation-deficit plots.

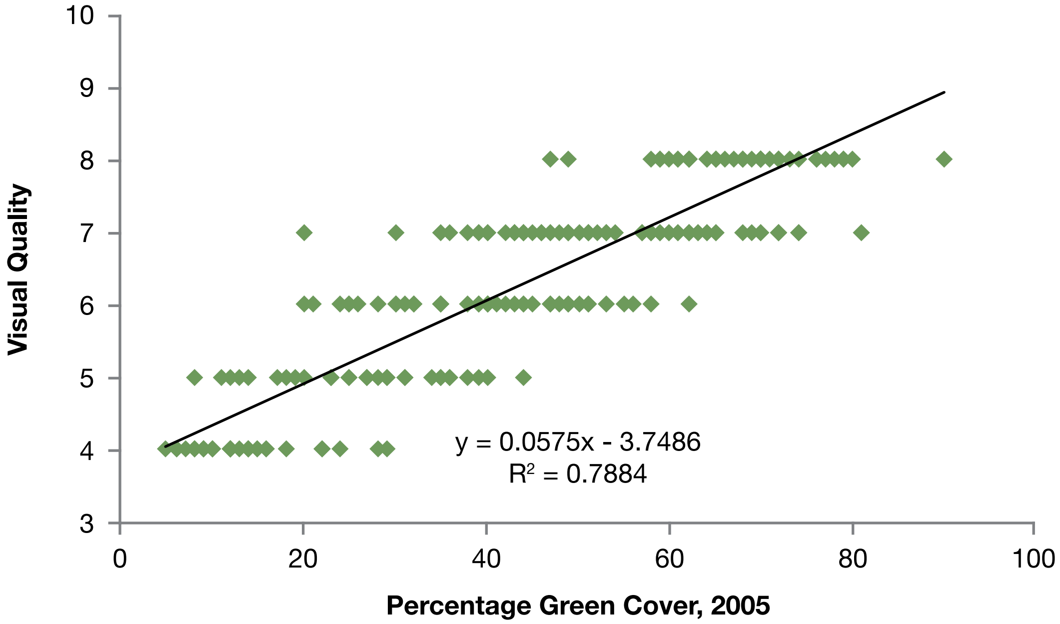

Figure 2. Relationship between percentage green cover (estimated from digital image analysis) and visual quality ratings.

All turfgrass species and water deficit treatments were pooled in this analysis.

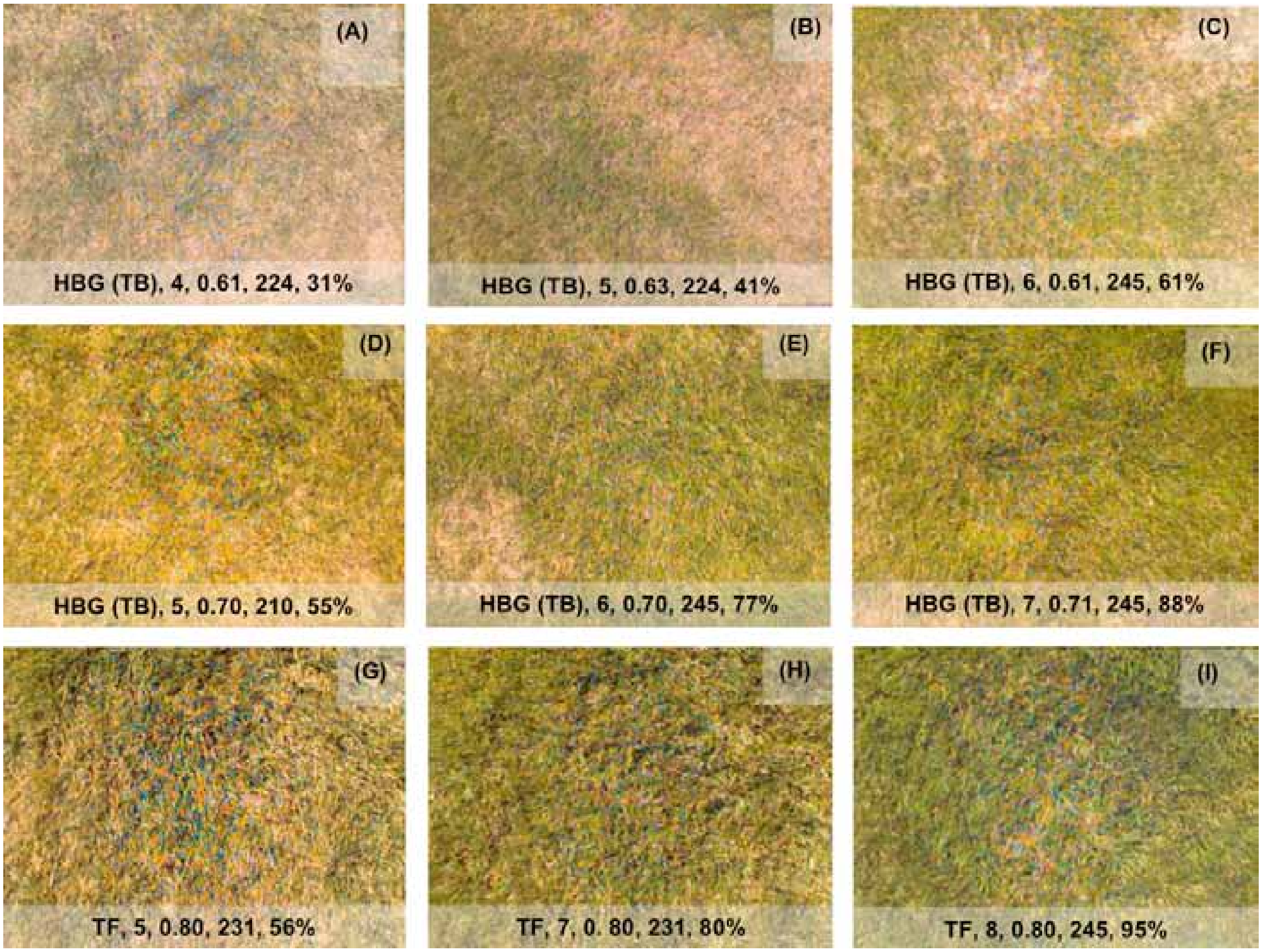

Figure 3. Digital images of individual turfgrass plots taken in 2005.
Text on each image represents (left to right): species (HBG = hybrid bluegrass, TB = 'Thermal Blue', and TF = tall fescue); visual quality ratings; normalized difference vegetation index; day of year; and percentage green cover.

Genetic Rooting Potential of 28 Kentucky Bluegrass Cultivars and Two Texas Bluegrass Hybrids

Objective:	Evaluate rooting characteristics in the 0- to 48-in. profile of 28 Kentucky bluegrass cultivars and Texas bluegrass hybrids in a greenhouse study.
Investigators:	Jason Lewis, Dale Bremer, Steve Keeley, and Jack Fry
Sponsors:	U.S. Golf Association, Turfgrass Producers International, Kansas Turfgrass Foundation

Introduction

One of the most important challenges facing the turfgrass industry is the increasingly limited supply of water for irrigation. Consequently, water conservation and improving turfgrasses' resistance to drought stresses have become increasingly important. One strategy to mitigate irrigation demands for turfgrass may be to identify cultivars that use less water and tolerate drought better. Rooting depth can 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. Kentucky bluegrass (KBG; *Poa pratensis* L.) is a popular turfgrass on golf course roughs and fairways, in sports fields, and in home and commercial lawns, and water requirements may vary among cultivars. In this study, rooting characteristics of 28 KBG cultivars and two Texas bluegrass hybrids (Table 1) were investigated in a greenhouse study. Texas bluegrass hybrids are genetic crosses between KBG and native Texas bluegrass (*Poa arachnifera* Torr.).

Methods

Cultivars were selected to include representatives from major "groups," based on similar phenotypic characteristics, of KBG; most cultivars were best performers in National Turfgrass Evaluation Program trials. Four standard entries were included in the mix: 'Midnight', 'Baron', 'Eagleton', and 'Kenblue'. Results from the first year of a concurrent field study, which investigated water requirements for maintaining acceptable quality for the same KBG in the summer of 2007, are summarized in the 2008 Kansas State University Turfgrass Research Report.[1]

The same cultivars used in the field study were evaluated for rooting depth in the greenhouse with slanted root tubes (Figure 1). Briefly, this involves seeding turfgrasses into clear polyethylene root tubes filled with fritted clay (Turface, Profile Products LLC,

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[1] See "Irrigation requirements of 28 Kentucky bluegrass cultivars and two Texas bluegrass hybrids in the transition zone," pp. 3-8 in Turfgrass Research 2008, Report of Progress 998. Kansas State University. Available at www.ksre.ksu.edu/library

Buffalo Grove, IL) and then inserting the polyethylene tubes into opaque PVC pipe (sleeves). Each species was planted in three tubes. Turfgrasses were seeded in the tubes in June 2007, and root growth was monitored periodically along the side of the clear root tubes. Once root growth ceased, we measured maximum root extension for each tube. The profiles were then split into 12-in. sections, the fritted clay was removed, and the roots were dyed with methyl blue. Roots were then scanned with root analyzing software that measured root surface area, average root diameter, and root length density. Roots were then dried in a forced convection oven and weighed to compare root biomass among cultivars.

Results

A broad range of rooting characteristics was observed. Root length density ranged from 16.6 in./in.^{3} for 'Midnight II' to 8.4 in./in.^{3} for 'Julia' in the 0- to 12-in. profile (Figure 2). In the 12-to 24-in. profile, root length density ranged from 4.3 in./in.^{3} for 'Apollo' to 0.6 in./in.^{3} for 'Blue Knight' (Figure 3). Several cultivars (but not all) had roots in the 24- to 36-in. profile. 'Abbey' had the greatest root length density (0.8 in./in.^{3}) at 24 to 36 in. (Figure 4). 'Abbey' and 'Touchdown' were the only cultivars that had roots deeper than 36 in., and both had similar root dry weight, surface area, maximum root extension, and mean root diameter (data not shown). There was no correlation between any rooting characteristics measured at any depth and the amount of water applied in the field study in 2006.

This rooting data combined with the ongoing field study should enhance our understanding of water use in KBG cultivars and provide guidance to turfgrass managers who are interested in KBG cultivars that can conserve water while maintaining acceptable quality.

Table 1. Kentucky bluegrass cultivars and Texas bluegrass hybrids selected for genetic rooting potential in greenhouse slanted growing tubes, Kansas State University

Group[1]	Cultivar[2]
Aggressive	Limousine
	Touchdown
Common	Kenblue
	Park
	Wellington
Compact	Diva
	Moonlight
	Skye
Compact America	Apollo
	Bedazzled
	Kingfisher
	Langara
	Unique
Compact midnight	Award
	Blue Velvet
	Midnight
	Midnight II
	Nu Destiny
European	Bartitia
	Blue Knight
Julia	Julia
Mid-Atlantic	Cabernet
	Eagleton
	Preakness
Shamrock	Abbey
BVMG	Baron
	Envicta
	Shamrock
Texas bluegrass hybrids	Longhorn
	Thermal Blue Blaze

[1] Groups are cultivars with similar phenotypic characteristics.

[2] Shaded boxes indicate the four standard entries.

Figure 1. Slant tubes used in the greenhouse to study drought resistance, recovery after drought, and genetic rooting depth potential of Kentucky bluegrass cultivars.

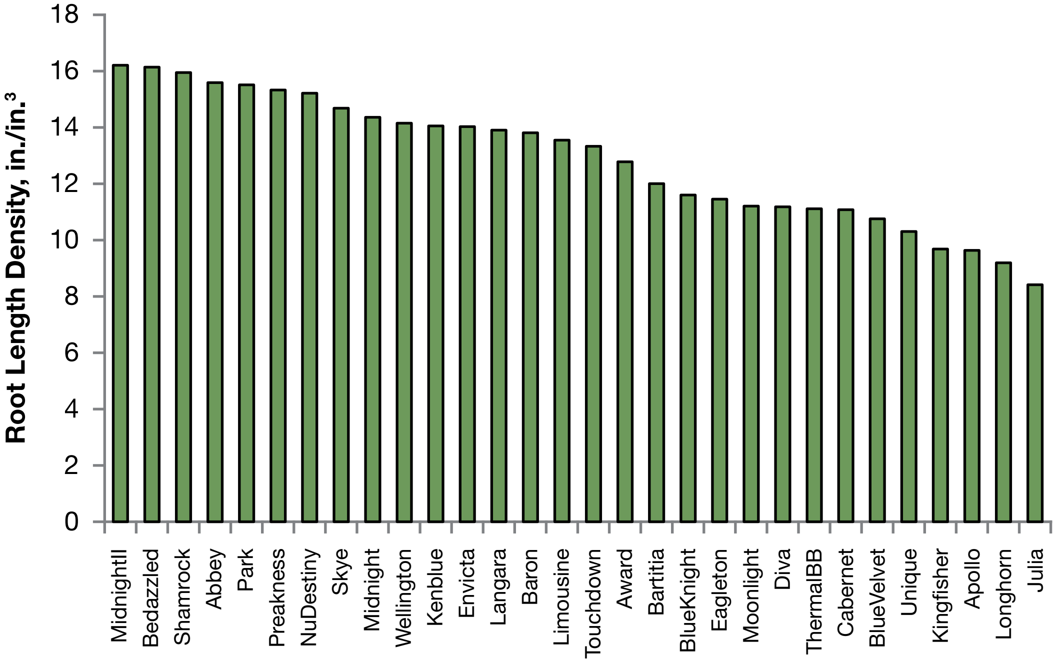

Figure 2. Root length density in the 0- to 12-in. depth.

Root length density is measured as inches of root length divided by the volume of soil.

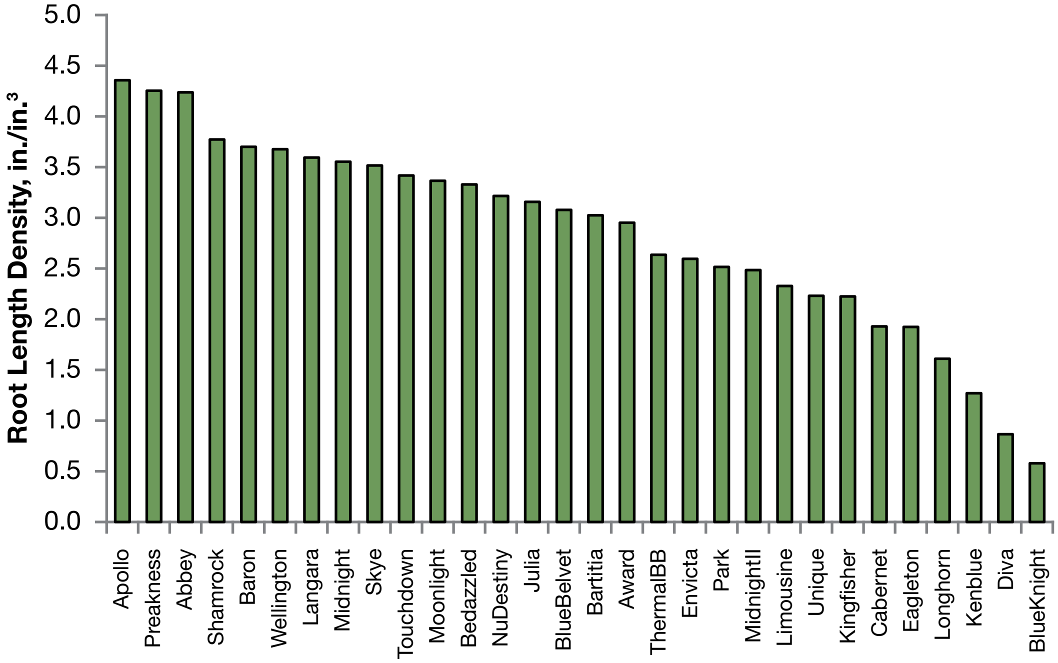

Figure 3. Root length density in the 12- to 24-in. depth.
Root length density is measured as inches of root length divided by the volume of soil.

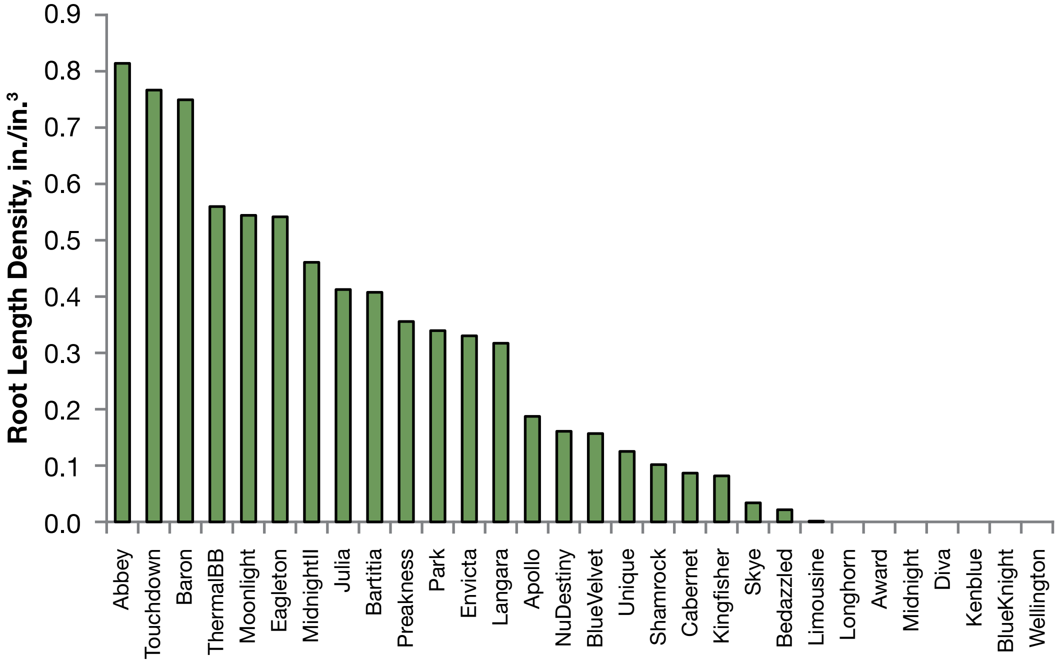

Figure 4. Root length density in the 24- to 36-in. depth.
Root length density is measured as inches of root length divided by the volume of soil.

Sod Strength and Recovery Growth of Experimental Zoysiagrass Progeny

Objective: Evaluate the suitability of new zoysiagrass progeny in terms of strong sod production and rates of recovery.

Investigators: David Okeyo, Jack Fry, and Rodney St. John

Cooperators: Milt Engelke, Ambika Chandra, and Dennis Genovesi, Texas A&M University

Sponsors: Heart of America Golf Course Superintendents Association, Kansas Golf Course Superintendents Association, Kansas Turfgrass Foundation

Introduction

Sod strength and recovery growth after harvest are important considerations when evaluating zoysiagrasses for potential use in the transition zone. An ideal zoysiagrass sod should have good strength after harvest for handling, shipping, and laying and rapid recovery growth from rhizomes and stolons to reduce time between harvestable crops.

Methods

Sod was harvested from plots established June 5, 2007, at the Rocky Ford Turfgrass Research Center in Manhattan, KS. Plots measured 5 × 5 ft and were arranged in a randomized complete block with three replications. The study included 18 experimental zoysiagrass progeny, DALZ 0102, and 'Meyer'. Turf received 1 lb of nitrogen from urea on May 19 and July 14 and 0.75 lb on Aug. 12, 2008. Turf was irrigated to receive about 0.75 in./week and mowed three times weekly at 0.5 in.

On July 9, 2008, sod pieces (20 in. wide, 40 in. long, and 2 in. thick) were harvested from zoysiagrass plots with a mechanical cutter (Figure 1). Each sod piece was reduced to a 13-in. length to fit the platform grate of the sod puller. Each cut section was placed on the platform grate with half of it lying on the mobile grate and half on the fixed grate (Figure 2). Tensile strength was determined from peak resistance measured by an S-beam load cell. Sod strength was recorded as the resistance of the sod to the longitudinal stress required to tear the sod mats. Two subsamples were measured from each of three replications, giving six measurements for each turfgrass progeny.

Sod regrowth from rhizomes, stolons, or both was determined from images of a 16- × 14-in. area within the harvested area of each plot (Figure 3). To determine recovery, defined as green color, overhead photographs of each plot were taken with a Nikon D100 AF LR 28:105 mm camera mounted on a tripod at 4 ft above the plots. Digital images were analyzed with Sigma Scan Pro 5 under a color hue threshold of between 30 and 100 and saturation of between 0 and 100.

Results

Zoysiagrass sod tensile strength ranged from 97 lb (5311-27) to 504 lb (5311-22); tensile strength of 'Meyer' was 310 lb (Table 1). On average, zoysiagrass tensile is much higher than that reported for other turfgrasses. For example, research with Kentucky bluegrass demonstrated that sod strengths were in the 88- to 132-lb range.

Sod regrowth in strips 90 days after harvest ranged from 17% (5324-18) to 96.9% (5324-27); 'Meyer' regrowth was 37.9%. The rapid recovery demonstrated by 5324-27 makes this progeny attractive to sod producers who want to speed the time to next harvest.

Table 1. Mean sod tensile strength and regrowth of zoysiagrasses, Manhattan, 2008

Cultivar or progeny[1]	Tensile strength (lb)[2]	Regrowth (% cover)[3]
8507 × Meyer		
5283-27	377ab	40.0bcdef
Cavalier × Chinese Common #2		
5311-3	409ab	40.8bcdef
5311-8	441ab	47.4bcde
5311-22	504a	30.3ef
5311-26	304b	51.0bcde
5311-27	97c	55.8bcde
5311-32	405ab	34.5def
Zorro × Chinese Common #2		
5312-36	481ab	30.0ef
5312-49	231bc	50.9bcde
Emerald × Meyer		
5321-3	375ab	40.9bcdef
5321-24	345ab	64.1bc
5321-45	395ab	68.7ab
5321-48	254bc	66.3bc
8501 × Meyer		
5324-18	315b	17.0f
5324-27	173bc	96.9a
5324-52	214bc	37.9cdef
5324-53	333b	49.7bcde
Meyer × Diamond		
5327-19	267b	52.0bcdef
DALZ 0102	497ab	62.0bcd
Meyer	310b	37.8cdef

[1] Grasses were planted on June 5, 2007.

[2] Tensile strength was determined by using a sod puller with two sliding bars to pull a fixed sod from opposite ends until it tore.

[3] Sod regrowth was determined with digital analysis of overhead pictures taken Sept. 9, 2008, 90 days after sod harvest.

Within a column, means followed by the same letter are not significantly different according to an LSD multiple comparison test at $P \leq 0.05$.

Figure 1. Sod strips were cut from plots of experimental zoysiagrass progeny.

Figure 2. Sod was evaluated for tensile strength.

Figure 3. Regrowth within harvested strips was evaluated from digital images.

Growth of Zoysiagrasses under Moderate Shade

Objective: Evaluate the performance of standard and experimental zoysiagrasses under moderate shade.

Investigators: David Okeyo, Jack Fry, and Dale Bremer

Cooperators: Milt Engelke, Ambika Chandra, and Dennis Genovesi, Texas A&M University

Sponsors: Heart of America Golf Course Superintendents Association, Kansas Golf Course Superintendents Association, Kansas Turfgrass Foundation

Introduction

Moderate shade in home lawns, perimeters of golf course fairways, and on tees often causes a decline in quality of 'Meyer' zoysiagrass (*Zoysia japonica*), the cultivar most commonly used in the transition zone. Emerald zoysiagrass (*Z. japonica* × *Z. tenuifolia*) and cultivars of *Z. matrella* generally are considered to have better shade tolerance than 'Meyer' and other *Z. japonica* cultivars. Our objective was to evaluate the shade tolerance of some of these cultivars and compare them with experimental progeny, most resulting from crosses of *Z. japonica* × *Z. matrella*.

Methods

Two study areas were established at the Rocky Ford Turfgrass Research Center in Manhattan, KS: one in full sun and the other to the immediate north of a line of large maple trees (Figure 1). Plugs (3 in. diameter) from four new zoysiagrass progeny and eight commonly used cultivars or species were planted as single plugs in the center of 5- × 5-ft plots on June 30, 2008. Both sets of plots were arranged in a randomized complete block design with six replicates. On Aug. 18, 2008, mean photosynthetically active radiation in the shade study area was 630 μmol/m^2 per second at 0730 hours, 2,913 μmol/m^2 per second at 1030 hours, 4,821 μmol/m^2 per second at 1330 hours, 471 μmol/m^2 per second at 1630 hours, and 69 μmol/m^2 per second at 1930 hours.

Urea was applied twice during the summer to provide a total of 2 lb. nitrogen/1,000 ft^2. Plots were irrigated to maintain 25% to 35% soil water content by volume. No mowing was done. Data were collected weekly on stolon number, length, and branching. The first three stolons to emerge from plugs were marked by attaching a loose thread. Stolon elongation was measured by marking the end of each stolon with a plastic toothpick and moving it once weekly. Tiller numbers in a 20-cm^2 area were counted at the beginning and end of the study, and values were converted to 1 cm^2. Total biomass was measured at the end of the study by uprooting all aboveground tissue, placing it in a paper bag, and drying it at room temperature (≈77°F) for 2 weeks. Soil was then shaken off samples, and roots were removed before weighing. Data were analyzed with the general linear models procedure, and means were separated by Fisher's protected LSD at $P \leq 0.05$.

Results

In moderate shade, stolon number declined from 80.3% ('Emerald') to 97.8% ('Meyer'), stolon length declined from 11.7% (5321-3) to 45.1% (5311-27), stolon branching declined from 50.2% (5327-19) to 91.8% ('Diamond'), and total biomass declined from 71.2% ('Diamond') to 93.7% ('Zorro') compared with values in full sun (Table 1).

Tiller number reflects the ability of zoysiagrass to maintain density in moderate shade. Only 'Emerald', Chinese Common #1 and #2, the Emerald × Meyer cross (5321-3), and the Diamond × Meyer cross (5327-19) exhibited an increase in tiller number in moderate shade from July 14 to September 17 (Table 2). These grasses are more likely to maintain density and sustain quality longer in moderate shade than grasses that exhibited a decline in tiller number.

There is potential for one or more of the zoysiagrasses evaluated in this study to have improved shade tolerance relative to Meyer, and all have freezing tolerance sufficient for use in the transition zone.

Table 1. Stolon number, length, branching, and total biomass of zoysiagrass cultivars and experimental progeny grown in shade and full sun, Manhattan, 2008[1,2]

	Number[3]			Length[4] (in.)			Branches[5] (no./stolon)			Total biomass [6] (oz)		
Cultivar or Experimental progeny	Sun	Shade	Change (%)	Sun	Shade	Change (%)	Sun	Shade	Change (%)	Sun	Shade	Change (%)
Z. japonica × *Z. tenuifolia*												
Emerald	62.5cd	12.3abcd	-80.3	8.9ef	7.2de	-19.1	47.2b	16.5abc	-65.0	1.81e	0.52abc	-71.2
Z. japonica												
Meyer	171.2a	3.8f	-97.8	9.5ef	6.4de	-32.6	47.3b	7.8cd	-83.5	1.95e	0.48abc	-75.4
Chinese Common #1	47.8d	7.5def	-84.3	24.3a	13.8ab	-43.2	55.6ab	15.2abc	-72.7	4.95ab	0.72ab	-85.5
Chinese Common #2	42.7d	6.8ef	-84.1	19.2bc	12.6abc	-34.3	50.6ab	15.1abc	-70.2	3.22cde	0.62abc	-80.7
Z. matrella												
Diamond	55.3d	3.2f	-94.2	5.7f	3.7e	-35.1	37.8b	3.1d	-91.8	1.70e	0.53abc	-68.8
Cavalier	72.0bcd	10.7bcde	-85.1	12.5de	9.6bcd	-23.2	38.4b	11.6bcd	-69.8	3.36bcde	0.55abc	-83.6
Zorro	115.8b	14.8ab	-87.2	17.8bc	11.9abc	-33.1	71.7a	19.6ab	-72.7	6.31a	0.40c	-93.7
Cavalier × Chinese Common #2												
5311-22	86.5bcd	17.5a	-79.8	17.7bc	12.2abc	-31.1	39.0b	13.3abc	-65.9	3.96bcd	0.54abc	-86.4
5311-27	61.3cd	12.0bcde	-80.4	15.3cd	8.4cde	-45.1	41.6b	10.9bcd	-73.8	2.72de	0.77a	-71.7
Zorro × Chinese Common #2												
5312-49	57.3cd	9.2cde	-83.9	20.9ab	13.2ab	-36.8	41.4b	15.2abc	-63.3	3.69bcd	0.47bc	-87.3
Emerald × Meyer												
5321-3	105.5bc	13.0abc	-87.7	17.1bcd	15.1a	-11.7	51.0ab	19.9ab	-61.0	4.92abc	0.47bc	-90.4
Meyer × Diamond												
5327-19	61.3cd	9.7bcde	-84.2	16.5bcd	13.7ab	-17	42.8b	21.3a	-50.2	2.47de	0.36c	-85.4

[1] Change is the percentage change in values from full sun to shade conditions.

[2] Grasses were planted in moderate shade as 3-in.-diameter plugs with six replicates on June 30, 2008.

[3] Average number of stolons per plug over six replicates on Sept. 17, 2008.

[4] Average total length of three randomly selected stolons per plug over six replicates.

[5] Average number of branches on three stolons per plug over six replicates on Sept. 17, 2008.

[6] Average dry weight of all aboveground plant parts over six replicates after harvest on Sept. 17, 2008.

Within a column, means followed by the same letter are not significantly different according to an LSD multiple comparison test at $P \leq 0.05$.

Table 2. Changes in tiller number of zoysiagrass cultivars and experimental progeny in moderate shade from July 14 to Sept. 17, 2008, Manhattan[1]

	Tiller no. (per sq. ft)[2]		
Cultivar or experimental progeny	July 14	Sept. 17	Change (%)
Z. japonica × *Z. tenuifolia*			
Emerald	76bcd	85b	+11.8
Z. japonica			
Meyer	81bc	62cd	-23.5
Chinese Common #1	33e	37e	+12.1
Chinese Common #2	33e	37e	+12.1
Z. matrella			
Diamond	212a	127a	-40.1
Cavalier	101b	73bc	-27.7
Zorro	81bc	78bc	-3.7
Cavalier × Chinese Common #2			
5311-22	53cde	40e	-24.5
5311-27	98b	52de	-46.9
Zorro × Chinese Common #2			
5312-49	48de	45de	-6.3
Emerald × Meyer			
5321-3	48de	52de	+8.3
Meyer × Diamond			
5327-19	71e	72e	+1.4

[1] Grasses were planted in moderate shade as 3-in.-diameter plugs with six replicates on June 30, 2008. Change values are the percentage of growth relative to an identical study area in full sun.

[2] Average number of tillers is the number of tillers counted within a 3-in.^{2} area of the planted plug over six replicates on July 14 and Sept. 17, 2008, and converted to number of tillers per square foot.

Within a column, means followed by the same letter are not significantly different according to a LSD multiple comparison test at $P \leq 0.05$.

Figure 1. The study was conducted just to the north of this line of maple trees in Manhattan, KS.

Evaluation of Fungicide Applications for Control of Dollar Spot on Creeping Bentgrass

Objective:	Determine the efficacy of conventional fungicides and biological controls for control of dollar spot in creeping bentgrass.
Investigators:	Megan Kennelly and Andrew Lance
Sponsors:	BASF, Cleary Chemical, Kansas Turfgrass Foundation

Introduction

Dollar spot is caused by the fungus *Sclerotinia homoeocarpa*. It is a common disease, appearing on golf course putting greens nearly every year. Dollar spot can develop throughout the growing season but is most common in spring through early summer and again in late summer through early fall. In putting-green-height turf, the disease appears as sunken patches of tan/brown turf up to about 2 in. in diameter. In severe cases, the infection spots coalesce to form larger blighted areas. Many fungicides are labeled for dollar spot suppression in golf courses. This study was conducted to evaluate several standard and newer conventional fungicides as well as several biological control agents.

Methods

Fungicides were evaluated on an established stand of a blend of 'Crenshaw' and 'Cato' creeping bentgrass grown on a sand-based putting green at the Rocky Ford Turf Research Center in Manhattan, KS. The turf was mowed 6 days/week to a height of 0.156-in., irrigated daily for 15 min, and fertilized with 2.25 lb nitrogen (N)/1,000 ft^2 during the season. Applications were made at 1, 2, or 3-week intervals beginning May 20 and ending July 30. A fertility treatment (urea at 0.14 lb N/1,000 ft^2) was included as a check for comparisons with Ecoguard, which contains that rate of N. All materials were applied with a CO_2-powered boom sprayer with XR Tee Jet 8003VS nozzles at 30 psi in water equivalent to 2.0 gal/1,000 ft^2. Plots were 4 × 5 ft and arranged in a randomized complete block design with four replications. Plots were rated every 1 to 2 weeks from June 2 through September 16 by visually estimating the percentage of each plot affected by dollar spot symptoms. Values were $\ln(x + 1)$ transformed prior to analysis, and treatment means were compared with Tukey's pairwise comparisons with family error rate $P = 0.05$ (Minitab 15 Statistical Software, State College, PA).

Results

See Table 1 for full results. On all rating dates, all of the conventional fungicides (Trinity, Emerald, Spectro, 26/36, and 3336F) reduced disease significantly compared with the untreated control, with disease severity < 1% through early August. On September 16, 7 weeks after the final applications, Trinity, Emerald, Spectro, 26/36, and 3336F still exhibited significant control of dollar spot. This long period of residual control is notable.

In most cases, the biological control products did not reduce disease. However, on July 15, the 7-day EcoGuard treatment reduced disease compared with the untreated control and the fertility control. On August 5, the 1.0-oz rate of EndoFine reduced disease compared with the untreated control, and both EcoGuard treatments reduced disease compared with the untreated control but not the fertility check. No phytotoxic effects were observed.

Table 1. Dollar spot severity as influenced by fungicides, 2008

Treatment[2] and rate/1,000 ft^2	Spray interval (days)	Disease severity[1] June 2	July 15	Aug. 5	Sept. 16
Trinity 1.69SC 1.0 fl oz	14	0.0a	0.0a	0.0a	3.0ab
Trinity 1.69SC 1.5 fl oz	21	0.0a	0.0a	0.0a	3.0ab
Emerald 70WG 0.13 oz	14	0.5ab	0.0a	0.0a	1.3a
Emerald 70WG 0.18 oz	21	0.5ab	0.0a	0.0a	1.3a
Spectro 90WDG 4.0 oz	14	0.0a	0.0a	0.0a	3.0ab
26/36 3.8SC 3.0 fl oz	14	0.0a	0.0a	0.0a	4.0b
3336F 3.0 fl oz	14	0.0a	0.0a	0.0a	5.8b
Insignia 20WG 0.5 oz	14	6.3bc	22.5b	6.0c	35.0c
EcoGuard L 20.0 fl oz	14	13.8c	6.5b	2.3b	22.5c
EcoGuard L 20.0 fl oz	7	17.5c	2.0a	0.8b	16.0c
Actinovate AG 0.27 oz + Revolution L 6.0 fl oz	14	15.0c	14.0b	9.5c	25.0c
Actinovate AG 0.27 oz + Revolution L 6.0 fl oz	7	13.0c	9.5b	5.8c	18.8c
EndoFine WP 1.0 oz	14	16.3c	9.5b	1.8b	21.3c
EndoFine WP 2.0 oz	14	13.8c	8.3b	5.8c	25.8c
Contans WG 2.25 oz	14	16.3c	13.3b	2.5bc	20.5c
Contans WG 1.5 oz	14	18.0c	14.5b	8.3c	23.3c
Revolution L 6.0 oz	7	13.8c	14.5b	3.3c	18.8c
Urea (46-0-0) 2.2 oz	7	10.0c	6.8b	2.5bc	16.8c
Untreated	–	11.3c	17.0b	7.0c	22.0c

[1] Values represent the mean percentage of the plot area showing symptoms for four replicates. Values were ln(x + 1) transformed prior to analysis.

[2] 7-day treatments were applied on May 20 and 29; June 3, 12, 18, and 26; and July 2, 9, 15, 24, and 30. 14-day treatments were applied on May 20; June 3 and 18; and July 2, 15, and 30. 21-day treatments were applied on May 20, June 12, and July 2 and 24.

Within columns, means followed by the same letter are not significantly different according to Tukey's pairwise comparisons (family error rate $P = 0.05$).

Evaluation of Fungicide Applications for Control of Brown Patch in Tall Fescue

Objective:	Determine the efficacy of current and experimental materials for brown patch control in tall fescue.
Investigators:	Megan Kennelly and Andrew Lance
Sponsors:	BASF, Cleary Chemical, Kansas Turfgrass Foundation

Introduction

Brown patch, caused by *Rhizoctonia solani*, is the most common disease in tall fescue (*Festuca arundinaceae*) lawns in Kansas. The disease causes large areas of blighted turfgrass during hot, humid, summer weather. On individual plants, symptoms are visible as tan lesions with dark borders. This study was conducted to test the efficacy of several standard and experimental fungicides for brown patch suppression.

Methods

Fungicides were evaluated in an established stand of 'Kansas Premium' tall fescue (a blend containing 'Olympia II', 'Bonanza', 'Apache', and 'Monarch') at the Rocky Ford Turf Research Center in Manhattan, KS. The turf was mowed one to two times weekly to a height of 3 in., irrigated three times weekly for a total of 0.75 to 1.0 in./week, and fertilized with 1 lb nitrogen (N)/1,000 ft^2 in May and again in July to promote disease pressure. Fungicide applications were made on July 9 and August 5. All materials were applied with a CO_2-powered boom sprayer with XR Tee Jet 8003VS nozzles at 30 psi in water equivalent to 2.0 gal/1,000 ft^2. Plots were 5 × 10 ft and arranged in a randomized complete block design with four replications. Disease severity was rated every 1 to 2 weeks from July 9 through September 4 by visually estimating the percentage of each plot exhibiting brown patch symptoms.

Results

Brown patch symptoms were absent until the last few days of July, when humid conditions led to a rapid outbreak. On August 5 and 14, both Heritage treatments provided complete control (Table 1). All other treatments reduced disease severity compared with the untreated control on August 5 but not on August 14. Disease severity in untreated plots decreased to trace levels by the end of August. No phytotoxic effects due to fungicide applications were observed.

Table 1: Brown patch severity as influenced by fungicides, 2008

Treatment and rate/1,000 ft^2	Spray interval (days)	Disease severity[1]		
		Aug. 5	Aug. 14	Aug. 21
Heritage 50 WG 0.4 oz	28	0.0a	0.0a	0.0
Heritage TL 0.8ME 2.0 fl oz	28	0.0a	0.0a	0.0
USF 10380T 1.6SC 3.0 fl oz + urea 0.046 lb	28	9.5b	5.8b	0.0
Chipco Triton 70WDG 0.45 oz	28	12.0b	8.0b	0.0
USF 10380T 1.6SC fl 3.0 oz	28	13.3b	7.8b	0.0
Legacy E 0.85SC 3.0 fl oz + urea 0.046 lb	28	13.8b	7.8b	0.0
Armada 50WP 1.2 oz	28	14.0b	10.5b	0.5
Legacy E 0.85SC 3.0 fl oz	28	20.0b	11.0b	0.8
Untreated	–	32.5c	8.8b	0.5

[1] Values represent the mean percentage of the plot area showing brown patch symptoms for four replicates. Values were transformed to $\arcsin\sqrt{(x/100)}$ prior to analysis.

Within columns, means followed by the same letter are not significantly different according to Fisher's protected LSD test at $\alpha < 0.05$.

2006 National Turfgrass Evaluation Program Tall Fescue Evaluation

Objective: Evaluate tall fescue cultivars under Kansas conditions and submit data collected to the National Turfgrass Evaluation Program.

Investigators: Linda R. Parsons and Rodney St. John

Sponsor: National Turfgrass Evaluation Program

Introduction

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

Methods

On Sept. 8, 2006, we seeded 348 study plots, each measuring 5 × 5 ft, at the John C. Pair Horticultural Center in Wichita, KS, with 116 tall fescue cultivars and experimental numbers in a randomized complete block design. We are maintaining fertility of the plots at 0.25 to 0.5 lb nitrogen/1,000 ft^2 per growing month. We mow plots weekly during the growing season at 2.5 in. and remove clippings. We irrigate as necessary to prevent stress and control weeds, insects, and diseases only when they present a threat to the trial.

During this 6-year study, we will collect information on establishment, spring greenup, genetic color, leaf texture, quality, fall color retention, and other measures when appropriate. Rating is done on a scale of 0 to 6 (0 = poorest, 6 = acceptable, and 9 = optimum).

Results

During the 2008 growing season, we collected data on turf greenup, genetic color, texture, quality, and fall color retention. We started by evaluating spring greenup on April 7; DP 50-9407, SC-1, ‘Talladega’ (RP 3), and ‘Wolfpack II’ (PST-5WMB) were the greenest. Throughout the growing season, we rated the turf monthly for quality. Ratings were influenced by degree of coverage, weed infestation, and disease resistance as well as turf color, texture, and density. DP 50-9407, RKCL, SC-1, ‘Talladega’ (RP 3), and ‘Honky Tonk’ (RAD-TF17) performed best overall. When we evaluated genetic color and texture, AST-2, AST-1, DP 50-9411, and LS-03 were the darkest green, and SC-1, ATM, DP 50-9440, 'Firecracker LS' (MVS-MST), IS-TF-138, and RKCL had the finest texture. On November 7, we rated the turf for fall color retention; BAR Fa 6363, JT-33, and RK 6, were the greenest.

More information on NTEP and the nationwide 2006 National Tall Fescue Test results are available online at: *http://www.ntep.org/*

Table 1. 2008 performance of tall fescue cultivars, Wichita[1]

Cultivar/experimental number[2]	Greenup	Genetic color	Leaf texture	Fall color retention	Quality Apr.	May	June	July	Aug.	Oct.	Avg.
DP 50-9407	6.3	7.7	6.0	4.7	6.7	7.0	6.3	6.3	7.0	6.7	6.7
RKCL	5.7	6.0	7.0	4.7	6.3	7.0	6.3	5.7	6.3	6.7	6.4
SC-1	6.3	6.7	7.7	4.3	6.0	7.0	6.7	6.0	6.3	6.3	6.4
Talladega (RP 3)*	6.3	6.0	6.0	4.0	6.0	6.3	6.7	6.3	6.3	6.0	6.3
Honky Tonk (RAD-TF17)*	5.7	6.7	5.3	4.7	6.3	7.3	5.7	6.0	5.7	5.7	6.1
LS-03	5.7	8.0	6.0	4.7	5.7	6.3	7.0	5.7	5.3	6.3	6.1
Spyder LS (Z-2000)*	5.3	6.3	6.3	3.7	6.0	6.7	6.0	6.0	5.7	6.0	6.1
JT-33	5.7	6.7	6.0	5.0	6.3	6.7	6.7	5.3	5.7	5.3	6.0
NA-BT-1	5.7	5.3	6.7	4.7	6.0	6.0	6.0	6.0	6.0	6.0	6.0
RP 2	6.0	6.3	6.0	4.3	6.0	5.7	6.3	5.7	6.7	5.7	6.0
Col-M	5.3	7.0	6.0	4.7	5.7	6.3	6.0	6.0	6.3	5.3	5.9
RK 6	5.3	6.3	6.7	5.0	6.0	6.0	6.3	5.7	6.3	5.3	5.9
AST-3	5.3	7.3	6.0	4.0	5.7	6.3	6.0	6.0	5.7	6.0	5.9
BAR Fa 6235	6.0	6.3	6.0	4.7	6.0	7.0	6.3	5.7	5.3	5.3	5.9
Firecracker LS (MVS-MST)*	6.0	5.7	7.0	4.0	6.3	6.3	5.7	5.7	5.7	6.0	5.9
IS-TF-138	5.3	6.7	7.0	3.7	5.7	7.0	6.7	5.3	5.7	5.3	5.9
MVS-1107	5.3	6.7	6.0	4.7	6.0	6.0	6.0	5.7	6.0	5.7	5.9
PSG-TTRH	5.7	6.0	6.0	4.7	6.0	6.7	6.7	5.3	5.0	5.7	5.9
Raptor II (MVS-TF-158)*	5.0	7.0	6.0	4.3	5.3	6.0	7.0	6.0	6.0	5.0	5.9
Speedway (STR-8BPDX)*	5.3	6.7	5.7	4.3	6.3	6.3	6.0	5.3	5.7	5.7	5.9
Turbo*	5.7	6.0	6.0	4.3	6.3	6.3	6.0	5.0	6.0	5.7	5.9
Wolfpack II (PST-5WMB)*	6.3	5.3	6.7	4.7	6.3	5.7	6.3	5.7	5.7	5.7	5.9
KZ-2	5.3	7.7	6.0	4.0	5.7	7.0	6.3	5.0	5.3	5.7	5.8
RK 5	5.7	6.7	6.7	4.0	6.0	6.0	6.0	5.3	5.7	6.0	5.8

continued

Table 1. 2008 performance of tall fescue cultivars, Wichita[1]

Cultivar/experimental number[2]	Greenup	Genetic color	Leaf texture	Fall color retention	Quality						
					Apr.	May	June	July	Aug.	Oct.	Avg.
STR-8GRQR	5.3	6.7	5.7	4.3	5.7	6.0	6.3	5.3	5.7	6.0	5.8
DP 50-9440	4.7	6.7	7.0	4.0	6.0	6.3	6.3	5.3	5.3	5.3	5.8
Firenza*	5.3	6.3	6.0	4.3	6.0	5.7	6.3	5.0	6.0	5.7	5.8
Turbo RZ (Burl-TF8)*	5.7	6.0	5.7	3.3	6.3	6.3	5.3	5.3	6.0	5.3	5.8
ATF-1199	5.3	6.3	5.3	4.3	6.3	5.7	6.0	5.7	5.3	5.7	5.8
ATM	5.7	5.3	7.0	4.0	6.0	6.0	5.7	5.3	5.7	6.0	5.8
PSG-85QR	5.0	5.3	5.7	4.3	5.7	7.0	6.0	5.0	5.7	5.3	5.8
SH 3	5.7	5.3	6.7	4.7	6.0	6.0	6.0	5.0	5.7	6.0	5.8
SR 8650 (STR-8LMM)*	5.3	7.0	5.7	4.0	6.0	6.0	6.0	5.3	5.7	5.7	5.8
Traverse SPR (RK-1)*	5.7	5.3	6.7	4.3	6.3	6.0	5.3	5.0	6.0	6.0	5.8
AST-2	5.0	8.3	6.7	4.7	6.0	5.7	6.3	5.3	6.0	5.0	5.7
DP 50-9411	4.7	8.0	6.0	3.7	6.0	6.3	5.3	5.0	5.7	6.0	5.7
PST-5HP	5.3	5.7	6.3	4.3	6.0	5.3	6.3	5.7	5.3	5.7	5.7
STR-8BB5	5.0	6.0	6.7	4.0	6.0	6.3	6.0	5.3	5.3	5.3	5.7
Skyline*	4.7	5.7	5.7	4.3	6.0	5.3	6.0	5.7	5.7	5.7	5.7
TG 50-9460	5.3	6.7	6.0	3.3	6.3	6.0	5.7	5.7	5.0	5.7	5.7
3rd Millennium SRP*	5.3	6.0	6.0	4.0	6.0	5.7	5.7	5.3	5.7	5.7	5.7
BGR-TF1	5.0	7.3	5.7	4.3	6.0	6.7	5.7	5.0	5.0	5.7	5.7
Rhambler SRP (Rhambler)*	5.0	5.7	5.7	4.7	5.7	5.7	6.0	5.3	5.7	5.7	5.7
Faith (K06-WA)*	5.0	5.7	6.3	3.7	6.0	5.7	5.3	5.7	5.0	6.0	5.6
GWTF	5.3	7.3	6.3	4.0	6.0	7.7	6.0	4.3	4.7	5.0	5.6
Jamboree (IS-TF-128)*	4.7	6.0	6.3	4.0	6.3	5.7	5.7	5.0	5.3	5.7	5.6
Rebel IV*	5.3	5.7	5.7	4.7	6.0	5.7	5.3	5.3	5.3	6.0	5.6
Tulsa Time (Tulsa III)*	5.0	6.7	6.3	4.0	5.7	6.0	5.7	5.0	5.7	5.7	5.6

continued

Table 1. 2008 performance of tall fescue cultivars, Wichita[1]

Cultivar/experimental number[2]	Greenup	Genetic color	Leaf texture	Fall color retention	Quality Apr.	May	June	July	Aug.	Oct.	Avg.
06-WALK	5.3	6.7	5.3	4.0	5.7	5.3	6.0	5.7	5.7	5.3	5.6
AST 7001	5.3	7.7	5.7	4.3	5.7	6.3	6.7	4.7	5.0	5.3	5.6
Monet (LTP-610 CL)*	5.3	5.3	6.7	3.7	5.7	6.7	5.3	5.3	5.3	5.3	5.6
IS-TF-152	4.0	7.0	6.0	4.3	5.0	6.0	5.0	5.7	5.7	5.7	5.6
AST 7003	5.3	7.3	6.0	3.3	5.3	6.0	5.7	5.3	5.0	6.0	5.6
Col-1	5.3	6.3	6.0	4.0	5.7	5.3	6.3	5.3	5.7	5.0	5.6
Hudson (DKS)*	4.7	6.7	6.0	4.0	5.7	6.0	6.0	5.3	5.0	5.3	5.6
RK 4	5.3	6.0	6.3	3.7	6.0	6.0	5.3	4.7	5.7	5.7	5.6
RNP	5.0	7.0	6.0	4.3	6.3	6.0	6.0	5.0	4.7	5.3	5.6
Rembrandt*	5.0	5.3	5.3	4.7	6.0	5.3	5.3	5.7	5.7	5.3	5.6
Titanium LS (MVS-BB-1)*	5.7	5.7	5.7	3.7	6.3	6.3	5.0	5.0	5.3	5.3	5.6
Hunter*	6.0	7.0	6.3	3.7	5.7	5.7	6.0	5.7	5.0	5.3	5.5
Col-J	5.3	7.0	6.0	4.0	5.7	6.3	5.7	5.0	4.3	6.0	5.5
Darlington (CS-TF1)*	5.0	7.7	6.3	4.7	5.7	6.0	5.7	5.0	5.3	5.3	5.5
Escalade*	5.3	6.0	6.0	3.7	6.3	5.7	5.0	5.3	5.0	5.7	5.5
Essential (IS-TF-154)*	5.7	5.7	6.3	3.7	5.7	6.0	5.7	5.3	5.0	5.3	5.5
JT-36	5.0	6.0	5.7	4.0	5.7	6.3	6.0	5.3	4.7	5.0	5.5
JT-42	5.0	5.7	5.7	3.7	5.7	5.7	5.7	5.3	5.3	5.3	5.5
NA-SS	5.0	7.0	6.0	3.3	5.3	6.0	6.0	5.0	5.0	5.7	5.5
PSG-82BR	5.3	5.7	6.3	3.7	5.3	5.7	5.7	5.7	5.0	5.7	5.5
Fat Cat (IS-TF-161)	4.3	6.3	6.0	4.3	5.7	5.0	5.7	5.3	5.3	5.7	5.4
LS-11	5.3	7.0	6.0	3.7	5.7	6.0	6.0	5.0	5.3	4.7	5.4
J-140	5.3	5.7	6.0	4.3	6.0	6.0	5.3	4.7	5.0	5.3	5.4
IS-TF-135	4.3	7.7	6.0	4.3	5.7	5.3	6.3	4.3	4.7	6.0	5.4

continued

Table 1. 2008 performance of tall fescue cultivars, Wichita[1]

					Quality						
Cultivar/experimental number[2]	Greenup	Genetic color	Leaf texture	Fall color retention	Apr.	May	June	July	Aug.	Oct.	Avg.
Lindbergh*	5.3	5.7	5.7	3.7	5.7	5.7	5.7	5.3	5.0	5.0	5.4
PSG-TTST	5.7	5.3	5.7	4.3	6.0	5.7	5.0	5.3	5.0	5.3	5.4
BGR-TF2	5.7	7.0	5.7	3.7	5.7	6.3	6.0	4.7	4.0	5.3	5.3
Bullseye*	5.0	6.3	6.3	3.7	5.3	5.7	5.0	5.3	5.3	5.3	5.3
Aristotle*	5.3	6.3	5.3	4.3	5.3	5.3	5.7	5.3	5.3	4.7	5.3
Biltmore*	5.3	6.7	5.0	4.0	5.7	6.0	6.3	4.3	4.3	5.0	5.3
MVS-341	5.3	6.7	5.7	4.0	6.0	5.7	5.7	5.0	4.0	5.3	5.3
AST-1	4.3	8.0	6.3	4.0	5.3	5.0	5.7	5.3	5.3	5.0	5.3
ATF 1247	5.0	6.3	5.7	4.0	5.7	5.7	5.7	4.7	5.0	5.0	5.3
Mustang 4 (M4)*	5.3	6.0	6.7	4.0	5.7	6.3	5.0	4.7	5.0	5.0	5.3
Van Gogh (LTP-RK2)*	5.3	6.0	6.0	4.3	5.7	5.7	4.7	5.0	5.3	5.3	5.3
06-DUST	5.3	6.3	6.0	3.7	5.7	5.7	5.7	5.0	4.7	4.7	5.2
Aggressor (IS-TF-153)*	4.7	6.3	5.7	4.3	6.0	5.7	5.3	4.7	5.0	4.7	5.2
CE 1	5.0	5.3	6.7	4.0	6.0	5.7	5.3	4.3	5.3	4.7	5.2
BAR Fa 6363	5.0	6.7	5.3	5.3	5.3	5.7	5.3	4.3	4.7	6.0	5.2
Padre*	5.3	5.7	5.7	3.7	5.7	5.7	5.3	4.7	4.7	5.3	5.2
Einstein*	5.3	5.3	6.0	3.7	5.7	5.3	5.7	4.7	5.0	4.7	5.2
GE-1	5.0	6.0	5.7	4.0	5.7	5.7	5.3	4.7	4.3	5.3	5.2
Hemi*	5.0	5.7	5.7	4.0	5.3	5.3	5.0	5.0	5.7	4.7	5.2
JT-41	4.7	6.0	6.0	4.0	5.7	6.0	5.3	4.7	4.3	5.0	5.2
PSG-RNDR	4.7	6.0	5.3	3.3	5.3	6.0	5.7	4.7	4.0	5.3	5.2
Tahoe II*	5.7	6.3	5.3	4.3	6.0	5.7	6.0	4.3	4.3	4.7	5.2
ATF 1328	4.7	7.3	6.0	4.0	6.0	5.7	5.3	4.7	4.0	4.7	5.1
Falcon IV*	4.7	6.0	5.0	4.7	5.7	4.7	4.7	5.0	5.0	5.3	5.1

continued

Table 1. 2008 performance of tall fescue cultivars, Wichita[1]

Cultivar/experimental number[2]	Greenup	Genetic color	Leaf texture	Fall color retention	Quality						
					Apr.	May	June	July	Aug.	Oct.	Avg.
IS-TF-159	5.0	7.0	6.0	3.0	5.3	5.3	5.0	5.3	4.7	4.7	5.1
LS-06	5.3	7.3	6.0	3.7	5.3	5.7	5.3	4.7	4.3	5.0	5.1
GO-1BFD	5.0	5.0	5.3	4.3	5.0	5.3	5.0	5.3	4.0	5.3	5.0
JT-45	4.3	6.0	6.0	4.3	5.3	5.0	5.3	4.7	5.0	4.7	5.0
Rocket (IS-TF-147)*	4.3	5.7	6.0	3.7	5.3	5.7	4.7	4.3	4.3	5.7	5.0
Justice*	5.3	5.3	6.0	4.0	5.3	5.3	5.3	4.3	4.3	5.0	4.9
J-130	4.3	5.3	6.0	3.7	5.7	5.0	5.0	4.7	4.3	5.0	4.9
Magellan*	4.7	5.7	5.3	3.7	6.0	5.3	5.0	3.7	4.3	5.0	4.9
Cezanne Rz (LTP-CRL)*	4.7	5.3	6.0	3.7	5.3	5.0	5.0	4.3	4.7	5.0	4.9
Plato*	5.3	5.0	6.0	4.3	5.0	5.3	4.7	4.7	4.3	5.0	4.8
0312	5.3	5.7	6.0	3.7	5.7	5.7	4.7	3.3	4.3	5.0	4.8
AST 7002	5.0	6.3	6.0	3.3	5.3	5.3	4.7	4.3	4.0	5.0	4.8
AST-4	5.0	7.3	6.0	3.3	5.0	5.7	4.7	4.7	3.7	4.7	4.7
Toccoa (IS-TF-151)*	4.3	7.0	6.3	3.3	4.7	5.0	4.7	4.7	5.3	4.0	4.7
KZ-1	4.0	6.3	5.3	4.7	5.0	4.3	4.3	4.7	4.0	5.7	4.7
Solverado*	5.0	4.0	4.3	3.3	4.3	3.3	4.0	3.7	3.3	4.0	3.8
Ky-31*	5.7	3.0	4.0	4.7	3.7	3.0	3.3	3.0	2.3	2.7	3.0
LSD[3]	2.3	1.3	1.0	3.8	2.0	1.8	2.6	2.1	1.9	1.2	1.1

[1] Ratings based on a scale of 0 to 9 (0 = poorest, 6 = acceptable, and 9 = optimum).

[2] Cultivars marked with an asterisk (*) will be commercially available in 2009.

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

2007 National Turfgrass Evaluation Program Zoysiagrass Evaluation

Objective:	Evaluate standard and experimental zoysiagrass cultivars for adaptation to the Midwest.
Investigator:	Jack Fry
Sponsor:	National Turfgrass Evaluation Program

Introduction

Although 'Meyer' is the predominant zoysiagrass cultivar used in Kansas, there is continuing interest in new cultivars. This National Turfgrass Evaluation Program zoysiagrass evaluation is being conducted at several locations across the United States. The most important consideration in our climate is freezing tolerance. High-density, fine-textured cultivars are usually from the *Zoysia matrella* group, but these cultivars are also less hardy.

Methods

Grasses were plugged into 5- × 5-ft plots on June 27, 2007. Turf was mowed 3 days weekly at 0.5 in. and irrigated as needed to receive about 0.75 in./week. Turf received two separate summer applications of 1 lb nitrogen/1,000 ft^2 from urea. Plots were rated for winterkill, summer coverage, spring greenup, leaf texture, and quality. Winterkill and summer coverage were rated on a scale of 0% to 100%. Other characteristics were visually evaluated on a scale of 0 to 9 (0 = worst, 9 = best).

Results

Winter hardiness is the limiting factor for introduction of new warm-season turf cultivars in the transition zone (Figure 1). When winterkill was evaluated in May, 'Shadowturf', L1F, and DALZ 0501 had the greatest injury. DALZ 0701 and DALZ 0702 also had more than 50% winterkill. Less than 5% winterkill was observed in 'Zenith', 'Meyer', 29-2, and 240. Spring greenup was greatest in zoysiagrasses that experienced the least winterkill.

Essentially, full coverage had occurred by midsummer in 240, 29-2, 'Meyer', and 'Zenith'. Less coverage was observed in zoysiagrasses still recovering from effects of winterkill.

Finest leaf texture was observed in 'Shadowturf', DALZ0702, 380-1, DALZ 0501, DALZ 0701, L1F, and 'Zorro'. 'Meyer' was intermediate in texture, and coarsest texture was observed in 240, 29-2, and 'Zenith'.

Mean quality between June and September was highest in 'Zorro', DAL0701, 380-1, and 'Meyer'.

Fall color, evaluated in November, was highest in 29-2, followed by 'Zenith'. All other grasses had similar color rankings.

In summary, nearly all of the grasses from *Z. matrella* experienced severe wintkerkill. The hardiest of the group was 'Zorro', which also had 15% winterkill. Among grasses from *Z. japonica*, 29-2 exhibited early spring greenup and good fall color retention but is slightly coarser in texture than 'Meyer'.

Table 1. Performance of zoysiagrasses at Manhattan, 2008

						Quality				
Name	Winter-kill[1]	Spring greenup[2]	Leaf texture	Summer coverage	Fall color	June	July	Aug.	Sept.	Mean
Zorro	14.7	5.0	8.0	88.3	2.3	6.3	8.0	6.7	8.0	7.3
DALZ 0701	66.7	3.3	8.0	66.7	2.0	5.0	6.7	6.3	8.0	6.5
380-1	26.7	5.3	8.0	93.0	2.7	6.3	7.3	5.7	5.7	6.3
Meyer	0.0	7.7	6.0	99.0	2.0	7.3	7.0	4.7	5.7	6.2
29-2	0.0	8.0	5.0	99.0	5.0	6.0	6.0	5.0	6.7	5.9
DALZ 0702	68.3	3.0	8.0	51.7	2.0	4.7	5.0	6.3	7.7	5.9
DALZ 0501	96.3	0.3	8.0	33.3	2.3	4.0	5.0	6.0	7.3	5.6
240	0.0	7.7	5.3	99.0	2.7	5.3	6.0	3.7	5.0	5.0
Zenith	5.0	7.0	5.0	99.0	4.0	5.3	5.0	4.3	5.0	4.9
Shadowturf	99.0	0.0	8.0	11.7	2.0	3.0	3.3	5.0	7.0	4.6
L1F	99.0	0.0	8.0	1.7	2.3	1.3	0.7	2.7	3.3	2.0
LSD[3]	10.1	0.6	0.3	9.7	0.8	1.2	1.0	1.7	1.7	0.9

[1] Winterkill and summer coverage were rated visually on a scale of 0% to 100%.

[2] Spring greenup, leaf texture, fall color, and quality were rated visually on a scale of 0 to 9 (0 = worst, 9 = best).

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

Figure 1. Greenup of zoysiagrasses in spring 2008 shows that some suffered severe winter injury.

University of Nebraska-Lincoln 2008 Buffalograss Experimental Lines and Cultivars Evaluation

Objective:	Evaluate buffalograss cultivars under Kansas conditions and submit data collected to the University of Nebraska.
Investigators:	Linda R. Parsons and Rodney St. John
Sponsor:	University of Nebraska

Introduction

Buffalograss is the only native turfgrass that performs well in Kansas. It requires little maintenance and is heat and drought tolerant. Because the introduction of many new selections, both seeded and vegetative, has aroused considerable interest, further evaluation of these new releases is needed to determine their potential for use by Kansas consumers.

Methods

During the summer of 2008, we established nine seeded and eight vegetative buffalograss cultivars and experimental numbers in 51 study plots, each measuring 5 × 5 ft, at the John C. Pair Horticultural Center in Wichita, KS, in a randomized complete block design. Vegetative types were plugged on 1-ft centers with 16 plugs per plot, and seeded types were planted at 2.0 lb/1,000 ft^2 pure, live seed or 22.7 g of seed per plot. We incorporated a starter fertilizer into the plots at a rate of 1.0 lb nitrogen (N)/1,000 ft^2 to support establishment. We added an additional 1.0 lb N/1,000 ft^2 a month later. To help with weed control during establishment, we applied Drive at 1.0 lb a.i./acre (i.e. 0.17 g/16 ft^2 of the 75% DF product) in two applications.

Results

During the initial summer of the study, we collected information on the rate of establishment as a percentage of turfgrass cover at 1-month intervals following planting. By the end of the summer, vegetative varieties NE-BFG07-09 and 609 and seeded varieties NE-BFG07-03 and NE-BFG07-04 were the best established (Table 1).

Table 1. 2008 performance of buffalograss cultivars, Wichita

Cultivar/ experimental number	Type	Rate of establishment (% cover)		
		July	Aug.	Sept.
NE-BFG07-09	Vegetative	53.3	55.0	66.7
609	Vegetative	33.3	40.0	65.0
NE-BFG07-03	Seeded	53.3	50.0	56.7
NE-BFG07-04	Seeded	33.3	41.7	56.7
Legacy	Vegetative	46.7	48.3	55.0
NE-BFG07-08	Seeded	40.0	43.3	55.0
NE-BFG07-01	Seeded	41.7	43.3	53.3
NE-BFG07-02	Seeded	50.0	43.3	51.7
NE-BFG07-11	Vegetative	40.0	43.3	51.7
NE-BFG07-10	Vegetative	28.3	48.3	50.0
NE-BFG07-12	Vegetative	36.7	36.7	48.3
Texoka	Seeded	43.3	45.0	48.3
Cody	Seeded	48.3	36.7	45.0
Prestige	Vegetative	30.0	36.7	40.0
NE-BFG07-13	Vegetative	26.7	28.3	33.3
Bison	Seeded	18.3	28.3	30.0
Bowie	Seeded	8.7	13.3	23.3
LSD[1]		14.8	32.1	30.2

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

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