K-STATE
TURFGRASS
RESEARCH

Turfgrass Research 2013

Report of Progress 1089

K-STATE
Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

K-STATE TURFGRASS RESEARCH 2013

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Foreword

Turfgrass Research 2013 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, August 1, 2013, at the John C. Pair Horticulture Research Center in Haysville, Kan. Articles included in this Report of Progress present summaries of 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 turf establishment and management, variety evaluations, pest management, and water issues and drought.

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. You can access this report, reports from previous years, and all K-State Research and Extension publications relating to turfgrass online at:

www.ksuturf.org and ***www.ksre.ksu.edu/bookstore***

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

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Growth and Quality Responses of *Zoysia* Species Grown in Shade

Objective: Determine changes and differences among selected *Zoysia* genotypes grown under a shaded environment over a three-year period.

Investigators: Kenton Peterson, Jack Fry, Dale Bremer

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

Introduction

Zoysiagrass (*Zoysia* Willd.) is used extensively for golf courses throughout the transition zone and, to a more limited extent, in the southeastern U.S. The lower input requirements of zoysiagrass, compared with other available turfgrasses, is a major reason driving its popularity. Zoysiagrasses vary in shade tolerance. In general, *Z. matrella* cultivars, which are generally finer and more dense, as well as 'Emerald' (*Z. japonica* × *Z. pacifica*), are considered more shade-tolerant than *Z. japonica* cultivars, including 'Meyer.' This is problematic for golf course superintendents who may have a considerable amount of turf under moderate to heavy shade. Although 'Meyer' is hardy in the transition zone, *Z. matrella* cultivars and 'Emerald' often suffer winter injury and are used only the southernmost part of this region.

Previous research has shown that experimental progeny have improved shade tolerance based on growth from vegetative plugs. In addition, research at Kansas State University has demonstrated that some of these experimental grasses have freezing tolerance comparable to 'Meyer.'

Methods

The study was conducted at the Rocky Ford Turfgrass Research Center in Manhattan, Kan. (Figure 1). Zoysiagrass was planted as plugs in flats in the greenhouse to establish sod pieces. Sod was planted in the field as 4 ft^2 plots on June 10, 2010, on the north side of a mature line of silver maple (*Acer saccharinum*) trees. Plots were fertilized at planting with 1 lb N/1,000 ft^2 using an 18-20-0 (N-P-K) fertilizer. Plots were maintained at a 2.75 in. mowing height and received 1 lb N/1,000 ft^2 (46-0-0) annually. Irrigation was applied to prevent severe stress.

Plots were arranged in a randomized complete block design with five replications. The treatment design was a single factor, zoysiagrass genotype. The genotypes selected for this study were 'Zorro' (*Zoysia matrella*), 'Emerald,' 'Meyer,' Chinese Common, and the experimental progeny 5313-46, 5321-18, and 5321-45.

Data collected included shoot elongation rate, tiller density, and leaf width. Visual ratings for genetic color, density, quality, fall color retention, and spring greenup were taken monthly on a 1 to 9 scale (6 = minimum acceptable, 9 = superior). Beginning in 2011, a lighted camera box was used to evaluate percentage green cover.

Results

All zoysiagrass genotypes maintained acceptable visual quality ratings through 2010, the establishment year (Table 1); however, entering 2011, 'Emerald,' 'Zorro,' and 5313-46 had the lowest quality ratings, likely due to winter injury. Both 'Emerald' and 'Zorro' are considered southern adapted zoysiagrasses and are not winter-hardy in Manhattan. The experimental progeny 5313-46 is considered winter-hardy in Manhattan, but the severe low temperatures, along with the shade stress, may not have allowed it to acclimate to cold temperatures. All three of the genotypes that exhibited winter injury did recover somewhat during the summer of 2011. In June 2012, 'Emerald,' 5321-18, and 5321-45 had the highest quality ratings. By September 2012, only 'Emerald,' 'Zorro,' 5321-18, and 5321-45 had quality ratings greater than the minimum acceptable (rating of 6).

Tiller counts exhibited an overall decline over the period of the study (Figure 2). In 2010, no genotype exhibited a tiller count decline more than 15%; however, in June 2011, many of the genotypes exhibited severe declines in tiller count compared with 2010. This is likely due to the severe low temperatures observed in the winter of 2010–2011. Tiller count increased in all genotypes from June 2011 to August 2011, which indicates that the zoysiagrasses used in this study do have the ability to recuperate during the summer months, even under dense shade. Tiller counts did not decline drastically entering 2012, likely the result of a milder winter in 2011–2012 than the previous winter, which resulted in winter injury for some of the genotypes. Tiller counts did decline over the summer of 2012, perhaps due to the longer growing season because of an earlier spring greenup and turfgrass damage from the bluegrass billbug (*Sphenophorus parvulus* Gyllenhal) observed in August 2012.

Percentage green cover was evaluated in 2011 and 2012. The greatest percentage green cover was observed earlier in the summer in 2012 than in 2011 (Figure 3). Several of the genotypes were recovering from winter injury in 2011, which may have caused the peak percentage green cover to occur later in the summer. In 2012, spring greenup of the zoysiagrass occurred much earlier than in 2011. The earlier spring greenup may have caused the greatest percentage green cover to occur earlier in the summer. This increase in green cover could have acted to stress the turf, because it would have to maintain more green tissue over the summer. This may be a contributing factor to the percentage green cover decline observed during the summer of 2012.

Zoysiagrass turf is greatly affected by dense tree shade; however, shade tolerance is improving. Overall, turfgrass quality and tiller count did decline over time, with variability exhibited among the genotypes studied. The 'Emerald' × 'Meyer' experimental progeny in this study may have improved shade tolerance.

Table 1. Mean zoysiagrass visual quality ratings for 2010, 2011, and 2012

	2010				2011				2012			
Genotype	June	July	Aug.	Sept.	June	July	Aug.	Sept.	June	July	Aug.	Sept.
	Quality rating (1–9)[1]											
Chinese Common	7.0	6.8	6.8	6.6	6.6	6.0	6.6	5.8	4.0	3.4	4.0	3.2
Emerald	8.4	7.2	7.6	8.0	4.0	5.2	6.4	5.8	7.2	7.4	8.0	7.0
Meyer	7.8	7.4	7.8	7.2	7.0	6.6	7.0	6.8	6.4	5.6	5.4	4.4
Zorro	8.8	7.8	8.0	8.0	3.4	4.6	5.8	5.6	6.2	6.4	7.4	7.2
5313-46	8.2	7.2	7.2	6.8	4.8	5.6	6.0	6.2	5.8	5.6	6.6	5.8
5321-18	8.6	8.0	8.0	8.2	8.2	7.8	8.2	7.8	8.2	8.0	7.4	6.4
5321-45	7.6	6.8	7.4	7.2	6.2	7.0	7.6	7.0	7.6	7.4	7.6	7.2
LSD (5%)[2]	0.7	0.7	0.5	0.7	1.3	1.3	1.3	1.1	1.6	1.6	1.5	1.5

[1] Visual turfgrass quality rated on a 1–9 scale. 6 = minimum acceptable quality and 9 = superior quality.
[2] To determine if one grass is statistically different from another, subtract the least significant difference (LSD) value from the mean with the higher value. If that number is higher than the mean of the lower-valued turfgrass, they are statistically different.

Figure 1. Zoysiagrass shade study research plots at Rocky Ford Turfgrass Research Center, Manhattan, Kan., on October 1, 2012.

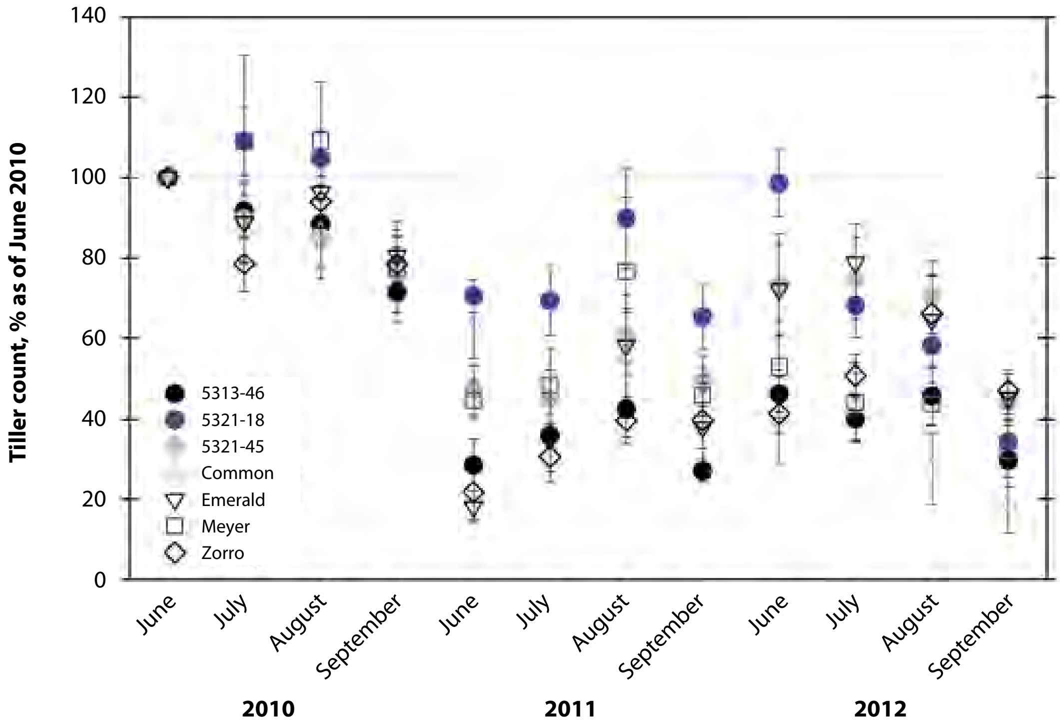

Figure 2. Mean zoysiagrass tiller counts for 2010, 2011, and 2012. Bars represent standard error of 5%.

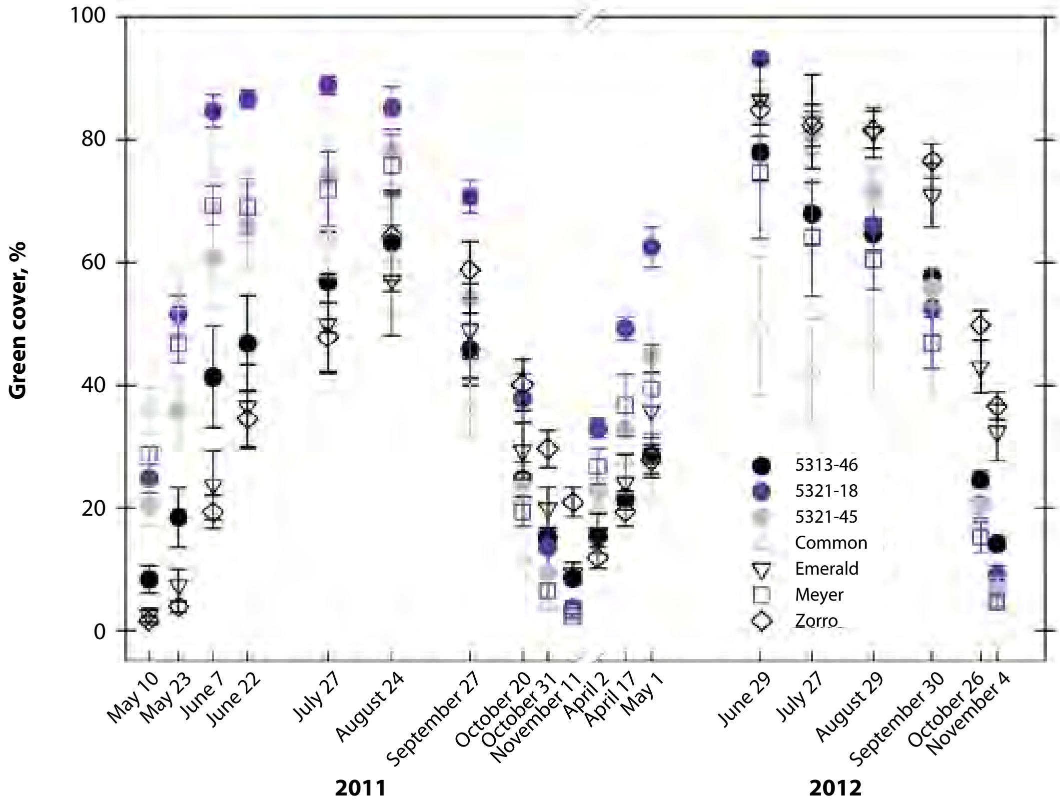

Figure 3. Mean zoysiagrass percentage green cover for 2011 and 2012. Bars represent standard error of 5%.

Recovery of an Experimental Zoysiagrass from Sod Harvest

Objectives: 1) Determine the importance of preemergent herbicide application on the recovery of DALZ 0102 zoysiagrass after harvesting sod, and 2) determine the effects of different nitrogen fertilization regimens on the recovery of DALZ 0102 zoysiagrass after harvesting sod.

Investigators: Cole Thompson and Jack Fry

Introduction

Since 2004, researchers at Kansas State University (Manhattan, Kan.) and Texas Agri–Life Research-Dallas (Dallas, Tex.) have evaluated zoysiagrass progeny associated with crosses between *Z. japonica* × Z. *matrella* or *Z. japonica* × Emerald for quality characteristics and freezing tolerance. DALZ 0102 zoysiagrass (*Zoysia japonica* Steud.) is an experimental zoysia resulting from the research that exhibits good freezing tolerance, quality, and resistance to damaging bluegrass billbug (*Sphenophorus parvulus* Gyllenhal) infestations. DALZ 0102 will be a joint release in the near future, and data pertaining to propagation of DALZ 0102 are of particular interest.

Methods

This study was conducted in 2011 and 2012 on established DALZ 0102 zoysiagrass at Rocky Ford Turfgrass Research Center in Manhattan, Kan. Turf was stripped to a depth of 1 in. from a 9-ft × 18-ft area on June 8, 2011, and May 22, 2012, with a sod cutter (Ryan Jr. Sod Cutter, Schiller Grounds Care, Inc., Johnson Creek, WI). The study was arranged with a split-plot treatment structure in a randomized complete block design. Whole plots measured 3 ft × 9 ft and were either treated with a preemergent herbicide, simazine (Princep), on June 13, 2011, or May 28, 2012, or left untreated. Fertility was the split-plot treatment factor. Individual subplots measured 3 ft × 3 ft and treatments were: 1) untreated, 2) 1 lb N/1,000 ft^2 every other week, and 3) 1 lb N/1,000 ft^2 monthly. Nitrogen was provided with urea (46-0-0 N-P-K) from spring through September in both years until 7 lb and 4 lb N/1,000 ft^2 had been applied to biweekly and monthly N treatment subplots, respectively.

Data Collection

Percentage cover of turf and summer annual weeds were monitored every other week from spring through September in both years. Turf cover was recorded in May 2012 for the 2011 study and in May 2013 for the 2012 study. Percentage cover data were taken as a visual estimate of each plot covered by DALZ 0102 zoysiagrass and summer annual weeds.

Data Analysis

All data were normally distributed in 2011 and 2012 and were subject to analysis of variance using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). Fisher's protected least significant difference (LSD) ($P \leq 0.05$) was used to detect treatment differences.

Preliminary Results

Year was not a significant factor when included in the statistical model for turf coverage data. As a result, turf coverage data from 2011 and 2012 were pooled. The year factor was significant when included in the model for weed coverage data. Weed coverage data was not pooled and is presented separately for 2011 and 2012.

Turf Recovery

Whole plots treated with simazine averaged nearly 90% turf coverage by 16 weeks after initial treatment (WAIT) and, compared with untreated, averaged greater coverage from 4 to 16 WAIT (data not shown). Weed coverage in untreated plots reached nearly 100% by 8 WAIT in both 2011 and 2012, making it very difficult to rate zoysiagrass recovery accurately (Figure 1). A final rating will be taken in May 2013 (approximately 52 WAIT) to get an accurate representation of the effects of simazine application on zoysiagrass recovery. Compared with untreated subplots and subplots fertilized monthly, biweekly N fertilization resulted in significantly greater turf coverage at 14 and 16 WAIT (Figure 2).

Weed Coverage

Whole plots treated with simazine never averaged more than 4% weed coverage in 2011, and never more than 32% in 2012, whereas untreated plots reached 100% weed coverage in both years. Compared with untreated, whole plots treated with simazine had fewer weeds from 4 to 16 WAIT in both 2011 and 2012 (data not shown). There were no differences in weed coverage in response to fertilizer regimen in 2011. In 2012, plots receiving biweekly N fertilization averaged fewer weeds than untreated plots and plots fertilized monthly at 12, 14, and 16 WAIT and 8, 12, 14, and 16 WAIT, respectively (Figure 3).

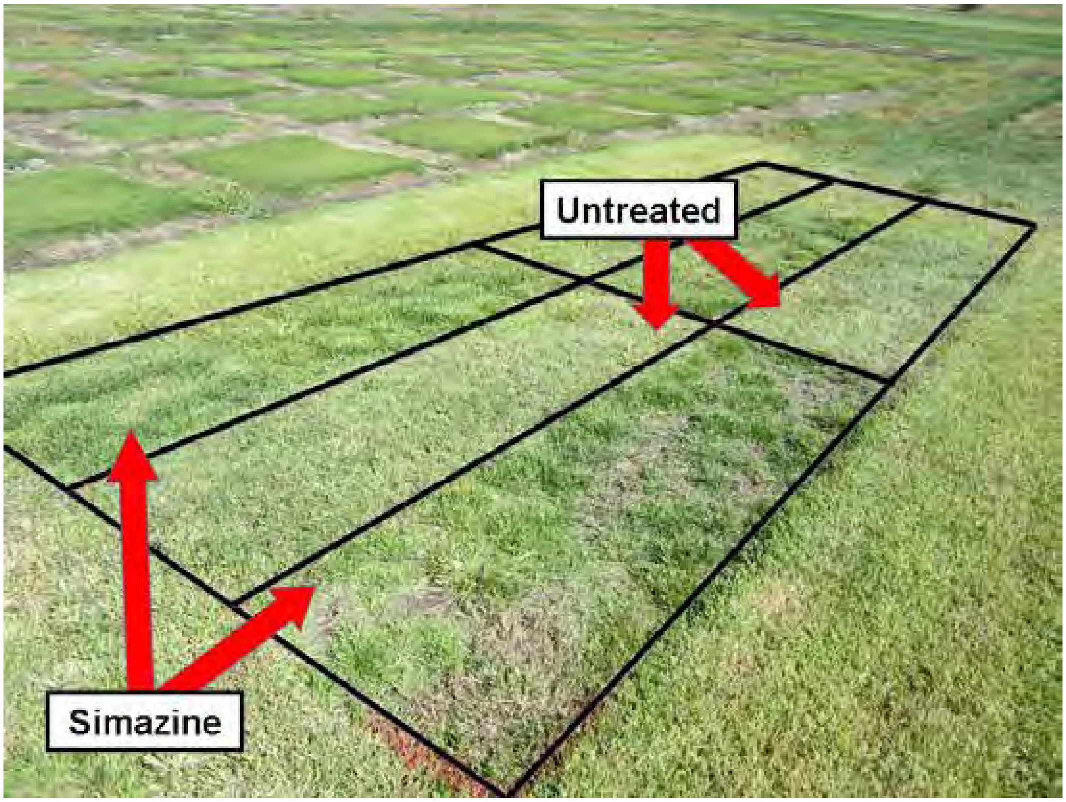

Figure 1. Effects of simazine on summer annual weed establishment in Manhattan, Kan., in 2012. Simazine-treated whole plots had very few weeds, whereas untreated whole plots reached 100% weed coverage.

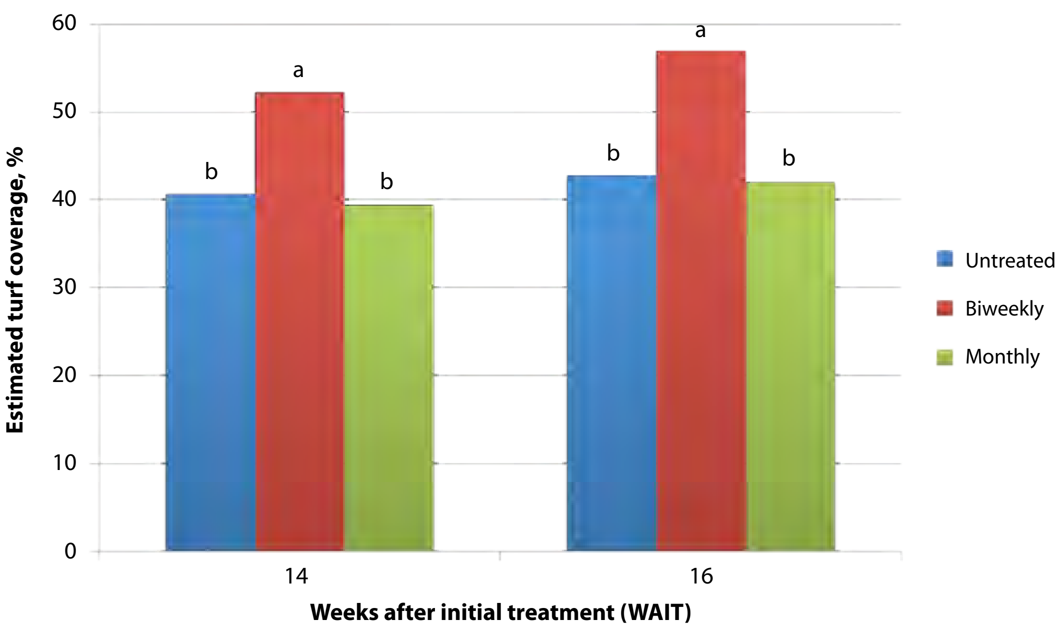

Figure 2. Effects of fertilization regimen on zoysiagrass recovery in Manhattan, Kan., in 2011 and 2012. Values represent a pooled average of data from 2011 and 2012. On each rating date, bars with the same letter are not significantly different according to Fisher's protected least significant difference (LSD) ($P \leq 0.05$).

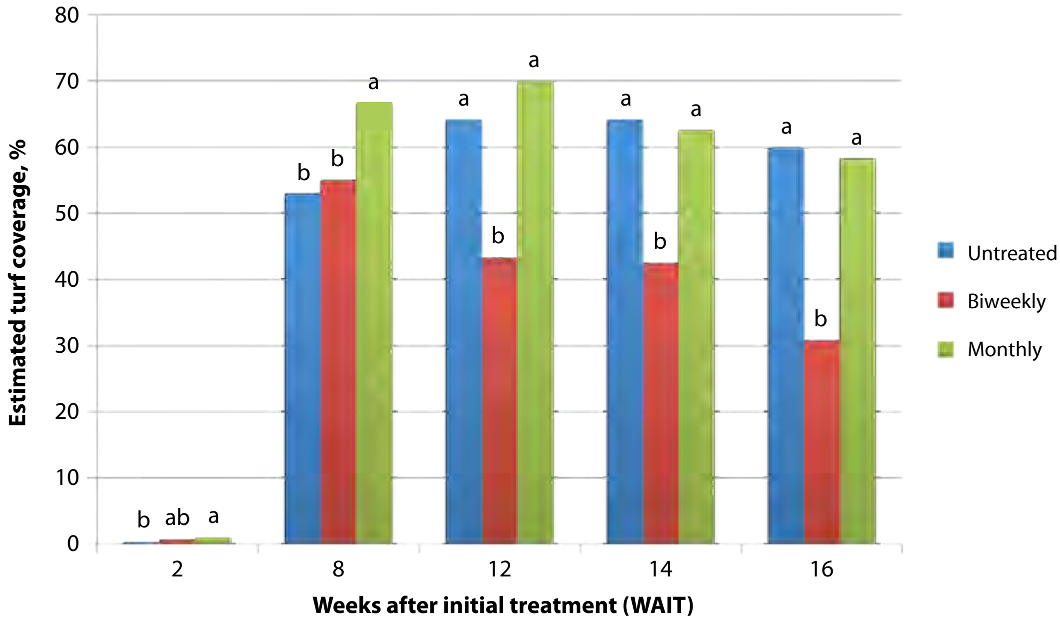

Figure 3. Effects of fertilization regimen on summer annual weed coverage in Manhattan, Kan., in 2012. On each rating date, bars with the same letter are not significantly different according to Fisher's protected least significant difference (LSD) ($P \leq 0.05$).

Evaluation of Turf Colorants on Dormant 'Chisholm' Zoysiagrass

Objective: Evaluate turf colorants' enhancement of green color on dormant lawn-height zoysiagrass.

Investigators: Ross Braun and Jack Fry

Sponsor: Kansas Turfgrass Foundation

Introduction

Overseeding dormant warm-season lawns is common in the southern U.S. but can be expensive due to costs associated with site preparation, seed, water, fertilizer, and mowing as the cool-season species continues to grow in autumn and early spring. Overseeding zoysiagrass is not commonly practiced, in part because the canopy is so dense that establishment can be difficult. Turf colorants have become popular on golf course fairways and putting greens in the South to provide lasting color during winter dormancy. The use of turf colorants could provide another option for turfgrass managers and homeowners who want to perpetuate the green lawn color from late autumn through early spring (Figure 1).

Methods

This experiment was conducted using the Rocky Ford Research Turfgrass Research Center in Manhattan, Kan., and the John C Pair Research Center in Haysville, Kan. Only procedures and results from Manhattan will be discussed. The study was conducted on 3-in. lawn/rough height of 'Chisholm' zoysiagrass. Plots at each site were 5 ft × 5 ft and arranged in a randomized complete block design with four replications. The six treatments included: (1) untreated; (2) Green Lawnger (Becker Underwood, Ames, IA) applied once in autumn; (3) Green Lawnger applied in autumn and midwinter; (4) Ultradwarf Super (Pioneer Athletics, Cleveland, OH) applied in autumn; (5) Ultradwarf Super applied in autumn and midwinter, and (6) overseeding with annual ryegrass. Colorants were applied using a 3-nozzle, CO_2-pressurized sprayer with 8004VS nozzles calibrated to deliver 131 gallons/acre. Turf colorants were applied at the same rate/dilution of 1:6 (colorant:water) in two directions to provide uniform coverage. The first colorant application was applied to predominantly brown zoysiagrass on October 20, 2012, and the second was applied on January 23, 2013. Plots to be overseeded with annual ryegrass were power-raked with a Billy Goat Power Rake/Overseeder (Billy Goat Industries, Inc., Lee's Summit, Mo.) in two directions on #4 setting, resulting in a 1/2-in. soil cutting depth. After power-raking, plots were seeded in two directions with a shaker bottle to provide seed at 10 lb/1000 ft^2 on September 28, 2012. Overseeded plots were watered by hand two to three times daily the first week after seeding and as needed thereafter and a late-fall application of 0.5 lb of N/1000 ft^2 from urea was applied with a shaker bottle in two directions on October 31, 2012.

Data Collection

Visual turf color was rated weekly on a 1 to 9 scale where 1 = straw brown; 6 = acceptable green color, and 9 = dark green. A digital photograph of each plot under a lighted camera box was taken once a month from initial application through initial spring greenup to evaluate the percentage of relative dark green cover. Images were analyzed with SigmaScan Pro 5.0 (version 5.0, SPSS Science Marketing Dept., Chicago, Ill.) using a macro created by researchers at the University of Arkansas for analysis of turfgrass color and percentage cover.

Data Analysis

All data were subjected to analysis of variance using the GLIMMIX procedure of SAS 9.2 (SAS Institute, Inc., Cary, N.C.). Treatment differences were separated using Fisher's protected least significant difference (LSD) ($P < 0.05$).

Preliminary Results

Dark Green Color Index

Monthly digital photographs showed that the digital green color index (DGCI) of plots receiving two Green Lawnger applications was significantly higher than all other treatments during the entire study (Figure 2). Plots receiving one application of Green Lawnger had higher DGCI ratings than plots treated once with Ultradwarf Super; however, after receiving the second application in winter, plots treated with the Ultradwarf Super had a higher DGCI than the Green Lawnger (one application) treatment, but still lower than Green Lawnger plots receiving two applications. All four colorant treatments were significantly higher than overseeded and untreated plots during the study. Plots that were overseeded had a higher DGCI than untreated plots in November, December, and April.

Colorants can be used to enhance the green color of dormant zoysiagrass. Green Lawnger colorant provided a darker, longer-lasting color than the Ultradwarf Super colorant. Both colorants provided a significantly higher DGCI throughout the study compared with overseeded plots. Regardless of which colorant was used, an autumn plus midwinter application provided a more persistent green color than a single autumn application.

Figure 1. Study area after the second application of Ultradwarf Super and Green Lawnger treatments at the John C. Pair Research Center, Haysville, Kan., on February 5, 2013. Front row, from left to right: (1) Ultradwarf Super (two applications: October 31, 2012, and February 5, 2013); (2) Green Lawgner (two applications, October 31, 2012, and February 5, 2013); (3) Green Lawnger (one application on October 31, 2012); 4) Ultradwarf Super (one application on October 31, 2012); (5) untreated; and (6) overseeded with annual ryegrass on October 11, 2012.

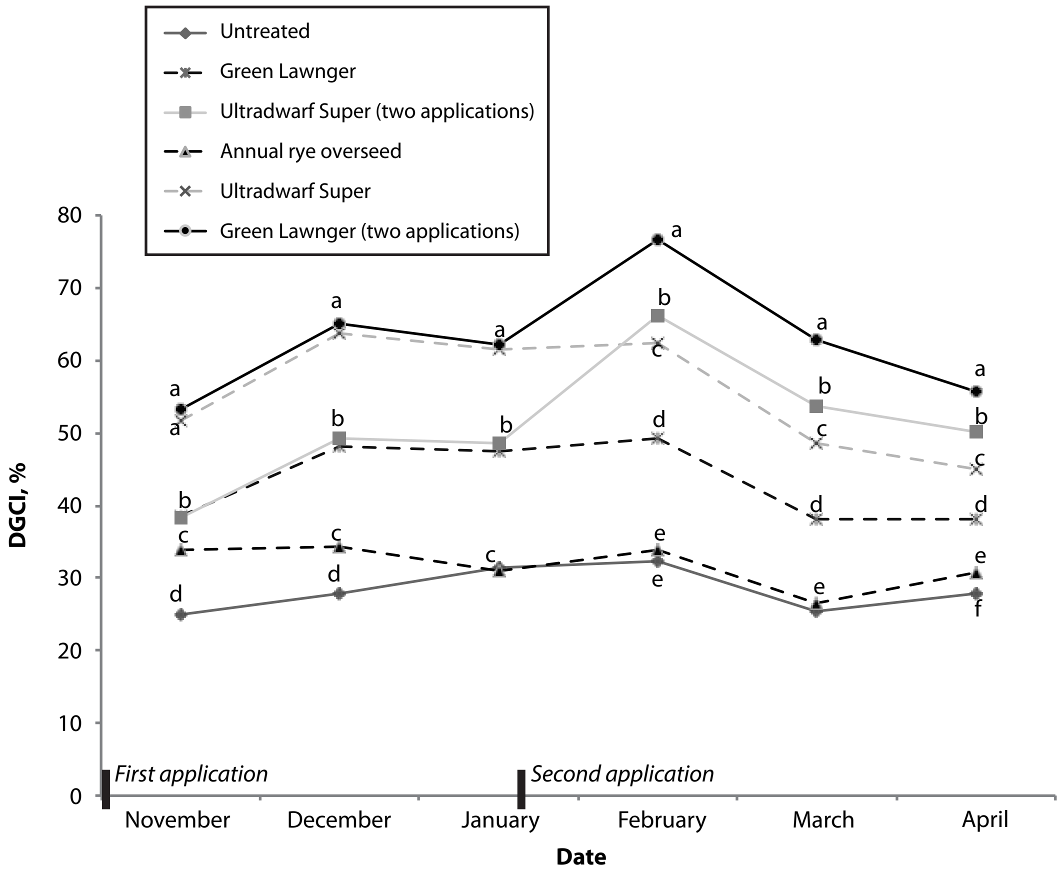

Figure 2. Dark Green Color Index (DGCI) percentage for all six treatments from November through April in Manhattan, Kan. The first colorant application was applied to dormant zoysiagrass on October 20, 2012, and the second colorant application was applied on January 23, 2013, as indicated by the green lines above. Means followed by the same letter on a date are not significantly different according to Fisher's protected least significant difference (LSD) test (*P* ≤ 0.05).

Cultural Promotion of Tall Fescue in a Mixed Stand with Rough Bluegrass

Objectives: (1) Determine the effects of mowing height on tall fescue and rough bluegrass establishment grown in a mixed stand, and (2) determine the effects of seeding rate on rough bluegrass establishment when rough bluegrass is a seed contaminant.

Investigators: Cole Thompson, Jack Fry, and Megan Kennelly

Introduction

Roughstalk bluegrass (*Poa trivialis* L.) is a problematic weed in tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) lawns, and chemical control can prove challenging because herbicides labeled for the selective removal of the species are limited. Recent studies have shown that rough bluegrass remains a problematic seed contaminant in creeping bentgrass seed lots, and the same may be true for other desired species. Promoting tall fescue over rough bluegrass during establishment may be possible using cultural strategies.

Methods

Two separate areas were seeded for this study. The first (previously perennial ryegrass) was sprayed with glyphosate (Glyphomate 41, PBI Gordon, Kansas City, Mo.) on August 13, 2011. The borders and alleyways of the study area were seeded with perennial ryegrass at 8 lb/1,000 ft^2 on September 7, 2011. The second study (also previously perennial ryegrass) was sprayed with glyphosate on August 15, 2012. The borders and alleyways of the study were seeded with perennial ryegrass at 8 lb/1,000 ft^2 on September 7, 2012. Seeding rate of tall fescue and rough bluegrass was a treatment factor and is described below. The study was designed as a randomized complete block design with a split-plot treatment structure. Mowing height was the whole-plot treatment factor, and seeding rate was the subplot treatment factor. Whole plots were 5 ft × 15 ft and included three mowing heights: 1.5, 3.0, and 4.5 in. Subplots measured 5 ft × 5 ft and were seeded on September 15, 2011 (for evaluation in 2012 and 2013), and September 18, 2012 (for evaluation in 2013 and 2014), as if 1.0% by weight of a 50 lb bag of tall fescue seed were actually rough bluegrass seed. Subplots were seeded to represent seeding rates of 4, 8, and 12 lb/1,000 ft^2. As such, plots were seeded with 'Second Millennium' tall fescue at 3.96, 7.92, and 11.88 lb/1,000 ft^2 and with 'Laser' rough bluegrass at 0.04, 0.08, and 0.12 lb/1,000 ft^2, respectively. Rough bluegrass seed was spread with 1.0 lb N/1,000 ft^2 of a natural organic fertilizer (Sustane, 8-2-4 [N-P-K]; Cannon Falls, Minn.) to aid researchers in spreading rough bluegrass seed evenly throughout each plot.

Data Collection

Turfgrass quality is being monitored monthly (1 to 9 scale, 1 = completely brown, 6 = minimum acceptable quality, 9 = optimum color, density, and uniformity). Rough bluegrass frequency is being measured every other month (May, July, September, and November) by performing presence/absence counts with an 81-intersection grid (Figure 1). Percentage rough bluegrass coverage is then determined by dividing rough bluegrass frequency by 81. Brown patch (*Rhizoctonia solani*) was present in 2012 and was rated as the percentage of the plot blighted by brown patch symptoms.

Data Analysis

Turfgrass quality and rough bluegrass coverage data were normally distributed in 2012. Brown patch severity data were not normally distributed and were subject to an *arcsin* (y) transformation prior to analysis. All data were subject to analysis of variance using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). Fisher's protected least significant difference (LSD) ($P \leq 0.05$) was used to detect treatment differences.

Preliminary Results

No mowing height × seeding rate interaction was observed, but there were significant main effects of mowing height and seeding rate (Table 1).

Rough Bluegrass Coverage, 2012

Mowing height. Averaged across seeding rates, whole plots mowed at 3.0 in. resulted in greater rough bluegrass cover (62.1%) than 1.5- or 4.5-in. mowing heights (52.4 and 48.9%, respectively) in July. In September, whole plots mowed at 3.0 in. resulted in greater rough bluegrass cover (82.9%) than plots mowed at 1.5 in. (68.1%).

Seeding rate. Averaged across mowing heights, subplots seeded at 12 lb/1,000 ft^2 averaged greater rough bluegrass cover (81.9%) in September than subplots seeded at 4 lb/1,000 ft^2 (68.3%). In November, subplots seeded at 8 or 12 lb/1,000 ft^2 (76.2 and 77.6%, respectively) averaged greater rough bluegrass cover than plots seeded at 4 lb/1,000 ft^2 (62.7%).

Brown Patch Severity, 2012

Brown patch was observed on July 5, 18, and 30, 2012.

Mowing height. On July 5, whole plots mowed at 3.0 in. had significantly more brown patch (8%) than plots mowed at 1.5 or 4.5 in. (data not shown). On July 18, plots mowed at 3.0 or 4.5 in. averaged more brown patch (18 and 23%, respectively) than plots mowed at 1.5 in. (4%) (data not shown).

Seeding rate. On July 18, plots seeded at 12 lb/1,000 ft^2 had significantly ($P < 0.10$) more brown patch than plots seeded at 4 lb/1,000 ft^2 (data not shown).

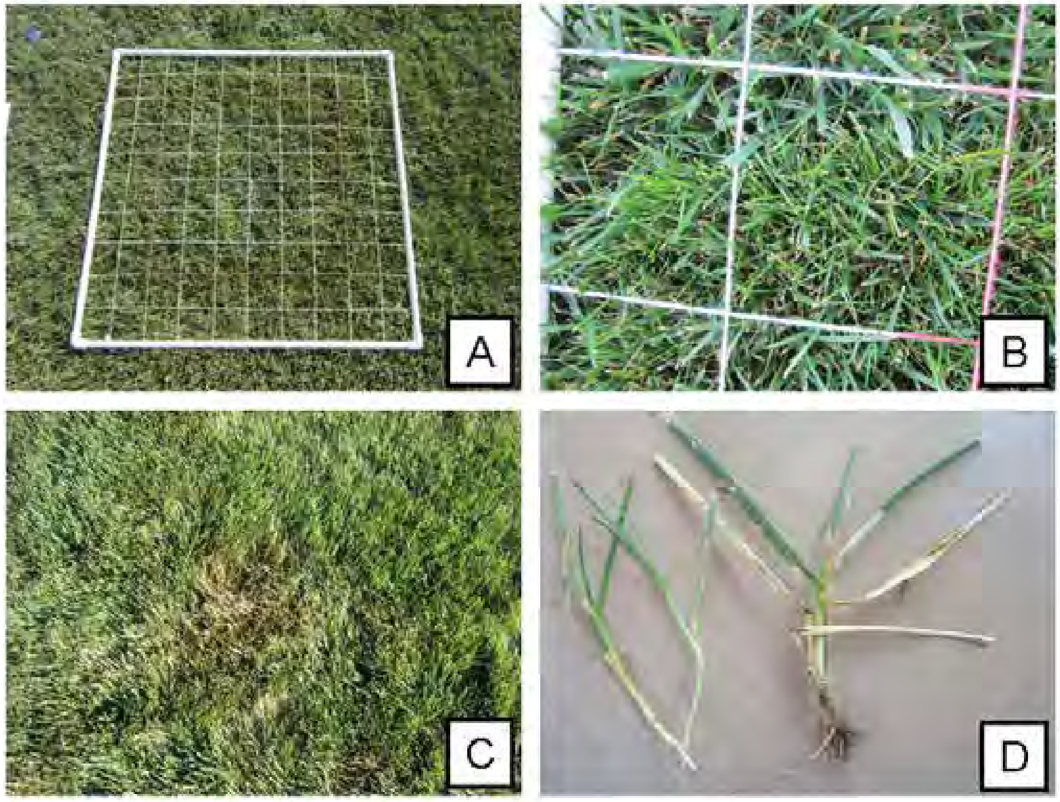

Figure 1. ***Poa trivialis*** **frequency rating grid and brown patch symptoms. A and B show the grid used to measure** ***Poa trivialis*** **frequency and visible** ***Poa trivialis*** **under an intersection of the frequency grid. C and D show symptoms of brown patch on** ***Poa trivialis*** **and tall fescue.**

Table 1. The effects of mowing height and seeding rate on *Poa trivialis* establishment in 2012.

	% *Poa trivialis*[1]			
Treatment effect	May 31	July 31	Sept. 30	Nov. 27
Whole plot				
1.5 in.[2]	64.1	52.4 b[3]	68.1 b	71.8
3.0 in.	67.6	62.1 a	82.9 a	76.5
4.5 in.	70.8	48.9 b	74.0 ab	68.1
Split plot				
4.0 lb[4]	72.9	55.1	68.3 b	62.7 b
8.0 lb	67.0	54.9	74.8 ab	76.2 a
12.0 lb	62.6	53.3	81.9 a	77.6 a

[1] Percentage of *Poa trivialis* is calculated by determining *Poa trivialis* frequency (presence/absence counts with an 81-intersection grid) and dividing the frequency by 81.
[2] Whole plots were mown at 1.5, 3.0, and 4.5 in. weekly.
[3] Within columns, means with the same letter are not statistically different according to Fisher's protected least significant difference (LSD) ($P \leq 0.05$).
[4] Subplots were seeded at 1.5, 3.0, and 4.5 lb tall fescue/1,000 ft^2 in September 2011, including 1.0% *Poa trivialis* contamination by weight.

Evaluation of Zoysiagrasses in Southern Kansas

Objectives: Evaluate experimental zoysiagrasses for their performance in Wichita, Kan.

Investigators: Linda R. Parsons and Jack Fry

Sponsor: Kansas Turfgrass Foundation

Introduction

Kansas State University has been cooperating with Texas A&M University since 2004 to identify zoysiagrasses that are superior in quality to 'Meyer,' the industry standard, and that have equivalent or better freezing tolerance. Eight of these potentially superior grasses were planted in 2009 in Wichita — as well as several other locations throughout the transition zone — for further evaluation.

Methods

During the summer of 2009, we established 'Meyer' and eight experimental hybrids of zoysiagrass in 27 study plots, each measuring 5 ft × 5 ft, in a randomized complete block design at the John C. Pair Horticultural Center in Haysville, Kan. The experimental zoysiagrasses are progeny from crosses between *Zoysia matrella* cultivars ('Cavalier,' 'Zorro,' or the experimental type DALZ 8501) or between 'Emerald' (*Z. japonica* × *pacifica*) and *Z. japonica* (either 'Meyer' or Chinese Common). During the course of this study, we will collect information on establishment, spring greenup, quality, genetic color, leaf texture, fall color retention, percentage cover, and other measures when appropriate. We rate spring greenup, quality, genetic color, leaf texture, and fall color retention visually on a scale of 1 to 9 (1 = poorest, 6 = acceptable, and 9 = optimum). We rate percentage cover visually on a scale of 0% to 100%.

Results

We started the 2012 growing season by looking at spring greenup and found that by May 9, SUZ 0802, KSUZ 0805, KSUZ 0806, and KSUZ 0807 were the greenest (Table 1). We rated turf quality, which was influenced by weed infestation, disease resistance, and degree of cover as well as turf color, texture, and density, every month throughout the growing season. The overall best performers for 2012 were SUZ 0802, KSUZ 0807, and DALZ 0102. During the course of the summer, we rated the turf plots for genetic color and leaf texture and found that KSUZ 0806, KSUZ 0801, KSUZ 0804, and KSUZ 0805 were the darkest green and that KSUZ 0802, KSUZ 0805, and KSUZ 0801 had the finest texture. At the end of the growing season, we looked at percentage cover and found that SUZ 0802, KSUZ 0807, and KSUZ 0803 had established the best cover. The zoysia plots usually start to lose color and go dormant toward the beginning of October, so we rated color retention at mid-October and the beginning of November. We found that on October 18, KSUZ 0804, DALZ 0102, and KSUZ 0803 were the greenest, but that by November 1, only DALZ 0102, KSUZ 0801, KSUZ 0806, and 'Meyer' retained much color.

Table 1. Performance of zoysia cultivars in Wichita, Kan., 2012[1]

Cultivar/ experimental number	Spring greenup	Genetic color	Leaf texture	Sept. % cover[2]	Fall color Oct. 18	Fall color Nov. 1	Quality					
							May	June	July	Aug.	Sept.	Avg.
KSUZ 0802	5.7	6.3	7.7	97.3	4.0	1.3	4.3	3.3	5.7	5.7	6.0	5.0
KSUZ 0807	5.3	5.3	6.0	92.3	4.0	1.7	4.7	3.7	5.3	5.3	5.0	4.8
DALZ 0102	4.7	6.7	6.0	85.3	5.0	2.0	4.7	3.3	4.3	4.7	5.3	4.5
KSUZ 0806	5.3	7.7	6.3	79.0	4.3	2.0	5.0	3.3	4.3	4.7	4.3	4.3
KSUZ 0803	4.3	6.0	6.3	89.0	4.7	1.7	3.7	3.3	5.0	4.7	4.7	4.3
KSUZ 0805	5.3	7.0	7.0	80.7	4.3	1.3	4.7	2.7	4.7	4.3	4.0	4.1
KSUZ 0804	5.0	7.0	6.0	88.3	5.3	1.7	4.0	3.3	4.3	4.3	4.0	4.0
KSUZ 0801	4.3	7.0	6.7	79.0	4.3	2.0	3.0	2.7	4.0	4.3	4.0	3.6
Meyer	4.7	6.3	6.3	78.7	4.3	2.0	3.3	2.3	4.0	3.7	4.0	3.5
LSD[3]	3.2	4.4	4.7	34.6	3.9	2.5	1.1	2.8	3.7	2.9	3.0	2.1

[1] Visual ratings were based on a scale of 1 to 9 (1 = poorest, 6 = acceptable, and 9 = optimum).
[2] Percentage cover was rated visually on a scale of 0% to 100%.
[3] To determine statistical differences among entries, subtract one entry's mean from another's. If the result is larger than the corresponding least significant difference (LSD) value, the two are statistically different.

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 (NTEP)

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. 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 September 8, 2006, we seeded 348 study plots, each measuring 5 ft × 5 ft, at the John C. Pair Horticultural Center in Haysville, Kan., with 116 tall fescue cultivars and experimental numbers in a randomized complete block design. We maintained fertility of the plots at 0.25 to 0.5 lb N/1,000 ft^2 per growing month. We mowed plots weekly during the growing season at 2.5 in. and removed clippings. We controlled weeds, insects, and diseases only when they presented a threat to the trial. From the time turf stands were established through May 2011, we irrigated as necessary to prevent stress.

During this six-year study, we collected information on establishment, spring greenup, quality, genetic color, leaf texture, fall color retention, drought tolerance, and other measures when appropriate. Rating was done visually on a scale of 1 to 9 with 1 = poorest measure, 6 = best acceptable measure, and 9 = optimum measure.

Results

After the fescue stands were established in 2006, we irrigated the study through May 2011 as necessary to prevent stress. In compliance with our National Turfgrass Evaluation Program (NTEP) grant, we did not provide the test plots with supplemental water from the beginning of June 2011 through the end of August 2011; we began watering again in September 2011 to evaluate stand recovery. The summer of 2011 was at that time, on average, the hottest summer in recorded history for the Wichita area; precipitation was also well below normal. A report summarizing the results of our study from fall 2006 through May 2011, during which time we were providing the turf with enough supplemental water to prevent drought stress, can be found at *www.ksre.ksu.edu/historicpublications/Pubs/SRP1071.pdf* starting on page 37. This report will summarize the results of our study from June 2011 through May 2012, during which time we evaluated the turf for drought tolerance and then recovery from drought stress.

During the years 2007–2010, we rated the turf monthly for quality throughout the growing season, which usually ran from April into October. Ratings were influenced by degree of cover, weed infestation, and disease resistance as well as turf color, texture, and density. For the period prior to June 1, 2011, when we started withholding supplemental water, 'Braveheart' (DP 50-9407), 'Talladega' (RP 3), 'Wolfpack II' (PST-5WMB), 'Cochise IV' (RKCL), PSG-TTRH, 'LS 1200' (SC-1), BAR Fa 6235, 'Rebel IV,' MVS-1107, 'Turbo,' and SR 8650 (STR-8LMM) were the top 11 best performers (Table 1). We withheld supplemental water from the test plots from June 1 through August 31, 2011, during which period we had 9.29 in. of rain: 3.63 in June, 3.13 in July, and 2.53 in August. At the end of August, 18 varieties obtained the highest rating we gave for quality at that time (2.7), including only PSG-TTRH and 'Turbo' of our initial top 11 performers as well as Col-1, Entry 115, 'Hunter,' JT-33, 'Rembrandt,' and 'Tahoe II' (Figure 1). By the end of November, Col-1, Entry 115, and 'Tahoe II' showed the best recovery (Figure 2), and Col-1, JT-33, 'Rembrandt,' 'Tahoe II,' and Entry 115 were rated overall best performers for the period from June through November. Recovery continued over the winter (Figure 3). The end of May 2012 marked a year since we had started withholding supplemental water as well as the end of our study. At that time, Col-1, 'Corona' (Col-M), Entry 115, JT-33, and 'Tahoe II' looked the best. The top performers for the June 1, 2011, through May 31, 2012, drought stress and recovery period were Col-1, JT-33, Entry 115, 'Tahoe II,' 'Hunter,' and 'Rembrandt.' The best overall performers for the entire 2006 National Turfgrass Evaluation Program Tall Fescue Evaluation were 'Wolfpack II' (PST-5WMB), 'Talladega' (RP 3), 'Braveheart' (DP 50-9407), PSG-TTRH, 'Cochise IV' (RKCL), 'Turbo,' MVS-1107, 'Rebel IV,' and BAR Fa 6235.

The nationwide 2006 National Tall Fescue Test results and more information on NTEP can be found online at: *www.ntep.org*.

Table 1. Performance of tall fescue cultivars in Wichita, Kan., 2007–2012[1]

Cultivar/ experimental number[2]	Quality average 2007–11	Quality June 2011	July 2011	Aug. 2011	Sept. 2011	Oct. 2011	Nov. 2011	Apr. 2012	May 2012	Quality average 2011	Quality average 2011–12	Quality average study
Wolfpack II (PST-5WMB)*	5.6	4.0	2.7	2.3	3.7	2.7	3.0	3.3	3.7	3.1	3.2	5.2
Talladega (RP 3)*	5.6	3.7	1.3	2.3	3.3	2.3	2.7	3.0	3.3	2.6	2.8	5.1
Braveheart (DP 50-9407)	5.6	2.3	1.3	2.0	2.3	2.3	2.3	2.0	3.0	2.1	2.2	5.1
PSG-TTRH	5.5	3.3	2.0	2.7	3.3	2.3	3.0	3.0	3.7	2.8	2.9	5.1
Cochise IV (RKCL)	5.6	4.3	1.7	1.7	2.7	2.3	2.3	2.3	2.7	2.5	2.5	5.0
Turbo*	5.4	5.0	2.3	2.7	3.0	2.7	3.0	2.7	3.3	3.1	3.1	5.0
MVS-1107	5.4	4.0	2.3	2.3	3.3	2.0	3.3	3.0	3.3	2.9	3.0	5.0
Rebel IV*	5.4	4.0	1.7	2.3	3.0	2.3	3.0	3.0	3.7	2.7	2.9	5.0
BAR Fa 6235	5.5	3.7	2.0	2.3	2.7	2.3	2.3	2.7	3.0	2.6	2.6	5.0
Corona (Col-M)	5.3	4.7	2.7	2.3	3.0	2.7	3.3	2.7	4.0	3.1	3.2	4.9
SR 8650 (STR-8LMM)*	5.4	3.3	1.7	2.3	3.3	2.7	2.7	3.0	3.3	2.7	2.8	4.9
LS 1200 (SC-1)	5.5	3.7	1.7	1.7	2.0	1.7	2.0	2.0	3.0	2.1	2.2	4.9
Turbo RZ (Burl-TF8)*	5.3	5.0	2.3	2.7	3.0	2.7	3.0	3.0	3.7	3.1	3.2	4.9
Finelawn Xpress (RP 2)	5.3	4.7	2.0	2.0	3.0	2.7	3.0	2.7	3.3	2.9	2.9	4.9
Hunter*	5.2	4.0	2.3	2.7	3.7	3.0	3.0	3.7	4.0	3.1	3.3	4.9
JT-33	5.2	4.7	2.7	2.7	3.7	3.0	3.3	3.7	4.0	3.3	3.5	4.9
STR-8GRQR	5.2	4.0	2.0	2.7	3.0	3.0	3.0	2.7	3.7	2.9	3.0	4.8
Firecracker LS (MVS-MST)*	5.2	4.7	2.3	2.3	3.0	3.0	3.0	3.0	3.3	3.1	3.1	4.8
Sunset Gold (KZ-2)*	5.3	3.7	1.3	2.0	2.3	2.3	2.3	2.7	2.7	2.3	2.4	4.8
Reunion (LS-03)*	5.3	3.3	1.7	2.3	2.7	2.0	3.0	3.0	3.0	2.5	2.6	4.8
Shenandoah Elite (RK 6)*	5.3	3.3	1.3	2.0	2.3	1.7	2.0	2.3	3.0	2.1	2.3	4.8
Col-1	5.1	4.0	2.3	2.7	4.3	3.3	3.7	3.7	4.0	3.4	3.5	4.8
Honky Tonk (RAD-TF17)*	5.2	4.0	2.3	2.7	3.0	2.0	3.0	3.0	3.7	2.8	3.0	4.8
J-140	5.3	4.0	1.7	1.7	2.3	2.0	2.0	2.3	2.7	2.3	2.3	4.8
PSG-85QR	5.2	3.0	1.7	2.3	2.3	2.0	2.3	2.7	3.0	2.3	2.4	4.8
AST 7001*	5.2	4.3	1.3	1.7	2.0	2.0	2.3	2.3	2.7	2.3	2.3	4.7
Hudson (DKS)*	5.1	3.7	1.3	2.3	3.0	3.0	2.7	3.0	3.7	2.7	2.8	4.7
Rembrandt*	5.0	4.3	2.3	2.7	4.0	3.0	3.3	3.3	3.3	3.3	3.3	4.7
AST9001 (AST-3)*	5.1	3.7	2.0	2.7	3.3	2.3	3.3	3.3	3.7	2.9	3.0	4.7
Faith (K06-WA)*	5.2	3.7	1.7	2.3	2.0	2.3	2.7	2.7	3.0	2.4	2.5	4.7
PSG-82BR	5.2	3.7	1.7	2.0	2.7	2.3	2.7	2.7	3.3	2.5	2.6	4.7

Table 1. Performance of tall fescue cultivars in Wichita, Kan., 2007–2012[1]

Cultivar/ experimental number[2]	Quality average 2007–11	Quality								Quality average 2011	Quality average 2011–12	Quality average study
		June 2011	July 2011	Aug. 2011	Sept. 2011	Oct. 2011	Nov. 2011	Apr. 2012	May 2012			
Pedigree (ATF-1199)*	5.1	3.7	2.3	2.7	3.3	3.0	3.3	3.0	3.3	3.1	3.1	4.7
Bullseye*	5.2	3.7	2.0	2.0	2.7	2.3	2.7	2.3	3.0	2.6	2.6	4.7
Entry 115	5.0	4.3	2.0	2.7	3.7	3.0	3.7	3.7	4.0	3.2	3.4	4.7
JT-36	5.1	2.7	1.3	2.0	3.0	2.7	2.3	3.0	3.7	2.3	2.6	4.7
Gazelle II (PST-5HP)*	5.1	3.7	2.0	2.3	3.0	2.7	2.7	3.0	3.0	2.7	2.8	4.7
Crossfire 3 (Col-J)	5.2	2.7	1.3	2.3	2.0	1.7	2.3	2.7	3.0	2.1	2.3	4.7
Umbrella (DP 50-9411)	5.2	3.3	2.0	2.3	2.0	2.0	2.7	2.3	2.7	2.4	2.4	4.7
Entry 116	5.1	3.7	2.0	2.3	2.3	2.3	2.3	3.0	3.3	2.5	2.7	4.7
Shenandoah III (SH 3)*	5.2	3.0	2.0	2.0	2.0	2.0	2.3	2.0	2.3	2.2	2.2	4.7
Biltmore*	5.0	4.3	2.0	2.3	3.7	2.7	3.0	3.3	3.0	3.0	3.0	4.7
Catelyst (NA-BT-1)	5.2	3.3	2.0	2.0	2.0	1.7	2.0	2.0	2.0	2.2	2.1	4.7
Lindbergh*	5.0	3.7	1.7	2.3	3.3	3.0	2.7	3.0	3.3	2.8	2.9	4.7
Greenbrooks (TG 50-9460)	5.1	3.7	1.7	2.3	3.0	2.3	2.7	3.0	3.0	2.6	2.7	4.7
Speedway (STR-8BPDX)*	5.2	3.0	1.7	2.0	2.0	1.7	2.3	2.3	2.7	2.1	2.2	4.7
Tulsa Time (Tulsa III)*	5.2	2.3	1.7	2.0	2.3	2.0	2.3	2.3	2.7	2.1	2.2	4.7
Raptor II (MVS-TF-158)*	5.1	3.7	1.3	2.3	2.7	2.0	2.0	2.3	2.7	2.3	2.4	4.7
GWTF	5.2	3.0	1.3	2.0	1.7	1.7	1.7	2.0	2.3	1.9	2.0	4.7
Traverse SPR (RK-1)*	5.1	3.3	1.3	2.0	2.3	2.3	2.3	2.0	2.7	2.3	2.3	4.7
AST9003 (AST-1)*	5.0	4.0	1.7	2.3	3.0	2.3	2.7	3.0	3.3	2.7	2.8	4.7
Rhambler SRP (Rhambler)*	5.2	2.7	1.3	1.7	1.7	1.7	2.0	2.0	2.3	1.8	1.9	4.7
Sidewinder (IS-TF-138)	5.2	3.3	1.7	1.7	1.7	1.7	2.0	2.0	2.3	2.0	2.0	4.7
RK 4*	5.1	3.0	1.3	2.0	2.7	2.3	2.3	2.7	2.3	2.3	2.3	4.6
RK 5	5.1	3.0	1.3	2.0	2.0	1.7	1.7	2.3	2.7	1.9	2.1	4.6
Einstein*	5.0	3.7	2.0	2.0	2.7	2.3	3.0	3.0	2.7	2.6	2.7	4.6
STR-8BB5	5.0	3.7	1.7	2.3	2.7	2.7	2.3	3.0	2.7	2.6	2.6	4.6
Entry 114	5.0	2.7	1.7	2.7	4.0	2.7	3.3	3.0	3.7	2.8	3.0	4.6
3rd Millennium SRP*	5.2	2.3	1.3	1.7	1.7	1.7	2.3	2.3	2.0	1.8	1.9	4.6
Firenza*	5.1	4.0	1.7	2.0	2.3	1.7	2.0	2.3	2.3	2.3	2.3	4.6
Trio (IS-TF-152)	5.0	3.3	2.0	2.0	2.3	2.0	2.7	2.7	3.0	2.4	2.5	4.6
Tahoe II*	4.9	4.0	1.7	2.7	4.3	3.3	3.7	3.3	4.0	3.3	3.4	4.6
Terrier (IS-TF-135)	5.0	4.0	2.0	2.3	3.0	2.7	2.7	3.0	2.7	2.8	2.8	4.6

Table 1. Performance of tall fescue cultivars in Wichita, Kan., 2007–2012[1]

Cultivar/ experimental number[2]	Quality average 2007–11	Quality June 2011	July 2011	Aug. 2011	Sept. 2011	Oct. 2011	Nov. 2011	Apr. 2012	May 2012	Quality average 2011	Quality average 2011–12	Quality average study
J-130	5.0	3.3	1.7	2.0	2.7	2.7	2.0	3.0	3.3	2.4	2.6	4.6
Renovate (LS-11)*	5.1	3.3	1.3	1.3	2.0	1.7	2.0	2.0	2.7	1.9	2.0	4.6
JT-45	4.9	4.3	2.0	2.0	3.0	2.3	2.7	2.7	3.0	2.7	2.8	4.6
Integrity (BGR-TF1)*	5.0	3.0	1.7	1.7	2.0	2.0	2.0	2.3	2.7	2.1	2.2	4.6
RNP*	5.1	2.7	1.3	1.7	1.7	2.0	2.0	2.3	2.7	1.9	2.0	4.6
Xtremegreen (BGR-TF2)*	4.8	4.7	2.3	2.7	3.0	3.0	3.3	3.3	3.7	3.2	3.3	4.6
PSG-TTST	4.9	3.7	2.0	2.0	3.3	3.0	3.0	3.0	3.0	2.8	2.9	4.5
JT-41	5.0	2.7	1.0	2.0	2.0	2.0	2.0	2.3	2.3	1.9	2.0	4.5
Aristotle*	4.8	3.3	1.7	2.7	3.7	2.7	3.3	3.3	3.3	2.9	3.0	4.5
Falcon V (ATM)*	5.1	3.0	1.3	1.3	1.0	1.3	1.7	1.7	2.0	1.6	1.7	4.5
Spyder LS (Z-2000)*	4.9	3.3	1.7	2.3	2.7	2.0	2.3	2.7	3.0	2.4	2.5	4.5
JT-42	4.9	3.3	1.3	2.0	2.0	2.0	2.7	2.7	3.3	2.2	2.4	4.5
Rocket (IS-TF-147)	5.0	2.7	1.3	2.0	2.0	1.7	2.0	2.3	2.7	1.9	2.1	4.5
Skyline*	5.1	2.7	1.0	1.7	1.3	1.3	1.7	1.7	2.0	1.6	1.7	4.5
AST 7003*	4.8	3.7	2.0	2.7	3.7	2.7	2.3	3.0	3.3	2.8	2.9	4.5
Essential (IS-TF-154)*	4.8	4.0	1.7	2.3	2.3	2.3	2.7	2.3	3.0	2.6	2.6	4.5
Falcon IV*	4.9	2.7	1.3	2.0	2.3	1.7	1.7	3.0	3.0	1.9	2.2	4.5
Mustang 4 (M4)*	4.9	3.0	1.3	1.7	2.3	2.3	2.7	2.3	2.3	2.2	2.3	4.5
06-WALK	4.9	2.7	1.3	1.7	1.7	1.7	2.3	2.3	2.3	1.9	2.0	4.4
Escalade*	4.9	2.3	1.0	2.0	2.0	2.0	2.0	2.7	2.3	1.9	2.0	4.4
Hemi*	4.8	3.3	2.0	2.0	2.3	2.3	2.3	2.3	2.7	2.4	2.4	4.4
MVS-341	4.9	3.3	1.3	2.0	2.7	2.0	2.3	2.3	2.7	2.3	2.3	4.4
AST9002 (AST-2)*	4.9	3.0	1.7	2.0	2.0	2.0	2.3	2.0	2.3	2.2	2.2	4.4
Falcon NG (CE 1)	4.9	3.0	1.7	2.0	2.0	1.7	2.7	2.0	2.0	2.2	2.1	4.4
Jamboree (IS-TF-128)	4.9	3.0	1.7	2.0	2.0	2.0	2.7	1.7	2.0	2.2	2.1	4.4
PSG-RNDR	4.7	3.7	2.0	2.7	3.0	3.0	3.0	3.7	3.7	2.9	3.1	4.4
Fat Cat (IS-TF-161)	4.8	4.0	1.3	2.3	3.0	2.0	3.0	2.3	2.7	2.6	2.6	4.4
Monet (LTP-610 CL)*	4.9	3.0	1.3	1.7	2.0	1.7	1.7	2.3	2.0	1.9	2.0	4.4
Van Gogh (LTP-RK2)*	4.9	2.7	1.3	1.7	2.3	1.7	2.3	2.0	2.3	2.0	2.0	4.4
Compete (LS-06)*	4.8	3.7	1.7	2.0	2.3	2.0	2.7	2.3	3.0	2.4	2.5	4.4
LS 1010 (ATF 1328)	4.8	3.0	1.3	2.0	2.0	1.7	2.3	2.3	3.0	2.1	2.2	4.4

Table 1. Performance of tall fescue cultivars in Wichita, Kan., 2007–2012[1]

Cultivar/ experimental number[2]	Quality average 2007–11	Quality June 2011	July 2011	Aug. 2011	Sept. 2011	Oct. 2011	Nov. 2011	Apr. 2012	May 2012	Quality average 2011	Quality average 2011–12	Quality average study
Cannavaro (DP 50-9440)	4.9	3.0	1.3	2.0	1.3	1.3	2.0	2.0	2.3	1.8	1.9	4.4
Magellan*	4.8	3.0	1.3	2.0	2.7	2.0	2.7	2.7	3.0	2.3	2.4	4.4
Titanium LS (MVS-BB-1)*	4.8	3.0	1.7	2.0	2.3	1.7	2.3	2.0	2.3	2.2	2.2	4.4
Darlington (CS-TF1)*	4.8	3.0	1.3	2.0	2.3	1.7	2.7	2.3	2.3	2.2	2.2	4.4
Tanzania (IS-TF-159)	4.8	4.0	1.7	1.7	2.0	1.7	2.0	2.0	2.3	2.2	2.2	4.3
0312	4.6	3.7	1.7	2.0	3.0	2.7	3.0	3.0	3.7	2.7	2.8	4.3
Ninja 3 (ATF 1247)	4.7	2.3	1.3	1.7	2.3	2.7	2.7	2.7	2.7	2.2	2.3	4.3
Garrison (IS-TF-153)	4.8	3.0	1.7	2.0	2.3	1.7	2.3	2.0	2.3	2.2	2.2	4.3
06-DUST	4.7	3.0	1.3	1.7	2.3	1.7	2.3	2.7	2.7	2.1	2.2	4.3
Padre*	4.8	3.0	1.7	1.3	1.7	1.3	1.7	2.0	2.3	1.8	1.9	4.3
Justice*	4.7	3.3	1.7	2.0	2.7	2.3	2.7	2.7	2.3	2.4	2.5	4.3
GE-1	4.7	3.0	1.7	2.0	2.3	2.0	2.7	2.7	2.3	2.3	2.3	4.3
Plato*	4.6	3.0	1.7	2.0	2.0	2.7	2.7	2.7	2.7	2.3	2.4	4.2
BAR Fa 6363	4.5	3.3	2.3	2.3	3.0	2.3	3.3	3.0	3.0	2.8	2.8	4.2
Toccoa (IS-TF-151)*	4.6	3.0	1.7	2.0	2.7	2.3	2.3	2.3	2.3	2.3	2.3	4.2
Cezanne Rz (LTP-CRL)*	4.6	3.0	1.3	1.7	1.7	2.0	2.0	2.3	2.3	1.9	2.0	4.2
Stetson II (NA-SS)	4.6	3.7	1.7	2.0	2.0	1.7	2.0	2.0	2.3	2.2	2.2	4.2
GO-1BFD	4.6	2.7	1.7	2.0	2.0	2.0	2.0	2.3	2.3	2.1	2.1	4.2
AST1001 (AST-4)	4.6	2.0	1.0	1.3	1.3	1.7	1.7	2.0	2.3	1.5	1.7	4.1
AST 7002*	4.5	3.0	1.0	1.7	2.3	1.7	2.3	2.7	2.0	2.0	2.1	4.1
Gold Medallion (KZ-1)*	4.5	2.7	1.3	1.7	2.0	2.0	1.7	2.0	2.3	1.9	2.0	4.1
Silverado*	4.0	3.0	1.3	2.0	2.7	1.7	2.3	2.7	2.7	2.2	2.3	3.7
Ky-31*	3.1	2.7	1.7	2.0	2.0	2.3	2.3	2.3	2.3	2.2	2.2	2.9
LSD[3]	0.8	4.6	3.1	1.9	2.3	2.2	1.8	2.3	2.7	1.9	1.9	0.8

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

[2] Cultivars marked with * were commercially available in 2011.

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

Figure 1. Tall fescue trial, August 10, 2011.

Figure 2. Tall fescue trial, November 30, 2011.

Figure 3. Tall fescue trial, April 26, 2012.

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 ft × 5 ft, in a randomized complete block design at the John C. Pair Horticultural Center in Haysville, Kan. 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 of 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 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 (BASF, Research Triangle Park, N. C.) at 1.0 lb ai/acre (0.17 g/16 ft^2 of the 75% DF product) in two applications. After establishment, we added 2 lb N/1,000 ft^2 to the area (1 lb in June and 1 lb in July). We applied Barricade every spring to prevent annual weeds. During the growing season, we mowed the plots at 2.0 in. and dropped clippings and irrigated to prevent dormancy.

During the course of the study, we collected information on establishment, spring greenup, quality, genetic color, leaf texture, density, fall color retention, and other measures when appropriate. Unless otherwise specified, we rated all measures on a scale of 1 to 9 with 1 = poorest measure, 6 = best acceptable measure, and 9 = optimum measure. For genetic color, 1 = straw brown, 5 = light-yellow green, and 9 = dark green; for leaf texture, 1 = very wide blades and 9 = very fine blades; for turf stand density, 1 = bare soil and 9 = complete coverage; for spring greenup, 1 = straw brown and 9 = completely green.

Results

We started the 2012 growing season at the end of April by looking for spring greenup only to find that it had already occurred a couple of weeks earlier. So we began the year by rating turf quality starting in April rather than in May (as we had in previous years), and we continued to do quality ratings monthly throughout the growing season. Turf quality was affected by degree of cover, weed infestation, and disease resistance as well as turf color, texture, and density. The overall best performers for 2012 were vegetative types '609,' NE-BFG07-09, and NE-BFG07-11 followed by seeded types 'Cody,' 'Texoka,' and NE-BFG07-02 (Table 1). We looked at stand density in spring, summer, and fall. At the beginning of the growing season, seeded types NE-BFG07-02, NE-BFG07-01, and NE-BFG07-03 and vegetative types '609' and NE-BFG07-09 were the densest. By midsummer, vegetative types '609,' 'Prestige,' and NE-BFG07-11 and seeded types 'Texoka,' 'Bowie,' NE-BFG07-01, and NE-BFG07-02 had developed the densest stands. At the end of the season, vegetative type '609' and seeded types 'Cody,' NE-BFG07-01, NE-BFG07-02, and NE-BFG07-03 tied for best stand density. During the course of the summer, we looked at genetic color and leaf texture and for the absence of seedheads. Seeded types 'Bison' and NE-BFG07-01 and vegetative types 'Prestige,' '609,' and NE-BFG07-11 were the darkest green. Seeded type NE-BFG07-02 and vegetative types 'Legacy,' '609,' NE-BFG07-10, and NE-BFG07-09 had the finest texture. Vegetative types NE-BFG07-10, NE-BFG07-11, and 'Prestige' had virtually no seedheads, and 'Texoka,' 'Bison,' 'Bowie,' and 'Cody' had the fewest seedheads of the seeded types. During October, we began to look at turf color retention as the stands began to go dormant. On October 18, vegetative type '609' showed by far the best color retention, followed by a group comprising seeded types 'Bowie,' 'Cody,' 'Bison,' NE-BFG07-04, and 'Texoka' and vegetative type NE-BFG07-09. By November 1, only vegetative type '609' retained any color.

In reviewing turf performance over the course of the study, we found that vegetative types '609,' NE-BFG07-09, and NE-BFG07-11 were the best overall performers and that the seeded types with the highest quality ratings were NE-BFG07-02, NE-BFG07-03, and NE-BFG07-01 (Figure 1, Table 2). We plugged/seeded the study in June 2008, and by September 22 of that year, vegetative types NE-BFG07-09 and '609' showed the best establishment as a percentage of turfgrass cover followed by seeded types NE-BFG07-03 and NE-BFG07-04. By the end of May 2009, vegetative types NE-BFG07-09, '609,' and 'Legacy,' followed by seeded types NE-BFG07-03 and NE-BFG07-08, showed the best percentage cover. During the springs of 2009–2011, we rated the turf plots for greenup, which did not occur until early May in 2009 and toward the later part of April in 2010 and 2011. The vegetative types NE-BFG07-13, NE-BFG07-09, and NE-BFG07-12 and seeded types NE-BFG07-03 and NE-BFG07-08 regularly greened up first. We rated stand density in May and July of 2009–2012 and September of 2009, 2010, and 2012. Best spring density was regularly exhibited by a number of vegetative types, with NE-BFG07-11 and 'Prestige' performing the best. Among the seeded types, those rating the highest for spring density were NE-BFG07-01, NE-BFG07-02, and NE-BFG07-03. Both best summer density and best fall density were exhibited by vegetative types '609' and 'Prestige' and seeded types NE-BFG07-02 and NE-BFG07-03. Once established, we regularly rated the turf plots for genetic color, leaf texture, and absence of seedheads. Those with the best color were seeded types 'Bison,' NE-BFG07-02, and 'Cody' and vegetative types NE-BFG07-11, '609,' and NE-BFG07-09. Vegetative types '609' and Legacy and seeded type NE-BFG07-02 had the finest texture. Virtually no seedheads were seen on vegetative types 'Prestige,' '609,' NE-BFG07-10, and NE-BFG07-12; 'Texoka,' 'Bison,' 'Cody,' and 'Bowie' had the sparsest seedheads among the seeded varieties. Throughout the years of the study, the turf plots usually began to lose color and go dormant toward the beginning of October. The exception was in 2011 when, after an unusually hot, dry summer, the plots started to go dormant by mid-September. All but one turf variety was usually dormant by early November except for 2009, when a number of varieties retained some color into December. By mid-October, vegetative types '609' and NE-BFG07-09 and seeded types 'Bison' and 'Texoka' regularly showed the best color retention, and by the first of November, vegetative type '609' had by far the best color, followed distantly by vegetative type NE-BFG07-09 and seeded types 'Texoka' and 'Bison' (Figure 2). Once completely dormant, vegetative type '609' retained a golden hue compared with the others in the study that were more straw-colored (Figure 3).

Table 1. Performance of buffalograss cultivars in Wichita, Kan., 2012[1]

Cultivar/ experimental number	Type[2]	Genetic color	Leaf texture	Seed-heads	Spring density	Sum-mer density	Fall density	Fall color Oct. 18	Fall color Nov. 1	Quality						
										Apr.	May	June	July	Aug.	Sept.	Avg.
609	V	6.3	8.7	8.0	5.7	7.7	6.0	6.3	2.0	6.7	7.3	7.0	6.7	7.0	6.3	6.8
NE-BFG07-09	V	5.7	8.3	7.0	5.7	4.3	4.7	4.0	1.0	7.0	7.7	5.3	6.0	7.3	5.7	6.5
NE-BFG07-11	V	6.3	8.0	8.3	5.3	5.7	5.7	3.0	1.0	6.3	7.0	6.0	5.0	6.7	6.0	6.2
Cody	S	6.0	8.0	5.0	4.7	5.3	6.0	4.3	1.0	6.3	5.7	5.7	6.7	5.7	5.0	5.8
Texoka	S	6.0	8.0	6.0	5.0	6.3	4.7	4.0	1.0	6.7	6.7	5.3	5.7	5.3	4.7	5.7
NE-BFG07-02	S	6.0	9.0	4.7	6.3	5.7	6.0	3.3	1.0	6.0	5.7	5.3	5.3	5.7	5.3	5.6
Bowie	S	6.0	8.0	5.0	5.0	5.7	5.7	4.3	1.0	6.3	5.3	5.0	4.7	5.7	5.0	5.3
NE-BFG07-01	S	6.3	7.7	4.7	6.0	5.7	6.0	3.3	1.0	5.7	5.3	5.3	5.0	5.0	5.3	5.3
NE-BFG07-04	S	6.0	8.0	4.0	5.3	5.0	5.7	4.0	1.0	5.3	5.7	5.3	4.7	5.3	5.0	5.2
Bison	S	7.3	7.7	5.0	4.0	5.3	5.0	4.0	1.0	6.0	4.7	5.0	5.0	5.3	4.7	5.1
NE-BFG07-03	S	5.3	6.7	4.7	5.7	5.0	6.0	3.3	1.0	5.7	5.0	5.0	4.7	5.3	4.7	5.1
NE-BFG07-10	V	4.7	8.7	8.7	5.0	5.0	3.7	2.3	1.0	5.3	6.0	5.7	3.7	5.0	4.0	4.9
Legacy	V	5.7	9.0	3.3	4.7	4.7	4.7	3.0	1.0	6.0	5.3	4.3	3.7	4.7	4.7	4.8
NE-BFG07-08	S	5.7	8.0	4.3	5.0	4.7	5.3	3.3	1.0	5.3	4.3	4.3	3.7	4.3	4.7	4.4
Prestige	V	7.0	4.3	8.3	5.0	6.0	5.3	3.0	1.0	5.7	6.0	5.0	2.0	3.0	3.0	4.1
NE-BFG07-12	V	5.7	7.3	7.7	4.7	4.0	3.3	2.0	1.0	5.3	6.0	4.0	3.0	3.0	3.0	4.1
NE-BFG07-13	V	5.7	5.0	8.0	4.7	4.3	3.7	2.0	1.0	4.3	3.7	3.3	3.3	5.0	3.7	3.9
LSD[3]		3.8	0.8	0.7	2.2	1.6	1.3	2.9	2.9	1.9	1.5	1.7	1.6	1.7	1.6	1.1

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

[2] Turfgrass types were vegetative (V) and seeded (S).

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

Table 2. Performance of buffalograss cultivars in Wichita, Kan., 2008–2012[1]

Cultivar/ experimental number	Type[2]	% cover, 2008	% cover, 2009	Spring greenup	Color	Leaf texture	Seed-heads	Spring density	Summer density	Fall density	Fall color Oct. 15	Fall color Nov. 1	Quality					
													May	June	July	Aug.	Sept.	Avg.
609	V	65.0	80.0	3.1	6.2	8.3	8.7	4.9	7.1	5.9	8.1	5.7	5.7	6.2	6.3	6.1	5.6	6.1
NE-BFG07-09	V	66.7	85.0	4.3	6.2	7.8	7.8	5.4	4.9	5.1	5.7	3.4	6.1	5.4	5.6	6.0	4.8	5.8
NE-BFG07-11	V	51.7	65.0	4.2	6.3	6.7	7.9	6.0	5.6	5.1	4.9	2.6	5.7	5.5	5.4	5.8	4.8	5.6
NE-BFG07-02	S	51.7	63.3	3.9	6.2	8.0	4.9	5.4	5.8	5.7	4.2	1.7	5.2	5.3	5.5	5.7	4.5	5.3
Legacy	V	55.0	75.0	3.6	6.1	8.0	3.0	5.0	5.3	5.3	4.8	2.3	4.9	5.2	4.8	5.7	4.8	5.2
NE-BFG07-03	S	56.7	71.7	4.6	6.1	6.8	5.0	5.4	5.7	5.7	4.0	1.6	5.1	5.2	5.2	5.5	4.7	5.2
NE-BFG07-01	S	53.3	65.0	4.0	6.1	7.3	5.0	5.4	5.5	5.2	3.9	1.7	5.0	5.4	5.2	5.3	4.7	5.2
Cody	S	45.0	56.7	3.8	6.2	7.2	5.7	4.8	5.0	5.1	4.8	1.9	4.6	4.9	5.3	5.5	4.4	5.2
Texoka	S	48.3	66.7	3.8	6.0	7.5	6.4	4.4	5.6	4.3	5.1	2.8	4.8	5.2	5.2	4.9	4.3	5.2
NE-BFG07-04	S	56.7	61.7	4.0	6.0	7.3	4.3	5.3	5.3	5.3	4.2	1.7	5.1	5.3	5.1	5.4	4.5	5.1
NE-BFG07-10	V	50.0	63.3	4.2	5.3	7.8	8.6	5.8	5.2	4.9	4.6	2.4	5.3	5.5	4.9	5.3	4.2	5.1
NE-BFG07-08	S	55.0	70.0	4.6	5.9	7.5	5.1	5.3	5.3	5.2	4.1	1.5	4.8	5.0	4.8	5.4	4.6	5.0
Bowie	S	23.3	33.3	3.2	6.1	7.0	5.6	4.8	4.8	5.2	4.6	1.6	4.5	4.7	4.5	4.8	4.3	4.8
Prestige	V	40.0	60.0	3.0	5.8	6.5	8.8	6.0	5.9	5.4	4.4	2.4	5.6	5.3	4.0	4.3	4.0	4.8
NE-BFG07-12	V	48.3	65.0	4.3	5.7	7.2	8.6	5.8	5.2	4.4	3.6	2.0	5.4	4.8	4.8	4.5	3.9	4.8
Bison	S	30.0	26.7	3.0	7.0	6.8	5.8	3.9	4.8	4.7	5.7	2.7	4.1	4.4	4.8	4.7	4.4	4.7
NE-BFG07-13	V	33.3	40.0	4.7	5.6	6.2	8.0	5.7	4.8	3.9	2.3	1.0	4.1	4.0	4.1	4.2	3.7	4.1
LSD[3]		30.2	24.4	1.3	0.9	0.8	0.6	0.8	0.7	0.7	0.5	0.5	0.8	0.8	0.9	0.6	0.5	0.6

[1] Visual ratings were based on a scale of 1 to 9 (1 = poorest, 6 = acceptable, and 9 = optimum).
[2] Turfgrass types were vegetative (V) and seeded (S).
[3] To determine statistical differences among entries, subtract one entry's mean from another's. If the result is larger than the corresponding Least Significant Difference (LSD) value, the two are statistically different.

Figure 1. University of Nebraska–Lincoln 2008 buffalograss experimental lines and cultivars evaluation at Wichita, Kan.

Figure 2. Buffalograss mid-fall color.

Figure 3. Buffalograss fall color in early November. Vegetative type '609' is the second plot up from the bottom right of the photograph.

Timing Nonselective Control of Rough Bluegrass

Objective: Determine the most appropriate time of year to apply glyphosate for optimum rough bluegrass control.

Investigators: Cole Thompson, Jack Fry, and Megan Kennelly

Introduction

Roughstalk bluegrass (*Poa trivialis* L.) is a problematic weed in tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) lawns and roughs, as well as creeping bentgrass (*Agrostis stolonifera* L.) fairways and tees. Chemical control of rough bluegrass can prove challenging, because herbicides labeled for the selective removal of the species are limited. Nonselective herbicides can control rough bluegrass, and properly timed applications may offer better control. Applying nonselective herbicides when rough bluegrass is dormant during hot summer months may not effectively control rough bluegrass.

Methods

This study was conducted on 'Laser' rough bluegrass in Manhattan, Kan., in 2011 and 2012 and in Lincoln, Neb., in 2012. Research plots were set up in a randomized complete block design with four replications. Treatments consist of three application timings: spring, midsummer, and late summer. Glyphosate (Glyphomate 41) was applied at 6.4 pints/acre on each of the three timings.

Data Collection

Percentage cover and turfgrass quality were monitored weekly from spring through fall. To measure rough bluegrass recovery, percentage cover was also measured in May 2012 for the 2011 study and will be recorded in May 2013 for the 2012 study. Percentage cover data were taken as a visual estimate of each plot covered by rough bluegrass. Turfgrass quality was taken, considering color, density, and uniformity on a 1 to 9 scale (1 = completely brown, 6 = minimum acceptable quality, 9 = optimum color, density, and uniformity).

Data Analysis

Turfgrass quality data were normally distributed. Percentage cover data were not normally distributed, and data were subjected to a $\log_{10}(y+1)$ transformation to normalize. All data were subject to analysis of variance using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). Fisher's protected least significant difference (LSD) ($P \leq 0.05$) was used to detect treatment differences.

Preliminary Results

Manhattan, 2011

By May 30, 2012, untreated plots averaged nearly 80% rough bluegrass cover, and all treatments averaged significantly less recovery. A single spring application allowed significantly less recovery (1.3%) than the midsummer application (8.8%), and the late-summer application was did not differ from either timing (Table 1).

Manhattan, 2012

The most recent ratings were taken on November 13, 2012 (Figure 1). Untreated plots averaged 95% cover, and all treatments averaged significantly less recovery. The spring timing allowed significantly less recovery (0%) than midsummer (47.3%) and late-summer (16.8%) timings. Furthermore, rough bluegrass cover in plots treated in late summer was significantly less than plots treated in midsummer (Table 1). Data will be collected in May 2013.

Lincoln, 2012

The most recent ratings were taken on November 5, 2012. Untreated plots averaged 86% cover. The spring, midsummer, and late-summer treatments allowed 6.3, 46.3, and 11.3% recovery, respectively, and all allowed significantly less recovery than plots that were left untreated. However, plots treated in mid-May or late summer allowed significantly less recovery than treatment in midsummer (Table 1). Data will be collected in May of 2013.

Table 1. The effects of different application timings of glyphosate on the recovery of roughstalk bluegrass in Manhattan, Kan., and Lincoln, Neb.

	% Recovery[1]		
	2011	2012	
	Manhattan	Manhattan	Lincoln
Treatment	May 30[2]	Nov. 13	Nov. 5
Untreated	79.8 a[3]	95.0 a	86.3 a
Spring	1.3 c	0.0 d	6.3 c
Mid-summer	8.8 b	47.3 b	46.3 b
Late-summer	5.8 bc	16.8 c	11.3 c

[1] Percentage recovery data were visually estimated. Data were subject to a $\log_{10}(y+1)$ transformation to normalize and back-transformed for presentation.

[2] Data were collected weekly from spring through fall, and only the most recent rating dates are shown to reflect rough bluegrass recovery.

[3] Within columns, means with the same letter are not statistically different according to Fisher's protected least significant difference (LSD) ($P \leq 0.05$).

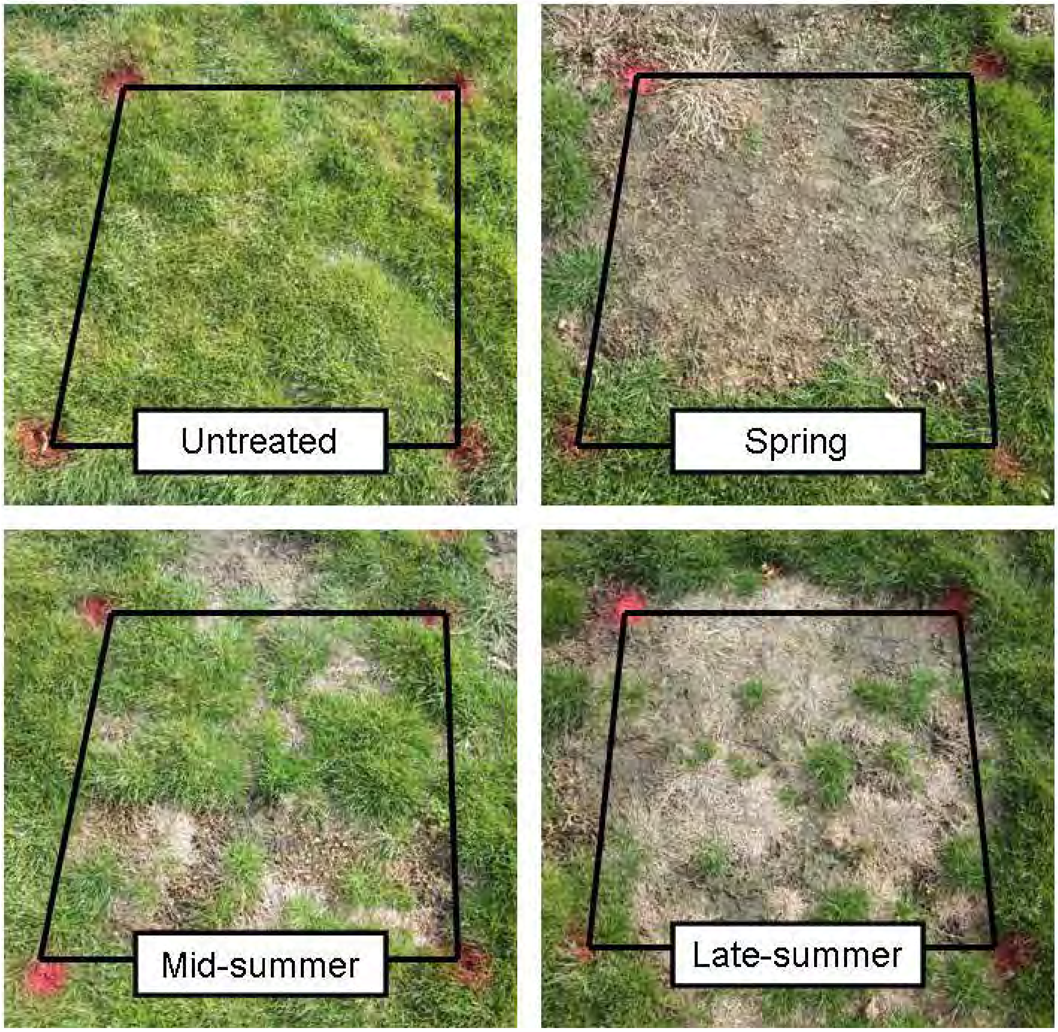

Figure 1. Research plots in Manhattan, Kan., on November 13, 2012. Treatment with glyphosate in the spring allowed less recovery than any other timing.

Physiological and Pathological Contributors to Rough Bluegrass Decline

Objectives: 1) Observe seasonal physiological changes of rough bluegrass, 2) evaluate the effect of fungicides on summer decline of rough bluegrass, and 3) determine if a pathogen is contributing to the seasonal decline of rough bluegrass.

Investigators: Cole Thompson, Jack Fry, and Megan Kennelly

Introduction

Roughstalk bluegrass (*Poa trivialis* L.) is a fine-textured, cool-season, perennial turfgrass species that spreads via seed and stolons. The species is used in wet, shady areas in northern climates and cool-humid regions and is also commonly used in warmer climates to overseed dormant bermudagrass (*Cynodon* spp.) during winter months. Rough bluegrass has excellent cold tolerance, but poor drought, heat, and wear tolerance, making it a problematic weed in tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) lawns and roughs as well as creeping bentgrass (*Agrostis stolonifera* L.) fairways and tees. Rough bluegrass will encroach on desired turf species with favorable growing conditions but will enter a stress-induced dormancy with undesirable heat or drought stress, leaving behind brown patches of dormant turf that can be easily mistaken for disease. The species is often unknowingly planted along with desirable turfgrass species, as it can be a contaminant included under the “other crop” category on seed labels.

Methods

The study was conducted on ‘Laser’ rough bluegrass in Manhattan, Kan., in 2011 and 2012 and in Lincoln, Neb., in 2012. Research plots were set up in a randomized complete block design with four replications. Treatments consisted of four fungicides: azoxystrobin (Heritage 50 WDG) at 0.4 oz/1,000 ft^2, azoxystrobin (Heritage TL) at 2 fl oz/1,000 ft^2, pyraclostrobin (Insignia 20 WG) at 0.9 oz/1,000 ft^2, and pyraclostrobin (Insignia SC) at 0.7 fl oz/1,000 ft^2. Treatments were applied at a 2-week interval from spring through summer.

Data Collection

Percentage cover, turfgrass quality, and photosynthetic rate were monitored weekly. Percentage cover data were taken as a visual estimate of each plot covered by rough bluegrass. Turfgrass quality was evaluated, considering color, density, and uniformity on a 1 to 9 scale (1 = completely brown, 6 = minimum acceptable quality, 9 = optimum color, density, and uniformity). Photosynthetic rate was estimated by monitoring carbon dioxide concentrations using a non-steady state chamber that was developed at Kansas State University and configured with a closed-path infrared gas analyzer (LI-840, Li-Cor Industries, Lincoln, Neb.).

Plots were sampled for the presence of pathogens on May 24 and July 11, 2011. On May 24, two 1-in. (diameter) × 6-in. (deep) plugs were removed from each plot and incubated in a sealed, clear bag with a moist paper towel. Foliage was analyzed for lesions the following day, and roots were soaked in water overnight to loosen field soil. Soil was removed from roots the following day, and roots were analyzed for the presence of pathogens/overall health. On July 11, one 4-in. (diameter) × 6-in. (deep) plug was removed from each plot. Plugs were incubated overnight, and foliage was examined the following day. Five pieces of leaf tissue (approximately 5 mm in length) that exhibited both healthy and necrotic tissue were plated on one-quarter-strength potato dextrose agar (¼ PDA + +). Tissue was surface-sterilized in 10% bleach, rinsed in sterile water, and blotted dry before plating. Cultures were examined after three days. For root analysis, approximately 1 in. of the margin of each plug was removed, soaked, and cleaned. On both sampling dates, roots were examined under a compound microscope in at least 10 fields of view. In 2012, plots were sampled for disease on June 11 and August 7 in Manhattan only.

Data Analysis

Single degree of freedom contrasts were used to compare each fungicide treatment to the untreated control. Cover data were not normally distributed and were subject to an *arcsine* (*y*) transformation prior to analysis.

Preliminary Results

Gross photosynthesis

Heritage TL and Insignia SC both averaged greater Pg than untreated plots on 2 of 10 dates in 2011 (Table 1). In 2012, Heritage 50 WDG, Heritage TL, Insignia 20 WG, and Insignia SC averaged greater Pg than untreated plots on 5, 5, 3, and 4 dates out of 14, respectively, in Manhattan. In Lincoln, Heritage 50 WDG and Insignia SC averaged greater Pg than untreated on 1 of 4 dates each. Fungicides did not have an effect on Pg until RBG was exposed to extended periods of heat stress.

Rough bluegrass cover

Heritage 50 WDG and Heritage TL increased RBG cover compared with untreated plots in 2011 (Table 2; Figure 1). In 2012, all fungicides increased RBG cover compared with untreated plots in Manhattan and Lincoln.

Rough bluegrass quality

Heritage 50 WDG and Heritage TL improved quality over untreated plots in 2011 (Table 3). In 2012, all fungicides increased quality over the untreated plots in Manhattan and Lincoln.

Rooting parameters

Compared with untreated plots in late summer of 2012, Heritage 50 WDG resulted in greater root length density (11.1 cm/cm^3 vs. 6.7 cm cm^3), surface area (175.2 cm^2 vs. 92.1 cm^2), average root diameter (0.15 mm vs. 0.13 mm), and total root biomass (0.15 g vs. 0.07 g) in Manhattan. No differences were observed in rooting in Lincoln.

Pathogenic contribution to decline

A small amount of dollar spot (*Sclerotinia homoeocarpa*) was observed in untreated plots in Manhattan and Lincoln in 2012. Incidence was very low, and dollar spot was not a major contributor to the summer decline of RBG. No other known or unknown foliar or root pathogens were detected consistently in 2011 or 2012.

Table 1. Effects of fungicide treatments on gross photosynthesis (Pg) in Manhattan, Kan., in 2011 and 2012, and in Lincoln, Neb., in 2012

	Pg (µmol CO_2 m^2/s)[1]									
	2011			2012						
	Manhattan			Manhattan						Lincoln
Treatment	June 15	June 28	Aug. 16	July 24	July 31	Aug. 8	Aug. 15	Aug. 21	Aug. 30	June 28
Untreated	12.8	14.4	0.1	12.7	9.1	6.2	5.9	6.7	5.9	10.7
Heritage 50 WDG	12.8	14.9	2.7	**17.3**	**11.6**	**12.7**	**16.9**	**17.1**	**18.8**	18.1
Heritage TL	**17.4**	16.2	**2.8**	15.5	14.6	**11.3**	**14.0**	**18.5**	**14.1**	12.7
Insignia 20 WG	15.3	13.2	1.3	16.3	**15.1**	**13.1**	10.2	13.6	**17.4**	14.5
Insignia SC	**17.0**	**17.5**	1.8	15.8	11.1	**15.3**	**15.9**	**15.1**	**18.2**	16.6
	Contrasts (fungicide vs. untreated)[2, 3]									
Heritage 50 WDG	NS	NS	NS	*	*	**	***	**	***	**
Heritage TL	*	NS	*	NS	NS	*	**	**	**	NS
Insignia 20 WG	NS	NS	NS	NS	*	**	NS	NS	***	NS
Insignia SC	*	*	NS	NS	NS	***	**	*	***	*

[1] Gross photosynthesis measurements were taken weekly from May 31 through September 8, 2011, and from June 4 through September 6, 2012, in Manhattan. In 2012, measurements were also taken monthly in Lincoln from June through September. Only means from significant rating dates are shown. Values in bold are significantly different from untreated plots.

[2] A set of single degree-of-freedom contrasts were used to compare fungicide treatments with the untreated control.

[3] *, **, and *** are significant at the 0.05, 0.01, and 0.001 probability level, respectively.

Table 2. Effects of fungicide treatments on rough bluegrass cover in Manhattan, Kan., in 2011 and 2012, and in Lincoln, Neb., in 2012

	Turfgrass cover[1]									
	2011			2012						
	Manhattan			Manhattan			Lincoln			
Treatment	Aug. 28	Sept. 28	May 30, 2012	July 27	Aug. 30	Sept. 26	June 29	July 31	Aug. 30	Sept. 28
Untreated	0.8	0.3	30.0	77.5	73.8	78.3	67.5	58.8	62.5	71.3
Heritage 50 WDG	**16.8**	**7.5**	**87.8**	85.5	**95.3**	**95.8**	**81.3**	**78.8**	**82.5**	**80.0**
Heritage TL	**21.3**	**7.8**	**91.0**	**95.8**	**98.0**	**99.3**	**76.3**	**70.0**	**83.8**	**80.0**
Insignia 20 WG	8.3	2.0	63.8	**93.0**	**93.8**	**96.5**	**78.8**	**72.5**	**76.3**	76.3
Insignia SC	7.5	1.0	**63.8**	88.3	**88.5**	**92.5**	**78.8**	**76.3**	**80.0**	76.3
	Contrasts (fungicide vs. untreated)[2, 3]									
Heritage 50 WDG	**	*	***	NS	***	**	***	***	**	**
Heritage TL	**	*	***	**	***	**	*	*	**	**
Insignia 20 WG	NS	NS	NS	*	***	**	**	**	*	NS
Insignia SC	NS	NS	*	NS	**	*	**	**	**	NS

[1] Turfgrass cover data was visually estimated. Cover data were subject to an *arcsine* (*y*) transformation prior to analysis and back-transformed for presentation. Only means from significant rating dates are shown. Values in bold are significantly different from untreated plots.
[2] A set of single degree of freedom contrasts were used to compare fungicide treatments with the untreated control.
[3] *, **, and *** are significant at the 0.05, 0.01, and 0.001 probability level, respectively.

Table 3. Effects of treatments on rough bluegrass quality in 2011 in Manhattan, Kan., and in 2012 in Manhattan and Lincoln, Neb.

	2011		2012			
	Manhattan		Manhattan		Lincoln	
Treatment	Quality[1]	% DBU[2]	Quality	% DBU	Quality	% DBU
Untreated	3.5	N/A	6.6	N/A	6.0	N/A
Heritage 50 WDG	**4.2**	56	**7.7**	41	**7.0**	72
Heritage TL	**4.6**	72	**8.1**	59	**6.7**	64
Insignia 20 WG	4.0	16	**7.8**	45	**6.5**	36
Insignia SC	3.9	8	**7.7**	41	**6.7**	45
	Contrasts (fungicide vs. untreated)[3, 4]					
Heritage 50 WDG	*	-	***	-	***	-
Heritage TL	***	-	***	-	***	-
Insignia 20 WG	NS	-	***	-	**	-
Insignia SC	NS	-	***	-	***	-

[1] Means represent season-long quality estimates. Values in bold are significantly different from untreated.
[2] Percentage days better than untreated (% DBU), out of 25, 22, and 11 total dates in 2011, 2012-Manhattan, and 2012-Lincoln, respectively.
[3] A set of single degree-of-freedom contrasts was used to compare fungicide treatments with the untreated control.
[4] *, **, and *** are significant at the 0.05, 0.01, and 0.001 probability level, respectively. Single degree-of-freedom contrasts were used to compare fungicides to untreated plots.

Figure 1. Untreated plots and plots treated with Heritage TL in Manhattan, Kan., on September 1, 2011 (*top*) and August 28, 2012 (*bottom*). Other fungicides yielded similar results.

Responses of Kentucky Bluegrass Cultivars to Prolonged Drought in the Transition Zone

Objective:	Evaluate the response of 30 bluegrasses to prolonged drought in the transition zone.
Investigators:	Tony Goldsby, Dale Bremer, Jack Fry, and Steve Keeley

Introduction

Water availability and restrictions are increasingly serious issues in the Midwest and across the U.S. Drought restrictions may be imposed on turf managers with no regard for damage to turfgrass. For turf managers, thriving in an industry where good turf quality is a priority is difficult when water is limited; therefore, research investigating turfgrass resistance to drought stress is becoming increasingly important.

Kentucky Bluegrass (KBG) (*Poa pratensis)* is the most widely used cool-season turfgrass in the United States. It can be found on lawns, golf courses, cemeteries, parks, school grounds, athletic fields, and other areas where a dense grass cover is desired. Because of differences in water use and substantial morphological and physiological diversity among cultivars of KBG, some cultivars may be better able to withstand long periods of drought and recover faster than others.

A fully automated rainout shelter located in the transition zone at Rocky Ford Turfgrass Research Center, Manhattan, Kan., offers the ability to compare multiple KBG cultivars while restricting water. Kentucky bluegrass cultivars with greater drought resistance and recovery ability may be useful in areas where water restrictions are expected. The objective of this study was to evaluate the responses of 30 bluegrasses to prolonged drought exposure and their recovery after rewatering.

Methods

Measurements

The plots were well watered during the spring until June 15, 2010, and June 1, 2011. Thereafter, plots were allowed to dry down with no precipitation or irrigation for 88 days in 2010 and 60 days in 2011. Overhead photos of all plots were taken weekly, and images were used to calculate percentage green turfgrass cover. In 2010, the camera was mounted on a tripod 3.0 m in height with a horizontal arm that was mounted at 90° from vertical and extended 1.0 m away from the tripod center. All images were collected under clear skies at (~1200 CST) to minimize changes in solar zenith angle. In 2011, construction of a camera light box allowed for more flexibility in the time of data collection. The images were analyzed for percentage green cover with SigmaScan Pro (v. 5.0, SPSS, Chicago, Ill.).

Statistical analysis

Digital image data were analyzed on a date-by-date basis with the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.). In cases where the F-test for treatment differences were significant ($P = 0.05$) on a given date, 95% confidence intervals were used for comparison among individual treatment means.

Scatter plots of percentage green turf cover vs. days after irrigation was withheld (DAIW) during drought stress, and days after irrigation (DAI) was applied during recovery from drought, indicated nonlinear relationships. Furthermore, the data fit very well to a sigmoid variable slope model. The slope parameter of both models defines how rapidly turf cover changes over time. For the drydown periods, a Day_{75} and Day_{25} value was calculated to estimate DAIW until each plot reached 75% and 25% green cover. For the recovery periods, Day_{75} was calculated to estimate DAI and was initiated before each plot reached 75% green cover. After the 2010 drydown, measurements of canopy green cover during the recovery were obtained only for 60 DAI, but most canopy regrowth in the bluegrass entries with the slowest recoveries occurred thereafter, primarily during the next spring, prior to the 2011 drydown. Therefore, Day_{75} during the 2010 recovery was extrapolated using the sigmoid models in most cultivars. In 2011, all plots had reached 75% green cover by 45 days after irrigation was returned. Nonlinear regression analysis of the turf percentage cover data was performed using GraphPad Prism version 4.0 for Windows (Graphpad Software, San Diego, CA).

Results

In 2010, plots were completely brown (0% green coverage) by the end of the 88-day drydown (Figure 1). Among cultivars, green coverage declined to 25% by 44.3 to 54.1 DAIW. In 2011, plots were less brown (15–30% green cover) by the end of the 60-day drydown because all plots received 39 mm of precipitation after the rainout shelter malfunctioned; green coverage declined to 25% by 39.0 to 57.1 DAIW (Figure 2). In both years, green coverage declined the slowest in 'Apollo,' 'Bedazzled,' 'Blue Velvet,' 'Envicta,' 'Midnight II,' and 'Thermal Blue Blaze' and fastest in 'Blue Knight,' 'Cabernet,' 'Kenblue,' 'Limousine,' and 'Touchdown' (Figures 3 and 4).

Predictions from the sigmoid models illustrate the slower post-drought recovery in 2010 (mean $Day_{75} = 86.9$ days) than in 2011 (mean $Day_{75} = 30.5$ days) (Figures 5–8), which was discussed earlier. Among cultivars, the Day_{75} during recovery averaged almost two months (56 days) more in 2010 than in 2011. Slower recovery in 2010 was likely caused by the longer (88-day) drought in 2010 than in 2011 (60-day), and by the 39 mm of precipitation inadvertently received by plots when the rainout shelter failed in 2011. The range in Day_{75} during recovery was from 57.8 to 148 days in 2010 and from 20 to 43.7 days in 2011. Recovery of green coverage after drydowns in both years was fastest in 'Apollo,' 'Award,' 'Baron,' 'Unique,' and 'Moonlight' and slowest in 'Abbey,' 'Bartitia,' 'Nu Destiny,' 'Park,' and 'Touchdown.' Overall, the amazing recuperative ability of all 30 bluegrasses was noteworthy, because all entries eventually recovered even after severe, prolonged drought in both years.

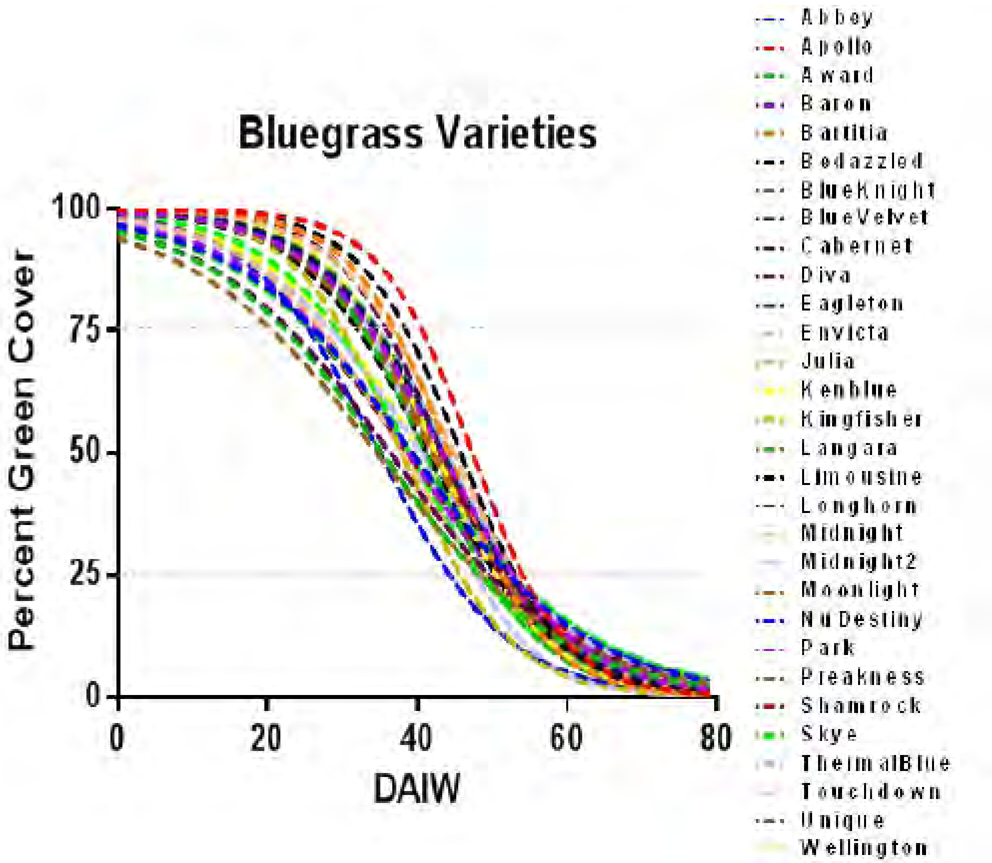

Figure 1. Predicted drydown curves for the 30 bluegrasses in 2010.

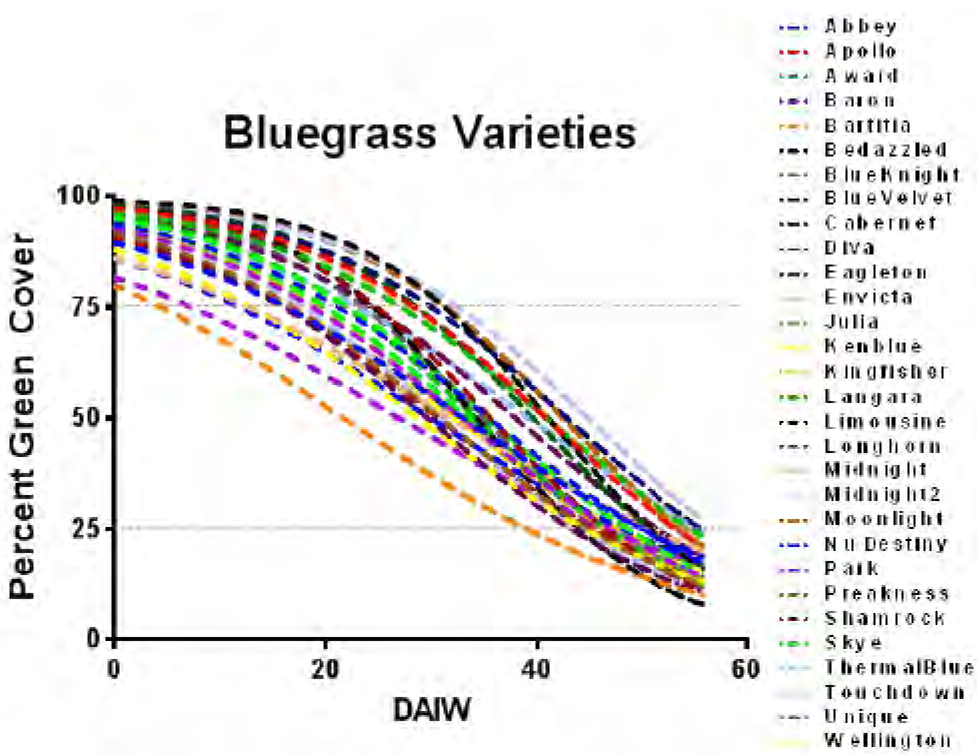

Figure 2. Predicted drydown curves for 30 bluegrasses in 2011.

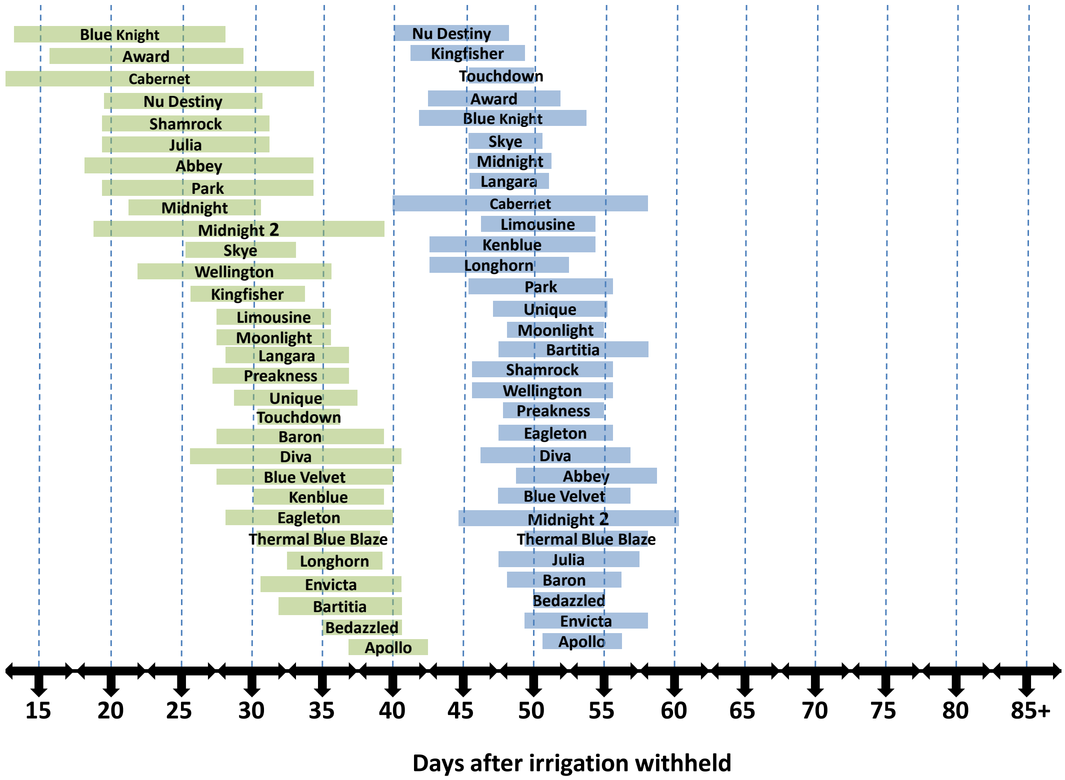

Figure 3. The 95% confidence intervals for the number of days after irrigation was withheld until bluegrass cultivars reached 75% and 25% green cover in 2010. Green bars represent days until cultivars reached 75%, and blue bars represent 25% green cover. Cultivars with overlapping bars were not significantly different.

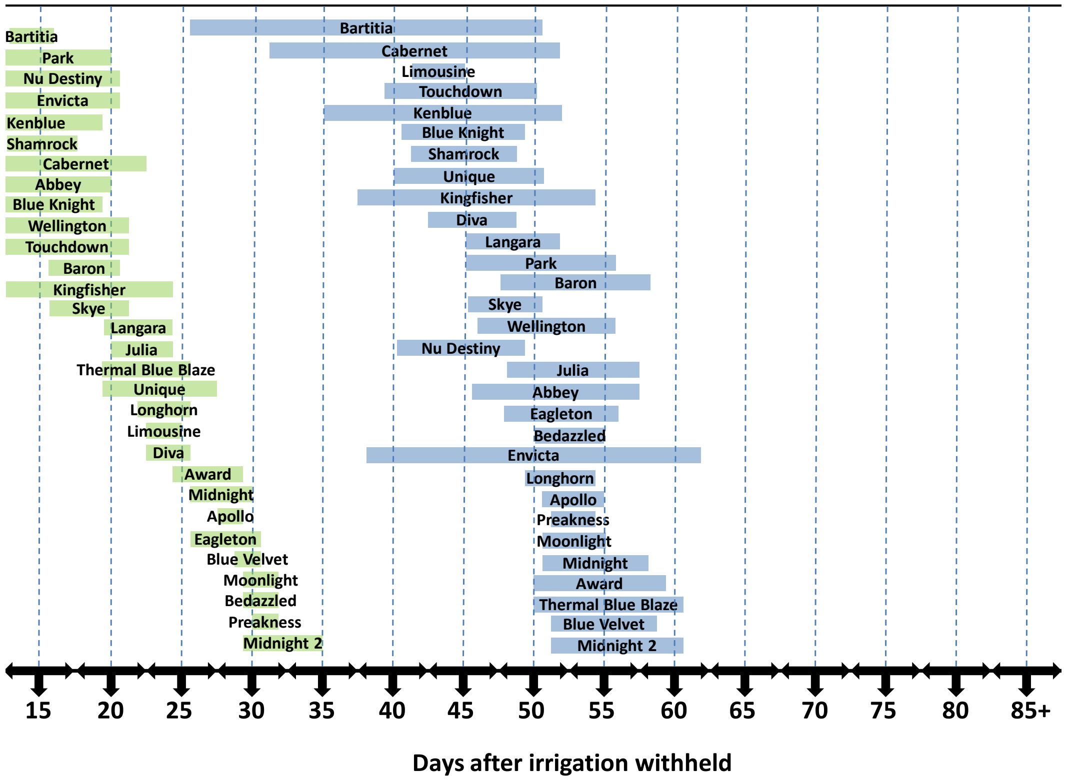

Figure 4. The 95% confidence intervals for the number of days after irrigation was withheld until bluegrass cultivars reached 75% and 25% green cover in 2011. Green bars represent days until cultivars reached 75%, and blue bars represent 25% green cover. Cultivars with overlapping bars were not significantly different.

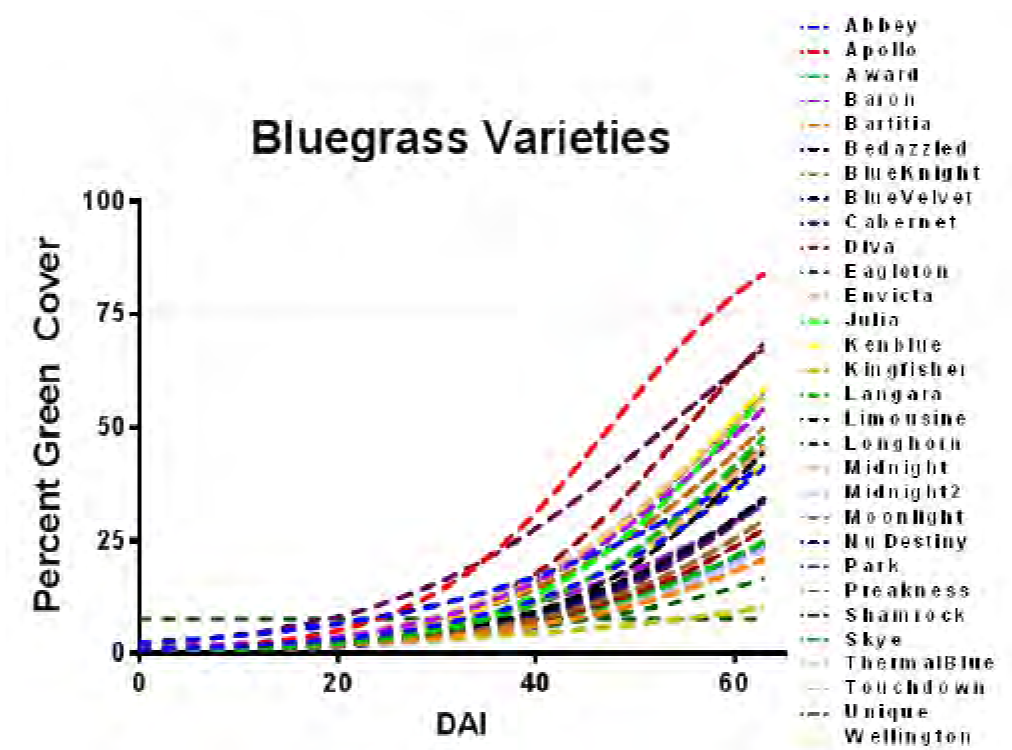

Figure 5. Predicted recovery curves for 30 bluegrasses in 2010.

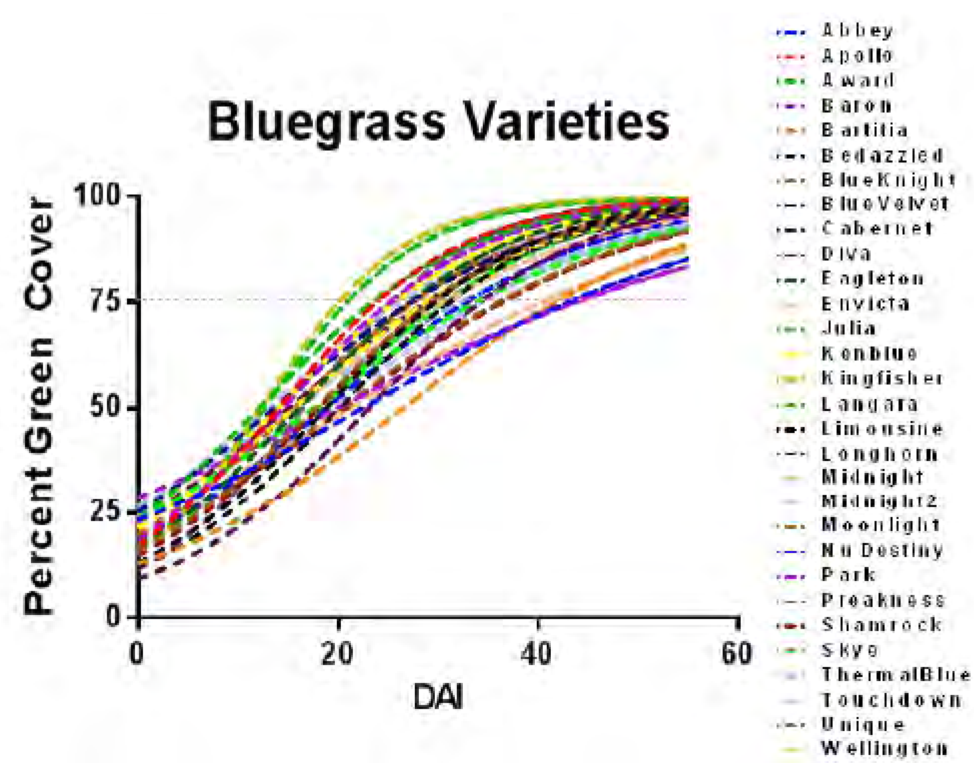

Figure 6. Predicted recovery curves for 30 bluegrasses in 2011.

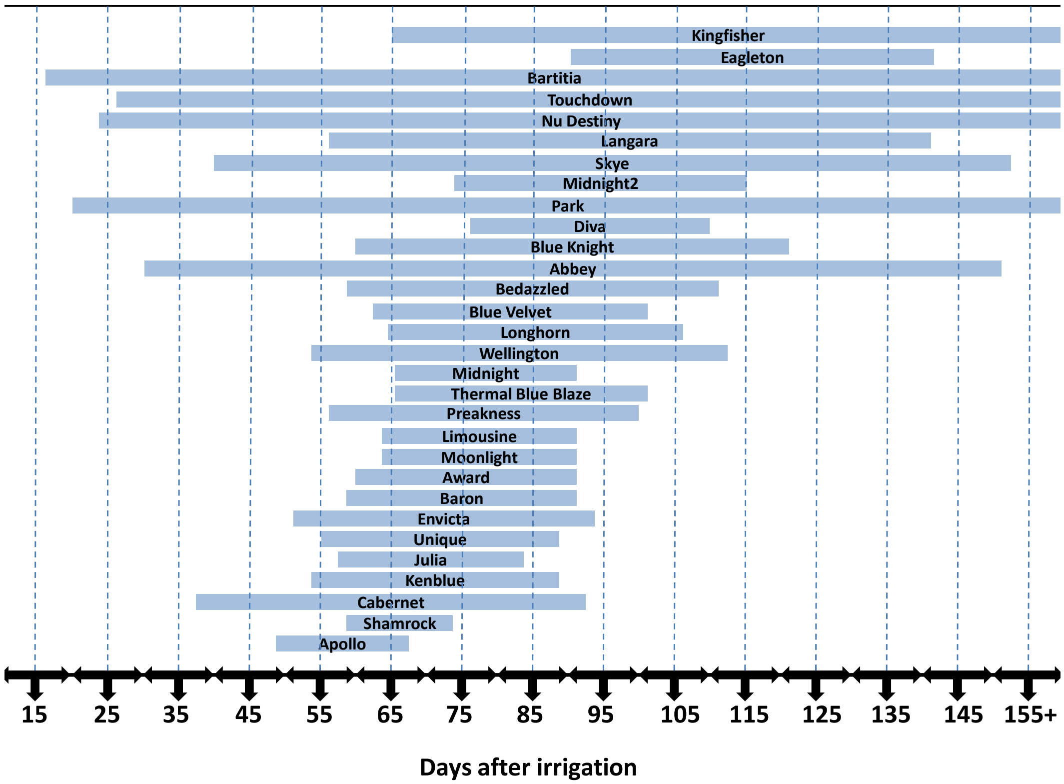

Figure 7. The 95% confidence intervals for the number of days after irrigation until bluegrass cultivars reached 75% green cover in 2010. Cultivars with overlapping bars were not significantly different.

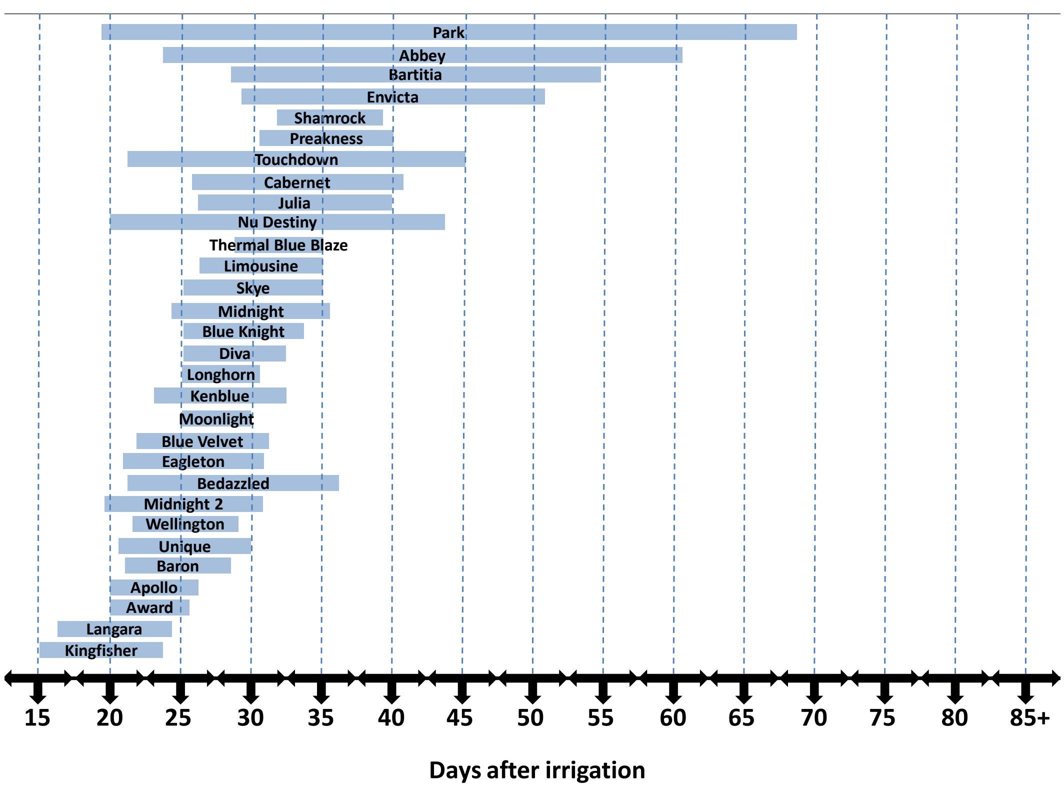

Figure 8. The 95% confidence intervals for the number of days after irrigation until bluegrass cultivars recovered in 2011. Cultivars with overlapping bars were not significantly different.

Physiological Responses of Kentucky Bluegrass Cultivars to Prolonged Drought Stress in the Transition Zone

Objective: Evaluate visual performance and physiological parameters of Kentucky bluegrass (*Poa pratensis* L.) cultivars during prolonged drought.

Investigators: Tony Goldsby, Dale Bremer, Jack Fry, and Steve Keeley

Introduction

The previous chapter in this report, "Responses of Kentucky Bluegrass Cultivars to Prolonged Drought in the Transition Zone" (see page 42), indicated wide variations in drought tolerance among Kentucky bluegrass (KBG) cultivars. A number of underlying physiological mechanisms likely affect drought tolerance. Such mechanisms may include plant water potential, cellular membrane stability, and photosynthesis. The maintenance of a favorable status in these mechanisms during drought stress may improve the performance of some cultivars relative to others.

Although the physiological mechanisms of leaf water potential, cellular membrane stability, and photosynthesis have been used to evaluate drought tolerance in cool-season turfgrasses, their responses in KBG cultivars exposed to prolonged drought have not been evaluated. Therefore, the objectives of this study were to evaluate the responses those physiological parameters in KBG cultivars exposed to the 88- and 60-day drydown in 2010 and 2011, respectively. Visual ratings of quality and color, as well as measurements of soil moisture, were also collected.

Methods

Because it was not practical in this study to evaluate physiological mechanisms in all 30 of the bluegrasses in a larger study, a subset of six KBG cultivars was selected; an additional cultivar was added in the second year because of its notably superior performance in the first year. The cultivars were selected based on results from a previous study conducted on these same plots, in which cultivars were ranked by the amount of water applied over the growing season using wilt-based irrigation. Specifically, we selected six cultivars from across a broad range of water requirements in a previous study to evaluate physiological mechanisms that may affect drought resistance in KBG cultivars. In both years (2010–2011), cultivars included 'Wellington,' 'Abbey,' 'Bedazzled,' 'Blue Velvet,' 'Moonlight,' and 'Cabernet.' The cultivar 'Apollo' was added in the second year after recovering the quickest among cultivars after the 2010 drydown.

Measurements

The plots were well watered until June 15, 2010, and June 1, 2011. Thereafter, plots were allowed to dry down, with no precipitation or irrigation, for 88 days in 2010 and 60 days in 2011. Visual evaluations of turfgrass color and quality were recorded weekly by the same researcher during the growing season. The rating scale for color was 1 to 9, where 1 = brown and 9 = dark green. The rating scale for visual quality was also 1 to 9, where 1 = brown, dead or dormant turfgrass, 6 = minimally acceptable for home lawns, and 9 = highest quality based on color, density, texture, and uniformity. Visual quality and color ratings, as well as digital images, were collected from all seven cultivars in both years.

Volumetric soil water content (θ_v) was monitored daily at 5 and 20 cm utilizing the dual-probe heat-pulse technique. Sensors were fabricated in the authors' laboratory. Measurements of θ_v were logged twice daily with a micrologger and accessories (CR10x and three AM16/32 multiplexors, Campbell Scientific, Logan, UT). In 2011, sensors in all plots of 'Bedazzled' at 5 cm malfunctioned.

Physiological measurements included leaf water potential, which was collected biweekly, and electrolyte leakage and photosynthesis, which were collected weekly; these measurements were not taken for 'Apollo' in 2010.

Results

Visual color declined during the drydowns in both 2010 and 2011. Analysis of variance indicated significant differences ($P = 0.05$) among the selected cultivars on 3 of 29 sampling dates in 2010 (data not shown). In 2010, visual color ratings were lower for 'Cabernet' at the start of the 60-day drydown, which suggests a genetic color difference. By August 12 and 18, or approximately 8 weeks into the drydown, color ratings for Apollo were highest among the cultivars, indicating a greater ability to maintain color during drought. In 2011, however, there were no differences in color ratings among cultivars on any measurement date.

Visual quality declined substantially during the drydowns of both years. In general, visual quality was similar among cultivars as drought effects intensified. In fact, differences in visual quality among cultivars occurred only on three measurement dates in 2010 and never in 2011 (Figure 1). Overall, the average quality among cultivars decreased from 7.0 on June 17 to 6.1 by June 30, 2010. On June 30, 2010, the visual quality of 'Apollo' and 'Bedazzled' (both are Compact Americas) were greater than 'Cabernet,' 'Blue Velvet,' and 'Abbey.' One week later (July 7, 2010), visual quality was greater in 'Bedazzled,' 'Apollo,' and 'Abbey' than in 'Wellington' and 'Cabernet.' On August 12, 2010, visual quality was greatest in 'Apollo' among cultivars.

In 2010, θ_v content at 5 cm was similar among cultivars at the beginning of the drydown (33–34%) (Figure 2). During the next 21 days, θ_v declined rapidly but then abruptly increased on July 5 after the plots received 25 mm of precipitation when the rainout shelter malfunctioned. During the next 25 days, θ_v again declined among cultivars before generally leveling off in the final 35 days of the drydown. In 2011, θ_v at 5 cm was also similar among cultivars at the beginning of the drydown (24–26%). Thereafter, θ_v declined rapidly for the first 15 days and began to level off in four cultivars by June 15; θ_v continued to decline in 'Blue Velvet' and 'Wellington' for an additional 10 days.

Volumetric soil water content increased substantially after all plots received 25 mm of precipitation on July 21, 2011, when the rainout shelter malfunctioned a second time in the study.

In both years, the greatest depletion of soil moisture at 5 cm was in 'Cabernet' and 'Apollo.' By the end of the period of soil moisture depletion in each year, when θ_v at 5 cm leveled off, θ_v had declined in 'Cabernet' by 29% in 2010 and 17% in 2011, and in 'Apollo' by 22% in 2010 and 16% in 2011. 'Cabernet' belongs to the KBG phenotypic group Mid-Atlantic, whose cultivars are known for having extensive root and rhizome systems and good tolerance and recovery from summer stress. Greater depletion of soil moisture at 5 cm by 'Cabernet' in this study supports these reports. Apollo belongs to the KBG phenotypic group Compact America, whose cultivars have been reported as having moderate ability to recover from summer stress. Both 'Cabernet' and 'Apollo' were among the top-performing cultivars in a previous study in these same plots that ranked minimum water requirements of these 30 bluegrasses.

In 2010, θ_v at 20 cm was similar among cultivars at the beginning of the experiment (36–38%) (Figure 3). Soil moisture declined rapidly during the first 15 days of the drydown, then abruptly increased after plots inadvertently received 25 mm of precipitation on July 5. Thereafter, θ_v declined for the next 30 days before generally leveling off. By the end of the entire 88-day drydown, the greatest decline in θ_v among cultivars was in Apollo (23%). In 2011, θ_v at 20 cm was also similar in all cultivars at the beginning of the drydown (30–31%). The θ_v generally declined from June 1 to July 2. During this 30-day period, the greatest reduction in θ_v was in 'Bedazzled' (19%).

In both years, the soil was much drier by the end of the drydown at 5 cm than at 20 cm (Figures 2 and 3). Presumably, greater root density nearer the surface resulted in greater depletion of soil moisture at 5 cm. At 20 cm, the greatest decline in θ_v was in cultivars from the phenotypic group Compact America (i.e., 'Apollo' and 'Bedazzled'), which indicates that cultivars from that group had a greater ability to mine water from deeper in the profile (20 cm). Studies by other researchers have indicated that soil moisture of drought-tolerant cultivars was significantly lower at the 15–30-cm depth compared with intolerant cultivars. Thus, our data suggest that 'Apollo' and 'Bedazzled' may be more drought-tolerant than the other cultivars; however, the cultivar 'Wellington' from the Common type phenotypic group also had large declines in θ_v at the 20-cm profile for both years. This suggests that Wellington may have depleted even greater soil moisture from deeper in the profile, perhaps because of a deeper root system (21–50 cm). Nevertheless, 'Wellington' did not display superior drought tolerance.

Leaf water potential began to decline in the first week of the drydown in both years (data not shown). There were differences in leaf water potential among cultivars on only 8 out of 55 measurement dates during the two-year study ($P = 0.05$), but there were no conclusive trends.

Electrolyte leakage was generally similar among the six cultivars during the drydown and recovery periods in both years (data not shown). In addition, there were no substantial increases in electrolyte leakage as the drydown progressed in both years, indicating the effects of drought stress on cellular membrane stability were negligible.

Photosynthesis decreased substantially in all six KBG cultivars over the course of the 2010 drydown and in all seven cultivars in 2011 (data not shown). Within 12 days in 2010, photosynthesis had declined by 50 to 73% among cultivars. Overall, photosynthesis declined by >95% in all cultivars from the study initiation through the end of the drydown. In 2011, photosynthesis decreased by 24 to 77% among cultivars during the first month of the drydown. By the end of the drydown in 2011, photosynthesis in all seven cultivars had declined by about 85%.

In general, there were no significant trends in electrolyte leakage, leaf water potential, and photosynthesis among cultivars during or after each drydown (data not shown).

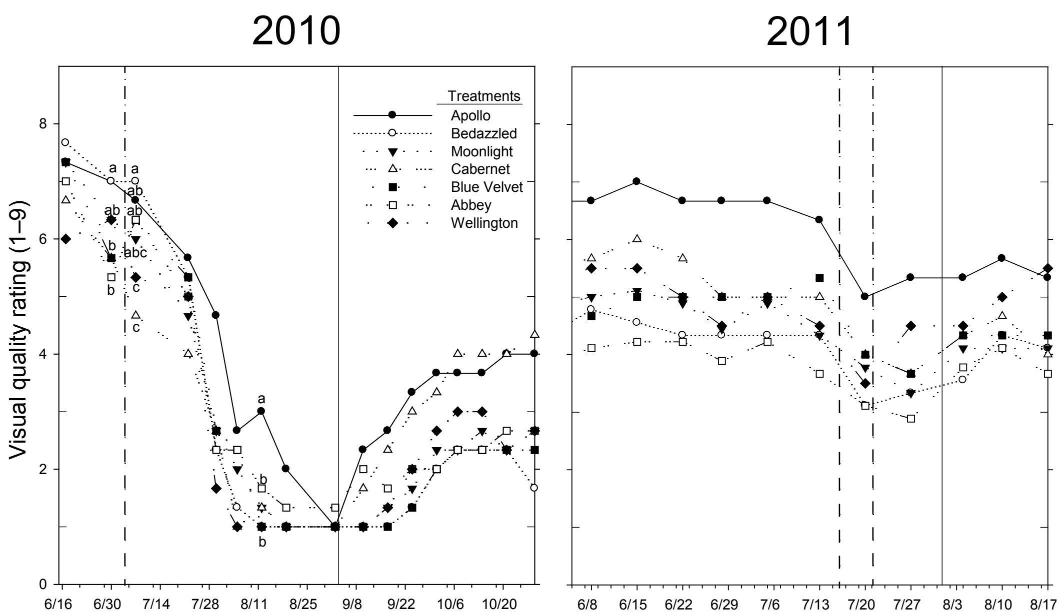

Figure 1. Visual quality rating of seven cultivars of Kentucky bluegrass during drydowns in 2010 and 2011. Treatments included 'Apollo,' 'Bedazzled,' 'Moonlight,' 'Cabernet,' 'Blue Velvet,' 'Abbey,' and 'Wellington.' Vertical solid black lines in the above graphs indicate the completion of the drydown. Vertical dotted lines in both years indicate rain shelter malfunctions. Means followed by the same letter on a date are not significantly different according to Fisher's least significant difference ($P < 0.05$).

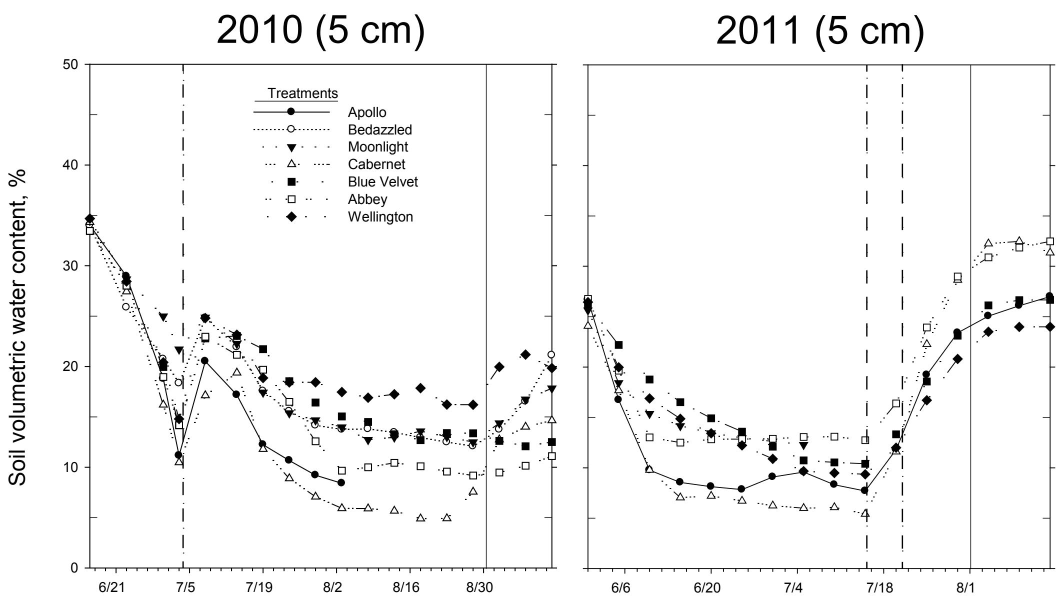

Figure 2. Volumetric soil water content at 5 cm of seven cultivars of Kentucky bluegrass during drydowns in 2010 and 2011. Treatments included 'Apollo,' 'Bedazzled,' 'Moonlight,' 'Cabernet,' 'Blue Velvet,' 'Abbey,' and 'Wellington.' Vertical solid black lines in the above graphs indicate the completion of the drydown. Vertical dotted lines in both years indicate rain shelter malfunctions. Markers represent 5-day averages. In 2011, data were not available for 'Bedazzled' because of sensor failure.

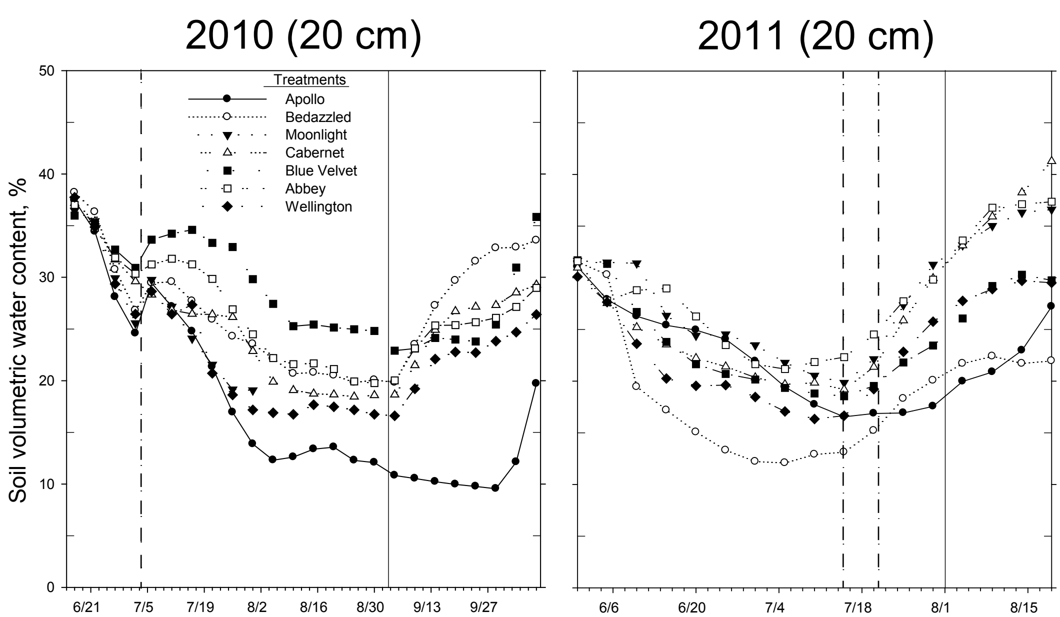

Figure 3. Volumetric soil water content at 20 cm in seven cultivars of Kentucky bluegrass during a 60-day drydown in 2010 and 2011. Treatments included 'Apollo,' 'Bedazzled,' 'Moonlight,' 'Cabernet,' 'Blue Velvet,' 'Abbey,' and 'Wellington.' Vertical solid black lines in the above graphs indicate the completion of the drydown. Vertical dotted lines in both years indicate rain shelter malfunctions. Markers represent 5-day averages.

Comparison of Turfgrass Evapotranspiration Measurement Techniques

Objective: Compare measurements of evapotranspiration (ET) from lysimeters with ET estimates from a number of techniques, including the FAO-56 Penman-Monteith and Priestley-Taylor empirical models, atmometers, eddy covariance, and transpiration from a stomatal conductance model, all at the same site.

Investigators: Kenton Peterson, Dale Bremer, and Jack Fry

Sponsor: United States Department of Agriculture National Integrated Water Quality Program

Introduction

Accurate measurement or estimation of evapotranspiration (ET) is very important for irrigation management and research methodologies. A number of techniques are available to measure or estimate ET. Practitioners and researchers will often select a single method of ET estimation to determine irrigation requirements. Each method has its strengths and weaknesses. Depending on a given situation, the selection of one method over another could lead to inaccurate or biased ET information that results in incorrect irrigation requirements.

Evapotranspiration can be measured using lysimeters or eddy covariance, estimated using empirical models, or simulated using an atmometer. For turfgrass research, lysimeters are the standard for ET measurement because they are easy to use, are relatively inexpensive, and measure ET directly from the turf. Eddy covariance measures ET by measuring the amount of water vapor evaporating from the turfgrass, but it is complex, expensive, and requires extensive data processing. Empirical models such as the Priestley-Taylor or Penman-Monteith require the inputs of meteorological data from weather stations that can be costly to set up and maintain. An atmometer is an inexpensive tool that estimates ET by measuring evaporation from a porous ceramic evaporation plate that simulates a turfgrass canopy. To our knowledge, no research in the literature compares ET data obtained from these techniques simultaneously and side-by-side. Such a comparison would be invaluable in demonstrating their performance relative to each other when placed in the same environment.

Methods

This investigation was initiated in July 2010 at the Rocky Ford Turfgrass Research Center at Manhattan, Kan., and continued during the growing seasons of 2011 and 2012. The study was conducted within a sward of mature tall fescue (*Festuca arundinacea* Schreb.) turfgrass. The turfgrass was maintained at a 4-in. mowing height. Irrigation was applied to prevent drought stress and to ensure that measurements were made under non-water-limiting conditions. ET comparisons were conducted on precipitation-free days and were continued on consecutive days until irrigation was necessary to maintain a plentiful supply of water to the turfgrass.

Three lysimeters were constructed from polyvinylchloride (11.8 in. diameter × 8.7 in. deep). Intact cores of tall fescue were obtained at the study site and placed in each lysimeter. A weather station was placed at the site to record air temperature, wind speed, relative humidity, net radiation, and canopy temperature. Meteorological data from the weather station were used to calculate ET using the FAO-56 Penman-Monteith and Priestley-Taylor empirical models and transpiration using a canopy stomatal conductance model. Three atmometers (ETgage Model E, ETgage Company, Loveland, Colo.) were positioned next to the weather station, and ET data from the atmometer were recorded by the weather station. An eddy covariance system also was installed at the site to measure water vapor fluxes.

Results

Evapotranspiration values from eddy covariance and the Priestley-Taylor model were closest to lysimeter ET, based on mean ET, mean bias error, *t*-tests, and percentage error (Table 1). The FAO-56 Penman-Monteith ET was intermediate, underestimating lysimeter ET by 0.016 in. per day. The FAO-56 Penman-Monteith model also produced a regression line closer to a 1-to-1 relationship with lysimeter ET than the other techniques (Figure 1). The atmometer underestimated lysimeter measured ET by 0.038 in. per day. Not surprisingly, the stomatal conductance model, which reflects water loss only from transpiration and not from evaporation from soil, underestimated lysimeter ET the greatest. A fully closed canopy will typically have 10–20% of ET as soil evaporation. This model predicted that 29.6% of ET was soil evaporation. Under well-watered conditions, such as this study, that value may be realistic.

This research could be strengthened by further investigation of these ET differences under various climatic conditions. The differences observed in this study do not attempt to lessen or strengthen the importance of any one technique; each has its advantages and disadvantages in a given situation. However, one must be aware that differences among ET measurement techniques exist and should be expected with the various techniques.

Table 1. Evapotranspiration measurement technique means and statistical analysis compared with lysimeter-measured evapotranspiration

Measurement technique	n	Mean ET	MBE[1]	%E[2]	*P*[3]
		------- in. per day -------			
Lysimeter	78	0.220	---	---	---
FAO56-PM	78	0.204	-0.016	-4.4	***[4]
Priestley-Taylor	78	0.214	-0.005	1.9	NS
Eddy covariance	70	0.209	-0.006	4.1	NS
Atmometer	78	0.182	-0.038	-15.0	***
Conductance model	42	0.163	-0.036	-29.6	***

[1] Mean bias error.

[2] Mean percentage error.

[3] Probability that ET_x and Lysimeter ET are significantly different from each other based on paired *t*-test at $P < 0.05$.

[4] *** indicates significant difference at $P < 0.001$.

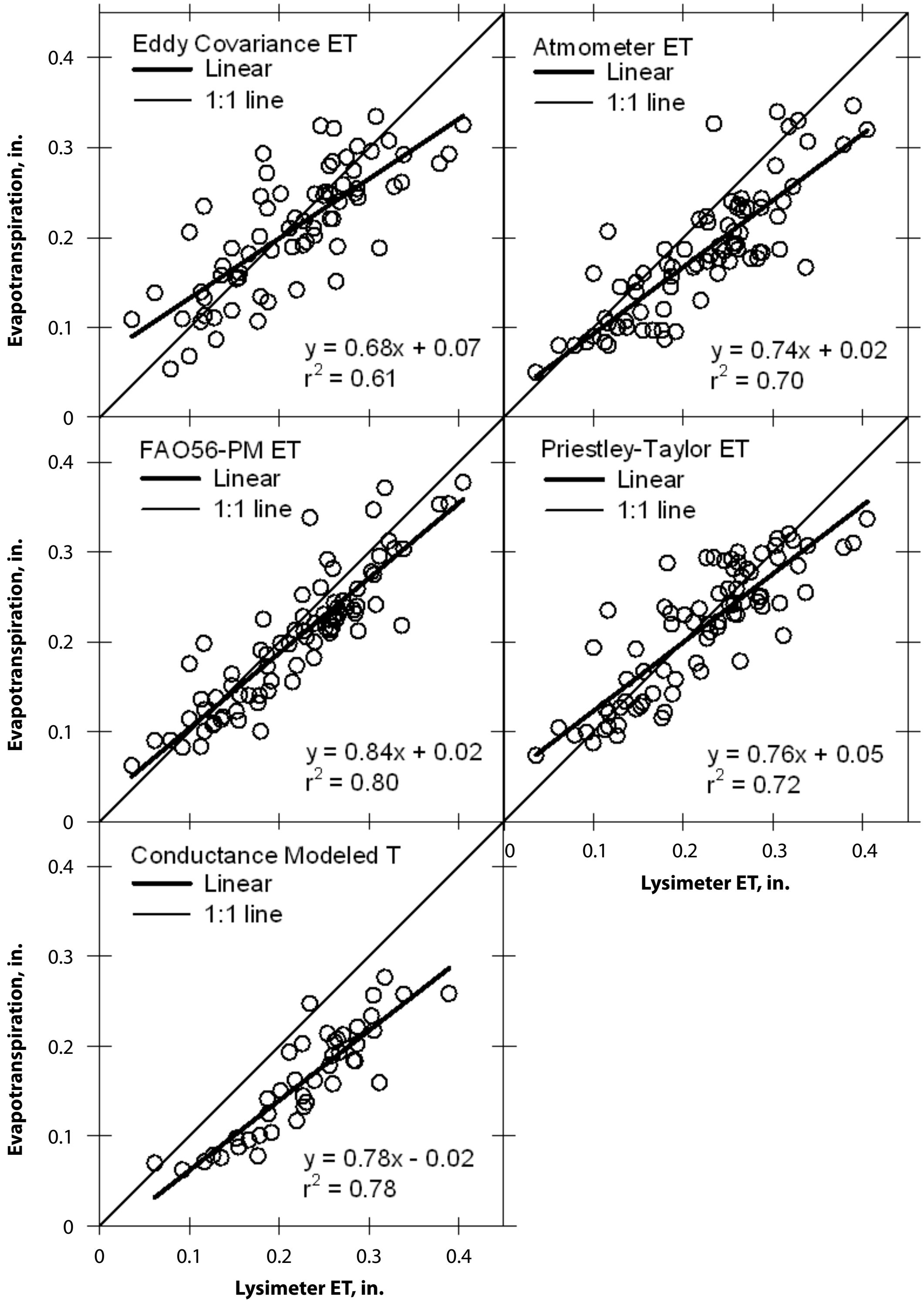

Figure 1. Comparison of evapotranspiration techniques to lysimeter-measured evapotranspiration. Bold line represents the linear regression.

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