Arkansas Turfgrass Report 2008

Michael Richardson, Douglas Karcher, and Aaron Patton, editors










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Conversion Table

Conversions for commonly used units in papers:

1 ft = 0.30 meters = 30 cm
1 inch = 2.54 cm = 25.4 mm
1 ounce = 28.3 g
1 lb = 0.454 kg = 454 g
1 PSI = 6.9 kPa
1 ppm = 1 mg / kg
1 gallon / acre = 9.35 L / ha
1 lb / 1000 ft^2 = 4. 9g / m^2
1 lb / 1000 ft^2 = 48.8 kg / ha
1 lb / 1000 ft^2 = 43.56 lb / acre
1 lb / acre = 1.12 kg / ha
1 bushel / 1000 ft^2 = 3.8 m^3 / ha
°F = (9/5*°C) + 32
°C = 5/9 * (°F-32)

To Our Colleagues and Constituents...

Turfgrass Industry:

As the green industry continues to expand across Arkansas and the nation, the University of Arkansas, Division of Agriculture, has assembled an outstanding team of researchers, extension personnel, and educators that are working to solve some of the most pressing needs of that industry. One segment of that industry that continues to provide a significant impact on the state's economy is the turfgrass industry, which includes lawn care, parks, sports turf, sod production, and golf course maintenance. In a recent survey, it was estimated that the turfgrass and lawn care industry in Arkansas provides over 8,600 jobs and contributes over 336 million dollars annually to the state's economy.

The Arkansas Turfgrass Report is a Research Series that is published annually by the Arkansas Agricultural Experiment Station and features significant findings made by turfgrass scientists over the past year. Although this publication primarily summarizes findings from the research program, it also highlights advancements in teaching and extension programs, as well as significant issues that affect the industry as a whole. It is our desire that this publication will keep our stakeholders abreast of significant changes and advancements that affect our industry.

We are very proud of this second installment of the Arkansas Turfgrass Report, which includes 33 papers from faculty, staff, and graduate students. We hope these findings will enhance your ability to conduct business in an efficient and productive manner.

We would also like to recognize the many organizations, companies, and individuals who have given their time, money, and talents to make our program successful. We are forever indebted to the many people who contribute to this program.

We hope that this publication will be of value to all persons with an interest in the Arkansas green industry.

Mike Richardson Professor	Doug Karcher Associate Professor	Aaron Patton Assistant Professor

University of Arkansas Turfgrass Research Cooperators

The University of Arkansas turfgrass research team is grateful for assistance in the form of donated equipment and product, and research grants from the following associations and companies. Our productivity would be significantly limited without this support.

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North Carolina State University
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Patten Seed Co.
Pennington Seed
Precision Labs
Profile Products Co.
Quail Valley Sod
Seed Research of Oregon
Segway
Spectrum Technologies
Syngenta
The Toro Company
Todd Towery, Pinnacle Country Club
Turfgrass Producers International
University of Florida
Winrock Grass Farm

We regret that some individuals or companies may have been inadvertently left off of this list. If your company has provided financial or material support for the program and is not mentioned above, please contact us so that your company's name can be added in future reports.

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Common Lespedeza Control in Cavalier Zoysiagrass

John Boyd[1]

Additional index words: *Lespedeza striata*

Boyd, J. 2009. Common lespedeza control in cavalier zoysiagrass. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:9-11.

Photo by John Boyd

Common lespedeza in flower

Summary. Common lespedeza is a turfgrass weed that is not controlled by 2,4-D amine. The objective of this study was to determine which postemergence broadleaf herbicides are most effective for control. Herbicide treatments included Lontrel, Spotlight, Manor, Trimec Southern, Confront, Escalade Low Odor, Millenium Ultra, Drive, Turflon Ester, Atrazine, Katana, Monument, Forefront and Dismiss. Spotlight, Confront, Turflon Ester, and Manor alone or in combination products provided complete control of common lespedeza at 71 days after application. Percent control with Millenium Ultra, Trimec Southern, and Forefront was 63, 65, and 83% respectively. Lontrel, Drive, Atrazine, Katana, Dismiss, and Monument were ineffective.

Abbreviations: DAA, days after application

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Common lespedeza (*Lespedeza striata*) (Figs. 1 and 2) is an aggressive summer annual that forms a tough taproot. It is commonly found in areas of thin, poorly fertilized turfgrass. This weed has wiry stems and forms low-growing mats. Common lespedeza is very tolerant of 2, 4-D amine (Yelverton and Warren, 2005), a major component of many postemergence broadleaf herbicides used in turfgrass. In fact, lespedeza seed growers routinely use 2, 4-D amine to control other broadleaf weeds in their fields. The objective of this study was to screen additional herbicide ingredients for their ability to control common lespedeza.

Materials and Methods

Research was conducted at Quail Valley Sod Farm near Little Rock, Arkansas. The treatments (Table 1) were sprayed on 3 July 2007. Experimental design was a randomized complete block with four replications of each treatment. Individual plots were 5 by 10 ft. Activator 90 non-ionic surfactant was added to all treatments at 0.25% v/v. Herbicides were applied at 30 gal/A with a CO_2-powered sprayer at 21 psi. Percent weed control was rated visually on a 0 to 100 scale where 0 = no control and 100 = completely dead weeds.

Results and Discussion

There were significant differences in the level of lespedeza control among the herbicides evaluated (Table 1). Spotlight, Confront, Escalade, Turflon Ester, and Manor were effective for common lespedeza control (Fig. 3). Lontrel and Forefront, which provide excellent control of many legume species, were ineffective for control of common lespedeza. Yelverton and Warren (2005, 2007) also found that products containing fluroxypyr (Escalade and Spotlight) provided excellent control of common lespedeza while Dismiss and Katana were ineffective. Our results for Trimec Southern (80% control) and Manor (100% control) were consistent with the results of Yelverton and Warren (2005) for these two herbicides.

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Yelverton, F.H. and L.S. Warren. 2005. Postemergence common lespedeza control with Spotlight 1.5EC combinations in common bermudagrass. 2005. Turfgrass Research Report: Weed Control and PGR's. Crop Science Department, North Carolina State University, Raleigh, N.C.

Yelverton, F.H. and L.S. Warren. 2007. Postemergence common lespedeza control using flazasulfuron combinations. 2007 Turfgrass Research Report: Weed Control and PGR's. Crop Science Department, North Carolina State University, Raleigh, N.C.

Fig. 1. Common lespedeza.

Fig. 2. Trifoliate leaves of common lespedeza.

Fig. 3. Common lespedeza control with Spotlight at 16 fl oz per acre.

Table 1. Common lespedeza control in Cavalier zoysiagrass.

Treatment	active ingredient	oz product / A	17 DAA[z]	28 DAA	41 DAA	71 DAA
			% Control			
Turflon Ester	triclopyr	16	90 a	99 ab	100 a	100 a
Spotlight	fluroxypyr	8	53 d	53 d	78 cd	100 a
Spotlight	fluroxypyr	16	75 abc	90 ab	100 a	100 a
Spotlight	fluroxypyr	24	74 abc	100 a	100 a	100 a
Manor	metsufluron	0.25	73 abc	83 abc	88 a-d	100 a
Manor	metsufluron	0.5	63 bcd	83 abc	98 ab	100 a
Escalade Low Odor	2,4-D + fluroxypyr + dicamba	32	75 ab	86 ab	95 abc	100 a
Confront	triclopyr + clopyralid	16	58 bcd	80 bc	100 a	100 a
Confront	triclopyr + clopyralid	32	83 a	95 ab	100 a	100 a
Trimec Southern	2,4-D + MCPP + dicamba	64	55 cd	68 cd	80 bcd	83 ab
Forefront	aminopyralid + 2,4-D	24	50 d	53 d	58 ef	65 bc
Millenium Ultra	2,4-D + clopyralid +dicamba	48	53 d	55 d	70 de	63 bc
Aatrex 90DF	atrazine	27	76 ab	58 d	48 f	43 cd
Katana	flazasulfuron	3.0	20 ef	18 efg	23 g	23 de
Drive	quinclorac	16	28 e	33 e	20 g	15 e
Monument	trifloxysulfuron	0.56	15 ef	13 fg	15 gh	0 e
Lontrel	clopyralid	4	10 ef	13 fg	8 gh	0 e
Lontrel	clopyralid	8	5 f	5 g	0 h	0 e
Lontrel	clopyralid	16	15 ef	13 fg	0 h	0 e
Katana	flazasulfuron	1.5	20 ef	13 fg	13 gh	0 e
Dismiss	sulfentrazone	12	20 ef	30 ef	0 h	0 e
CV			25	21	21	26
LSD 0.05			17	16	16	22

[z]Days after application.

Dormant Seeding Bermudagrass into an Overseeded Stand of Ryegrass Turf

Photo by Mike Richardson

Dew on dormant-seeded bermudagrass plots

Will Jellicorse[1], Mike Richardson[1], Aaron Patton[2], John McCalla[1], John Boyd[3] and Doug Karcher[1]

Additional index words: seeding date, seeded bermudagrass, chemically transition

Jellicorse, W., M. Richardson, A. Patton, J. McCalla, J. Boyd, and D. Karcher. 2009. Dormant seeding bermudagrass into an overseeded stand of ryegrass turf. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:12-16.

Summary. It has been demonstrated that improved cultivars of seeded bermudagrass can be dormant-seeded during the winter and this approach may provide turf managers with an alternative means to renovate damaged areas of turf. However, bermudagrass sports field are often overseeded with a cool-season grass during times of dormancy and the overseeded grass may prevent establishment of the dormant-seeded bermudagrass. This project was conducted to determine if dormant seeding into a stand of overseeded turf is an effective means of establishment. 'Riviera' bermudagrass was seeded on three different dates, including March (dormant seeding), April, and June. In addition, six herbicides, including an untreated control, were applied to each of those seeding-date treatments to selectively remove competition from the perennial ryegrass. Bermudagrass establishment was improved by herbicide application, but was not affected by seeding date. Roundup and Revolver provided the highest bermudagrass coverage compared to the other herbicide treatments. Establishment of seeded bermudagrass into an overseeded stand of perennial ryegrass turf was improved with herbicide use, regardless of the seeding date.

Abbreviations: PGR (plant growth regulator)

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Bermudagrass (*Cynodon* spp.) sports fields are often overseeded with perennial ryegrass (*Lolium perenne*) to maintain high-quality playing conditions during the dormant season. However, overseeded perennial ryegrass can be a persistent and problematic weed, especially in the transition zone (Horgan and Yelverton, 2001). To combat the persistence of overseeded perennial ryegrass, turf managers often choose to chemically remove (transition) the cool-season grass when bermudagrass initiates growth in the spring. Some of the commonly used herbicides for removing overseeded grasses are from the sulfonylurea class, including Revolver (foramsulfuron), Monument (trifloxysulfuron), and Katana (flazasulfuron) (Willis et al. 2007; Yelverton et al. 2003). Previous studies have demonstrated that seedling bermudagrass is relatively tolerant of a range of post-emergent herbicides, but it is unclear how these herbicides might interact when applied during the establishment of a seeded bermudagrass into an overseeded turf.

Studies have shown that dormant seeding of bermudagrass is an effective means of establishment (Shaver, 2006), with successful establishment occurring when seeding bermudagrass as early as February in Arkansas. However, those studies were conducted on non-overseeded turf and there have been no studies that have attempted dormant seeding of bermudagrass in a turf that has been overseeded with a cool-season grass such as perennial ryegrass. The objectives of this research are to determine if dormant seeding is an effective method of establishing seeded bermudagrass in a turf overseeded with perennial ryegrass and to determine the effects of transition herbicide applications on establishment of seeded bermudagrass.

Materials and Methods

This research was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville, Arkansas, on a sandcapped area where six inches of medium-coarse sand was placed over the native silt loam soil. This site has been developed to simulate a sand-capped athletic field. Prior to initiating the studies, an area of Tifway bermudagrass was eradicated using Roundup near the end of the summer in 2007. The entire area was seeded with Integra perennial ryegrass on 12 October 2007 at a rate of 12 lb pure live seed/1000 ft^2. The overseeded perennial ryegrass was maintained as a simulated athletic field, with a mowing height of 0.75 inches.

Plots were seeded with 'Riviera' bermudagrass at a rate of 1.0 lb pure live seed/1000 ft^2. Three seeding dates were tested in this study, including 6 March, 17 April, and 19 June, 2008. The March seeding date was considered a dormant seeding date, April was considered a spring seeding date, and June considered a summer, post-transition seeding date. Seed was applied using a drop seeder (Gandy Company, Owatonna, Minn.) and then topdressed with 0.25 inch of dry sand. Plots were irrigated twice daily until bermudagrass reached an acceptable percent of emergence. Irrigation was then reduced to three times a week the rest of the growing season.

Herbicide treatments included five herbicides (Roundup, Katana, Revolver, Monument, Kerb) and an untreated control (Table 1). With the exception of Roundup, the herbicide treatments were chosen based on their use in the turfgrass industry as a means of chemically removing perennial ryegrass from a bermudagrass turf. These herbicides were all applied on 25 May 2008, a timing that would reflect a typical time to remove perennial ryegrass from an overseeded athletic field. The Roundup treatment was applied seven days prior to each seeding date to remove all competition from the ryegrass prior to seeding the bermudagrass.

The dates for first germination were determined by daily visual evaluation of each seeded plot. Two weeks after germination was observed, a seedling stand count was determined for each specific treatment. Small rings were made from PVC pipe (3-inch diam.) and were tossed into each plot and seedlings within each ring were counted. The rings were tossed four times into each plot with the average of each seedling count taken.

Four weeks after germination, percentage bermudagrass coverage was determined and continued until full coverage was reached or until bermudagrass dormancy. A 2 by 2-ft grid was constructed that contained 121 intersects of string. The grid was randomly tossed into each plot and the presence or absence of bermudagrass was determined at each intersection and converted into a coverage percentage. The experimental design for the study was a split-plot design with four replications. The whole-plot treatment was seeding date, and plot size was 15 by 15 ft. Herbicide treatments were applied as the split-plot in 5 by 5-ft plots.

Results and Discussion

There was a significant herbicide x seeding date interaction for both dates of first germination (Fig. 1) and seedling density (Fig. 2). For both the dormant (March) and spring (April) seeding dates, germination was first observed in the Roundup-treated plots (Fig. 1). Bermudagrass germination also occurred earlier in plots treated with Katana, Revolver, Kerb, and Monument compared to the untreated control, but germination in those treatments was delayed compared to the Roundup treatment. Roundup-treated plots had the highest seedling density in the dormant-seeded (March) plots but were not statistically different from Revolver, Monument, and Katana in the April and June seeding dates (Fig. 2). Kerb reduced seedling density for all seeding dates compared to the Roundup and was only different from the untreated plots on the March seeding date (Fig. 1). Kerb tends to be persistent in the soil and will affect any plant tissue with which the compounds come in contact. Therefore, seedling development may be negatively affected. Williams and Burrus (2002) suggested that Kerb, when compared to plant growth regulators (PGRs), was an effective means of renovating from perennial ryegrass to seeded bermudagrass, but Kerb-treated plots didn't reach full coverage.

Bermudagrass establishment was significantly influenced by herbicide application but was not affected by seeding date. There was no seeding date x herbicide interaction. All herbicides enhanced turfgrass coverage over the untreated control (Fig. 3). Roundup and Revolver provided the highest bermudagrass coverage when compared to other treatments. At the end of the data collection period, the sulfonylurea herbicides and Roundup provided greater turfgrass coverage than the untreated control and Kerb; however, the Kerb enhanced bermudagrass establishment when compared to the untreated control. Roundup was the most effective treatment as it eliminated all competition from the ryegrass (Fig. 4) and allowed normal germination and development of the bermudagrass, regardless of seeding date.

Regardless of the seeding date, seeding into an overseeded stand of turf will not be an effective means of establishment without some form of herbicide use; however, all of the sulfonylureas improved bermudagrass establishment when compared to the untreated control and were more effective than Kerb at reducing ryegrass competition and enhancing bermudagrass establishment. Applying Roundup prior to seeding resulted in an excellent stand of bermudagrass with all seeding dates, including the dormant seeding, due to the fact that competition was completely removed.

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Williams, D.W. and P.B. Burrus. 2004. Renovation of perennial ryegrass fairways with seeded bermudagrasses. USGA Turfgrass and Environmental Research Online 1(7):1-6.

Willis, J.B., D.B. Ricker, and S.D. Askew. 2007. Sulfonylurea herbicides applied during early establishment of seeded bermudagrass. Weed Tech. 21:1035-1038.

Yelverton, F. 2003. A new herbicide for weeds in bermudagrass and zoysiagrass. Golf Course Mgmt. 71:119-122.

Table 1. Herbicide treatments used in study.

Herbicide	Trade name	Rate	Application timing
		oz / acre	
glyphosate	Roundup	32	7 days before seeding
foramsulfuron	Revolver	12	25-May
trifloxysulfuron	Monument	0.2	25-May
pronamide	Kerb	16	25-May
flazasulfuron	Katana	2	25-May

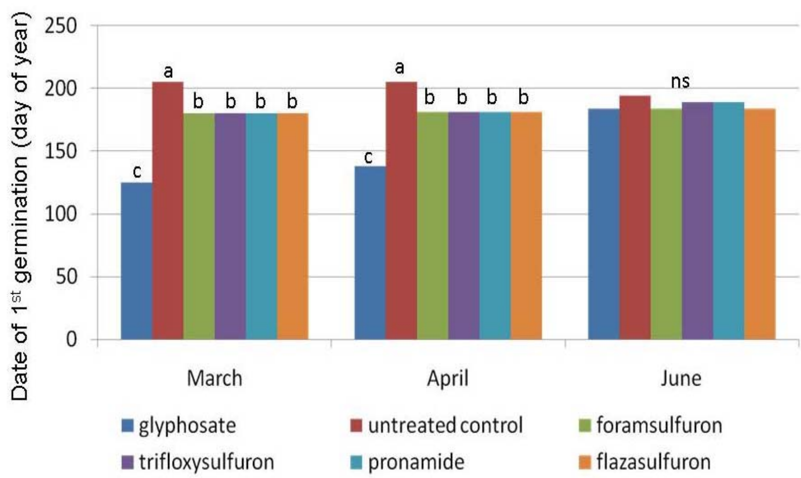

Fig. 1. Herbicide x seeding date effects on date (day of year) of first observed germination of bermuda -grass seedlings. Different letters within a seeding date indicate a significant effect of herbicide (P=0.05). ns – not significant

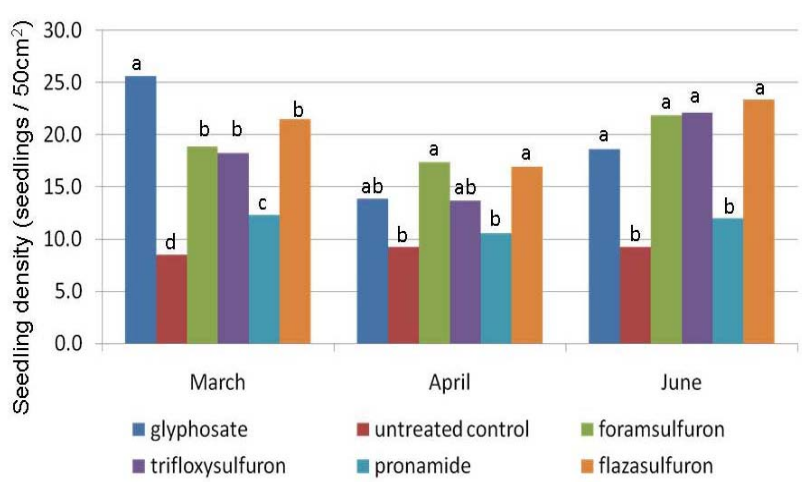

Fig. 2. Herbicide x seeding date effects on bermudagrass seedling stand density at two weeks after first germination was observed. Different letters within a seeding date indicate a significant effect of herbicide (P=0.05).

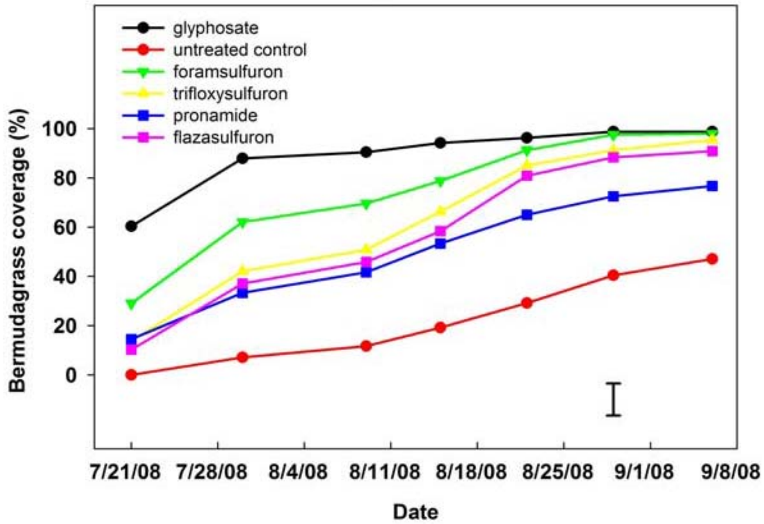

Fig. 3. Bermudagrass coverage as affected by date and herbicide treatment. Error bar can be used to separate differences in date or herbicide (LSD=0.05).

Fig. 4. Perennial ryegrass control with Roundup in dormant seeding treatments. Photo taken 19 March 2008.

Light Requirement for Emergence of Turf-type Bermudagrass Seed

Will Jellicorse[1], Mike Richardson[1], Aaron Patton[2], and John McCalla[1]

Additional index words: percent shade, reduced light, shade tolerance

Jellicorse, W., M. Richardson, A. Patton, and J. McCalla. 2009. Light requirement for emergence of turf-type bermudagrass seed. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:17-22.

Photo by Aaron Patton

Unhulled bermudagrass seed

Summary. In the transition zone, improved cultivars of seeded bermudagrass are becoming increasingly popular. Recent studies suggest that competition for light can significantly reduce germination, but there has been limited work on the light requirements for emergence of seeded bermudagrass. The objective of the present study is to determine how reduced light affected germination and emergence of three bermudagrass cultivars, including Transcontinental, Riviera, and SR-5990. Twenty-five seeds of each of the three cultivars were planted into two-inch diameter plastic pots. Three different types of shade cloth (30, 60, and 90% shade) were placed on top of each pot to reduce light and were compared to a non-shaded control. Emergence of seedlings was monitored for a 3-wk period to determine the effects of shading on germination and emergence. Shade significantly reduced the emergence of all cultivars. However, the emergence of Transcontinental was greatly inhibited by shade.

Abbreviations: DAS (days after seeding)

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Newer cultivars of seeded bermudagrass (*Cynodon dactylon*) are becoming some of the most popular turfgrasses in the transition zone due to their ease of establishment and excellent performance. For turf managers in the transition zone and southern United States, establishing or renovating a sports field or high-traffic area can be frustrating as optimal planting periods often coincide with periods of high use. It has been demonstrated that improved cultivars of seeded bermudagrass can be dormant-seeded during the winter (Shaver et al., 2006) and this approach may provide turf managers with an alternative means to renovate damaged turf areas.

Bermudagrass sports fields are often overseeded with a cool-season turfgrass in the dormant months to maintain a high-quality playing surface with an aesthetically pleasing green color. While winter overseeding with cool-season grasses is a well-accepted practice, the presence of an actively growing turf presents some limitations that are not conducive to seed germination. Competition for water, nutrients, oxygen, and light is the main limitation for germination to occur in an actively growing stand of turf. Of these four resources, light is likely the most limiting factor for adequate germination to occur. Shin et al. (2006) reported that seeded seashore paspalum germination is greatly influenced by light and temperature.

On a golf course or athletic field, water and nutrients can be made readily available for young seedlings to establish, but light is a limiting factor and is usually impractical to physically apply to the turf. In an overseeded stand of turf, light is extremely restricted from reaching the soil surface. In a mature overseeded turf, when temperatures are sufficient for bermudagrass seed germination, the overseeded turf will prevent light from entering the canopy and likely reduce the seed germination. Zuk et al. (2005) found that with lower light levels and lower temperatures, there was a reduction in zoysiagrass seedling germination and establishment.

Recent findings show that emergence of improved varieties of seeded bermudagrasses can occur at temperatures under 60ºF (Shaver et al., 2006); however, there has been limited work on the light requirements for emergence on newer varieties of seeded bermudagrass. Therefore, the objective of the study is to determine how reduced light conditions affect the germination and emergence of three varieties of seeded bermudagrass.

Materials and Methods

A growth chamber study (Conviron E7) was conducted at the University of Arkansas, Rosen Alternative Pest Control Center in Fayetteville, to determine the effects of reduced light on emergence of seeded bermudagrass. Three bermudagrass cultivars, Transcontinental, Riviera, and SR-5990, were evaluated for seedling emergence under varying light regimes. These cultivars were selected based on previous work that demonstrated they had different levels of shade tolerance as a mature turf (Baldwin et al., 2008). Twenty-five seeds of each bermudagrass cultivar were planted into two-inch-diameter plastic pots that contained a silt-loam soil. The soil was sterilized by fumigating with methyl bromide to ensure that there was no weed seed contamination. Cheese cloth was placed in the bottom of each container to ensure that the soil did not move out of the pot during watering. Four different shade treatments were used in this study, including 30%, 60%, and 90% shade and a non-shaded control. Shade rings that would fit directly over the pots were constructed out of PVC pipe (2.5-inch diam.). Shade cloth was stretched over the top of the PVC rings and cinched tightly to the outside of the ring with plastic fasteners (Fig. 2). After applying the seed to the soil surface, each pot received a light application of sand (1-2 mm) to ensure good seed-to-soil contact. Pots were placed in plastic trays and watered daily by allowing water to wick up through the soil profile and wet the growing media.

Light in the growth chamber was provided by a combination of fluorescent (Sylvania High-Output Fluorescents: F48T12/D/HO, 34 watt) and incandescent (Phillips 23096-1, 40 watt) bulbs.

Photon flux density data were collected through the shade cloths using a quantum foot-candle meter (Field Scout, Spectrum Technologies, Inc. Plainfield, Ill.). The photon-flux density readings of the control, 30%, 60%, and 90%, were 160 (100% of control), 100 (62.5%), 32 (20.0%), and 19 (11.9%) µmol m^{-2} s^{-1}, respectively. Temperatures were maintained at a constant 86°F and light was set on a 12 h day/12 h night schedule. Every two days, pots were checked for seedling emergence and emerged seedlings were removed after counting. The experimental design for this experiment was a randomized complete block design with four replications of each cultivar and shade treatment.

Results and Discussion

Shade and cultivar had a significant effect on seedling emergence on most evaluation dates, but there was no shade x cultivar interaction observed in this study. As such, the results will be presented and discussed as main effects only. Beginning at five days after seeding, shading had a negative effect on emergence of bermudagrass seedlings (Fig. 1). The slowest emergence was seen with the 60% and 90% shade treatments, while the 0% (control) and 30% shade treatments had similar emergence.

Emergence was significantly affected by cultivar at 4, 5, and 6 days after seeding (DAS). Riviera and SR9554 had greater emergence at 4, 5, and 6 DAS compared to Transcontinental (Fig. 2). The lack of a cultivar x shade interaction suggests that all cultivars were equally affected by reduced light and that differences in shade tolerance at maturity (Baldwin et al., 2008) may not affect germination under reduced light. These findings suggest that bermudagrass seed will be less capable of emerging when a dense stand of turf is present due to reduced light. However, some emergence was observed at the highest shade levels (Fig. 1), suggesting that turf managers can get emergence in areas that have weak or thin turf. In a previous investigation, Transcontinental was noted for having enhanced shade tolerance at maturity compared to other varieties of seeded bermudagrass (Baldwin et al., 2008). While Transcontinental took longer to reach a sufficient level of emergence, this cultivar could have the ability to sustain growth under low light once fully emerged. In conclusion, this research indicates that Riviera, Transcontinental, and SR9554 are dependent on light for emergence; therefore, successful establishment in an overseeded athletic field or fairway may be difficult due to a reduction in light at the soil surface.

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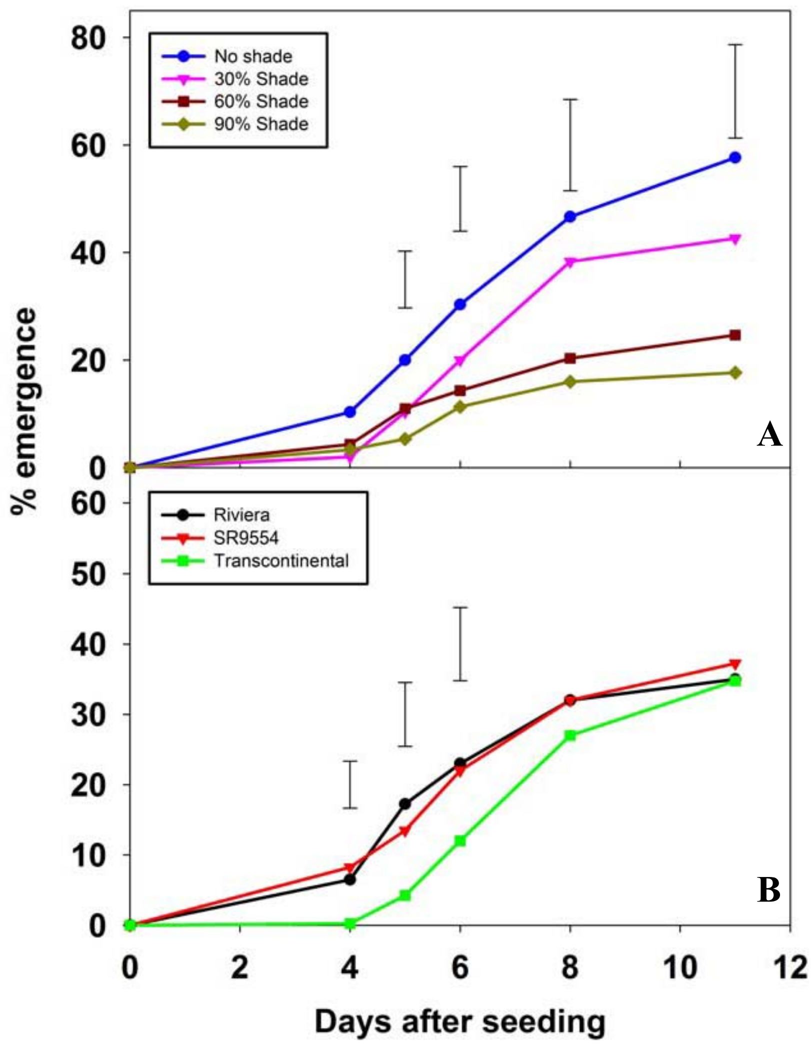

Fig. 1. Effects of varying levels of shade (A) and cultivar (B) on emergence of bermudagrass seedlings at 86°F. On dates when significant differences were observed, error bars can be used to compare treatments.

Fig. 2. Various intensities of shade cloth were stretched over the top of PVC rings and cinched tightly to the outside of the ring with plastic fasteners. These were then placed over the pots containing soil and bermudagrass seed.

Table 1. Analysis of variance results, testing the effects of cultivar and shade intensity on emergence of bermudagrass seedlings.

Treatment effects	4	5	6	8	11
	------------------------	days after seeding	------------------------		
Rep	ns	ns	ns	ns	ns
Cultivar	*	*	*	ns	ns
Shade	ns	*	*	**	***
Cultivar x shade	ns	ns	ns	ns	ns

* = $p < 0.05$
** = $p < 0.01$
*** = $p < 0.001$
ns = not significant

Effects of Mowing Height and Traffic on Germination of Dormant-Seeded Bermudagrass in an Overseeded Situation

Photo by Aaron Patton

Arkansas football team practices on Riviera bermudagrass

Will Jellicorse[1], Mike Richardson[1], Aaron Patton[2], Doug Karcher[1], and John McCalla[1]

Additional index words: competition, establishment

Jellicorse, W., M. Richardson, A. Patton, D. Karcher, and J. McCalla. 2009. Effects of mowing height and traffic on germination of dormant-seeded bermudagrass in an overseeded situation. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:22-24.

Summary. Bermudagrass sport fields in the transition zone are often overseeded during the winter months to provide an actively growing turf while the bermudagrass is dormant. While winter overseeding is a well-accepted practice in the turf industry, there are negative effects to germination with the presence of actively growing turf. Dormant seeding bermudagrass has been shown to be an effective means to renovate areas of the field that have been thinned due to excessive wear and traffic. Unfortunately, the field may still be receiving traffic from play while seedlings are germinating. This project was conducted to investigate how different mowing heights and traffic treatments affect germination of dormant-seeded bermudagrass. 'Riviera' bermudagrass was dormant-seeded into an overseeded perennial ryegrass turf at 1.0 lb pure live seed/1000 ft^2 on 6 March 2008. Three mowing height treatments and four traffic timing treatments were evaluated for their effects on establishment of the dormant-seeded bermudagrass. Bermudagrass germination and establishment was almost nonexistent in this turf area and was not enhanced by any of the mowing height or traffic treatments. Additional studies associated with this project have demonstrated that ryegrass competition must be removed to successfully establish bermudagrass via dormant seeding.

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Bermudagrass (*Cynodon dactylon*) sports fields are often overseeded with a cool-season turfgrass in the dormant months to maintain a high-quality playing surface with an aesthetically pleasing green color. Perennial ryegrass (*Lolium perenne*) has been the most commonly used turf species for overseeding applications due to its rapid establishment rate, high wear tolerance, ability to tolerate a range of mowing heights, medium to fine texture, and gradual spring transition (Batten et al., 1981; Ward et al., 1974; Schmidt and Shoulders, 1980). While winter overseeding with cool-season grasses is a well-accepted practice, the presence of an actively growing turf presents some limitations that are not conducive to seed germination. Competition for water, nutrients, oxygen and light is the main limitation for germination to occur in an actively growing stand of turf.

For turf managers in the transition zone and southern states, establishing or renovating a field or high-traffic area can be frustrating, as optimal planting periods often coincide with periods of high use. It has been demonstrated that improved cultivars of seeded bermudagrass can be dormant-seeded during the winter (Shaver et al., 2006) and this approach may provide turf managers with an alternative means to renovate damaged areas of turf. Although bermudagrass is well-known for its traffic tolerance at maturity, there has been little work to understand the effect that traffic or wear will have during establishment. Zuk et al. (2005) concluded that trafficking zoysiagrass after seeding reduces zoysiagrass (*Zoysia japonica*) emergence and cover. The objective of this research was to determine the effects of mowing height and traffic on germination and seedling development of dormant-seeded bermudagrass in an overseeded situation.

Materials and Methods

The study was conducted at the University of Arkansas, Agricultural Research and Extension Center in Fayetteville. The site is a simulated, sand-capped athletic field where six inches of medium-coarse sand has been placed over the native silt loam soil. The area was overseeded with Integra perennial ryegrass at a rate of 12 lb pure live seed/1000 ft^2 on 12 October 2007. Plots were seeded with Riviera bermudagrass at a seeding rate of 1 lb pure live seed/1000 ft^2 on 6 March 2008.

Three mowing-height treatments were applied to the area and were consistent with typical mowing heights of sport complexes in the region. The mowing heights were 0.5, 1.0, and 1.5 inch and were replicated three times. Four traffic treatments were applied using a Cady traffic simulator (Henderson et al., 2005). The traffic treatments included: (1) traffic for four weeks before expected germination, (2) traffic for four weeks after expected germination, (3) traffic for four weeks both before and after expected germination, 4) and no traffic.

The plots were seeded on 6 March, which is considered a dormant seeding date. Two weeks after germination, a seedling stand count was determined for the various mowing heights and traffic treatments in a companion study planted at the same site. Small rings were made from three inches in diameter PVC pipe to be tossed four times into each plot. Then, seedlings within each ring were to be counted. Four weeks after germination, percent coverage was determined for that specific treatment. Percent coverage was determined by taking visual assessments, which were then measured against the findings of the grids; however, because germination of bermudagrass was almost nonexistent, neither seedling counts nor percent coverages were used. The experimental design was a strip plot with 3 replications. Plot size for traffic treatments was 5 by 15 ft and for mowing height treatments was 5 by 20 ft.

Results and Discussion

Minimal germination was observed among the plots in this trial and there were no discernable differences between any of the mowing heights and traffic treatments (data not shown). The perennial ryegrass remained competitive throughout the spring and inhibited germination in all plots. As noted in a companion study, germination of seeded bermudagrass is significantly inhibited by reduced light (Jellicorse et al., 2009b) and establishment could have been enhanced by the use of a selective herbicide such as foramsulfuron (Jellicorse et al., 2009a). The findings from this study suggest that the existing stand of perennial ryegrass must be removed for germination and establishment to occur. Furthermore, reducing the turfgrass canopy by lowering the mowing height to as low as 0.5 inch or by thinning the turf through up to eight weeks of traffic had no effect on germination and establishment of a dormant-seeded bermudagrass.

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Drought Tolerance of Tall Fescue and Bluegrass Cultivars – 2nd Year Data

Photo by Doug Karcher

Differences in drought tolerance among bluegrass and tall fescue varieties growing in a rain-out shelter

Doug Karcher[1], Mike Richardson[1], and Josh Summerford[1]

Additional index words: hybrid bluegrass, Kentucky bluegrass, digital image analysis, lawn, irrigation, rain-out shelter

Karcher, D., M. Richardson, and J. Summerford. 2009. Drought tolerance of tall fescue and bluegrass cultivars–2nd year data. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:25-28.

Summary. Newer cultivars of tall fescue, Kentucky bluegrass, and hybrid bluegrass may have improved drought tolerance and expanded the range of cool-season turfgrasses for home lawn use in Arkansas. The objective of this research is to compare the drought tolerance of 42 cultivars of these species when maintained as a lawn. Cultivars were established in fall 2006 and dried down during the summers of 2007 and 2008 in a rain-out shelter, which prevented rainfall from reaching the plots. Green turf coverage was evaluated twice weekly as the cultivars were subjected to drought stress. In 2008, the amount of time after irrigation was withheld until green turf coverage dropped to 50% varied by over three weeks among cultivars. On average, the tall fescue cultivars were the most drought tolerant and Kentucky bluegrass the least, while there was no clear trend in drought tolerance among the hybrid bluegrass cultivars. These results are similar to those reported in 2007.

Abbreviations: KBG, Kentucky bluegrass; HBG, hybrid bluegrass; TF, tall fescue

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A desirable trait of cool-season lawn grasses, such as tall fescue (TF, *Festuca arundinacea*) and Kentucky bluegrass (KBG, *Poa pratensis*), is that they stay relatively green throughout most of the year and do not go into complete winter dormancy like bermudagrass (*Cynodon spp.*) or zoysiagrass (*Zoysia spp.*). The use of cool-season grasses for Arkansas lawns has been limited to northern regions of the state due to their poor heat- and drought-tolerance relative to warm-season grasses. In recent years, hybrid bluegrass (HBG) cultivars, which are crosses between Kentucky bluegrass and Texas bluegrass (*P. arachnifera*), have been released as a cool-season lawn turf option with improved heat and drought tolerance (Abraham et al., 2004). In addition, it has recently been de-monstrated that there is variation in drought tolerance among cultivars within tall fescue (Karcher et al., 2008) and Kentucky bluegrass species (Richardson et al., 2008). Identifying cultivars of tall fescue, Kentucky bluegrass, and hybrid bluegrass with excellent drought tolerance may expand the use of cool-season turfgrasses for lawns in Arkansas. Research was initiated recently to compare the relative drought tolerance of various tall fescue, Kentucky bluegrass, and hybrid bluegrass cultivars (Karcher et al., 2008a). The following is a summary of the second year (2008) of drought tolerance data from that study.

Materials and Methods

This research was conducted at the Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. Forty-two cultivars of tall fescue, Kentucky bluegrass, or hybrid bluegrass (Table 1) were seeded into three replicate plots in the fall of 2006 on a native soil experimental area that was constructed under a rain-out shelter. The experimental area was maintained as a home lawn and was mowed weekly at a 2-inch height of cut. On 26 June 2008, the experimental area was saturated with 2 inches of irrigation to ensure uniform soil moisture across the plots. Immediately thereafter, drought stress was initiated by discontinuing irrigation and activating the rain-out shelter so that an automated, sliding roof would cover the plots, keeping them dry during rainfall events. Digital images were collected from each plot regularly during drought stress to evaluate green turf coverage over time and determine the drought-tolerance characteristics of each cultivar. Non-linear regression (using a variable slope, Sigmoid curve) was performed on the digital image analysis data to predict Days_{50} values for each cultivar, which are the estimated number of days after irrigation was withheld until green turf coverage decreased to 50%. A complete description of digital image analysis and statistical methods is presented elsewhere (Karcher et al., 2008b).

Results and Discussion

The 42 cultivars tested in this trial were ranked from most to least drought tolerant (Table 1). The number of days after irrigation was withheld until green turf coverage dropped to 50% ranged from 60 d for Tulsa tall fescue to 37 d for Mallard Kentucky bluegrass. This range of greater than three weeks (23 d) is significant when considering that a rainfall event would be probable during this period on a non-irrigated lawn in Arkansas. In such a case, cultivars in this trial that were most drought tolerant would be much more likely to retain acceptable green turf coverage between rainfall events compared to the more drought-sensitive cultivars and not need supplemental irrigation. There were eight other tall fescue cultivars that had statistically similar drought tolerance as Tulsa (Fig. 1), including 2nd Millennium, which was the top-performing variety in 2007. There were two cultivars with drought tolerance as poor as Mallard: P707 and Champlain Kentucky bluegrass (Fig. 1).

In general, the tall fescue cultivars were more drought tolerant (higher Days_{50} values) than the bluegrasses. Twenty-seven of the 29 most drought-tolerant cultivars were tall fescue whereas only one of the six least drought-tolerant cultivars was tall fescue. All of the Kentucky bluegrass cultivars were among the bottom half of those tested with regard to drought tolerance.

There was not a clear trend in drought tolerance among hybrid bluegrass cultivars with one of the four (TB 390) having a Days$_{50}$ value among the top-performing half of the cultivars tested. These results are similar to those reported from the 2007 growing season (Karcher et al. 2007).

Conclusions

These results demonstrate that there are differences in drought tolerance among cool-season grasses used in Arkansas lawns. Therefore, drought-tolerance screening should be performed routinely on these species so that cultivars may be selected that are best adapted for lawns where irrigation in not available or is limited.

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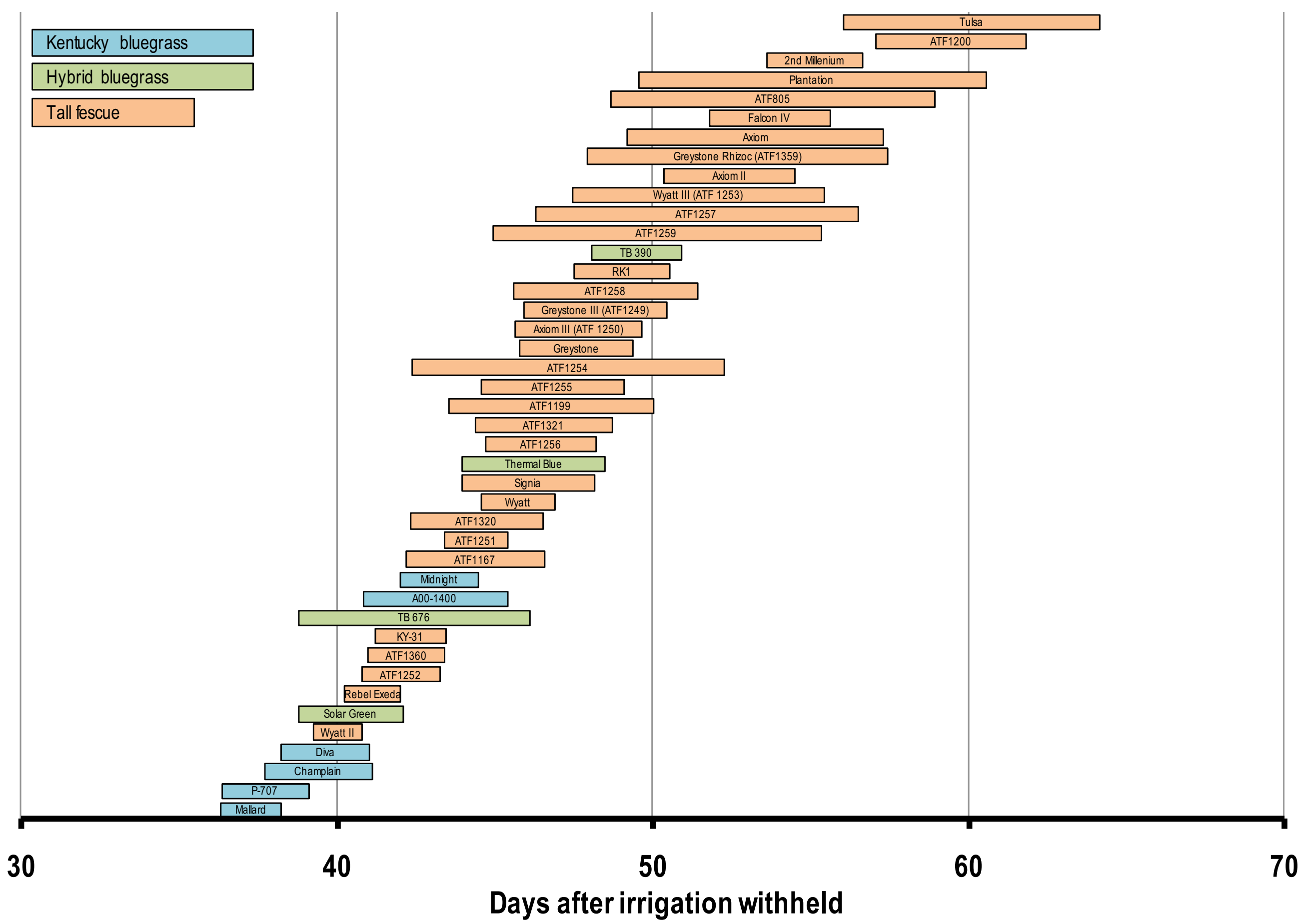

Fig. 1. Confidence intervals (95%) for the number of days after irrigation is withheld before cultivars reach 50% green cover. Cultivars with overlapping bars are not significantly different.

Table 1. Drought tolerance ranking of tall fescue, Kentucky bluegrass, and hybrid bluegrass selections based on the $Days_{50}$ values, the predicted number of days after irrigation is withheld when 50% green turf cover is reached.

Rank	Selection	Species[z]	$Days_{50}$
1.	Tulsa	TF	60.1
2.	ATF1200	TF	59.5
3.	2nd Millenium	TF	55.1
4.	Plantation	TF	55.1
5.	ATF805	TF	53.8
6.	Falcon IV	TF	53.7
7.	Axiom	TF	53.2
8.	Greystone Rhizoc (ATF1359)	TF	52.7
9.	Axiom II	TF	52.4
10.	Wyatt III (ATF 1253)	TF	51.4
11.	ATF1257	TF	51.4
12.	ATF1259	TF	50.1
13.	TB 390	HBG	49.5
14.	RK1	TF	49.0
15.	ATF1258	TF	48.5
16.	Greystone III (ATF1249)	TF	48.2
17.	Axiom III (ATF 1250)	TF	47.6
18.	Greystone	TF	47.6
19.	ATF1254	TF	47.3
20.	ATF1255	TF	46.8
21.	ATF1199	TF	46.8
22.	ATF1321	TF	46.6
23.	ATF1256	TF	46.5
24.	Thermal Blue	HBG	46.2
25.	Signia	TF	46.1
26.	Wyatt	TF	45.7
27.	ATF1320	TF	44.4
28.	ATF1251	TF	44.4
29.	ATF1167	TF	44.4
30.	Midnight	KBG	43.2
31.	A00-1400	KBG	43.1
32.	TB 676	HBG	42.5
33.	KY-31	TF	42.3
34.	ATF1360	TF	42.2
35.	ATF1252	TF	42.0
36.	Rebel Exeda	TF	41.1
37.	Solar Green	HBG	40.4
38.	Wyatt II	TF	40.0
39.	Diva	KBG	39.6
40.	Champlain	KBG	39.4
41.	P-707	KBG	37.7
42.	Mallard	KBG	37.3

[z] HBG = hybrid bluegrass, KBG = Kentucky bluegrass, and TF = tall fescue.

Application Timings of Cascade Plus Wetting Agent Affect Season-Long Control of Localized Dry Spot

Photo by Doug Karcher

Irregular dew patterns on putting green turf afflicted with localized dry spot

Doug Karcher[1] and Josh Summerford[1]

Additional index words: creeping bentgrass, sand-based, putting green, turf quality

Karcher, D. and J. Summerford. 2009. Application timings of Cascade Plus wetting agent affect season-long control of localized dry spot. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:29-33.

Summary. Cascade Plus is a commonly used wetting agent for treating localized dry spot (LDS) on putting greens; however, the suggested application timing on its current label may not provide season-long LDS control in the transition zone. The objective of this research was to determine how various Cascade Plus application timings affected season-long LDS control and turf quality on a sand-based putting green. Three Cascade Plus application timings (7 days after initial treatment (DAIT); 60 DAIT; and 7, 60, 90, and 120 DAIT) and an untreated control were applied on an 'SR 1020' creeping bentgrass putting green from May through September of 2008. Visual quality and LDS incidence were evaluated bi-weekly throughout the 2008 growing season. Cascade Plus applications at 60 DAIT significantly reduced LDS incidence and improved turf quality compared to applications at 7 DAIT and the untreated control. Late-season applications did not result in excessive phytotoxicity when the treatments were applied during early morning hours and immediately irrigated following application.

Abbreviations: DAIT, days after initial treatment; LDS, localized dry spot

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Localized dry spot is a prevalent problem on golf course putting greens throughout world. The most common treatment of LDS is wetting agent application and there are many commercially available products that are effective in reducing LDS symptoms (Karcher et al., 2008; Karcher et al., 2009). Cascade Plus is a wetting agent that is commonly used to treat LDS and, according to label instructions, should be applied early in the growing season in sequential applications (7 to 10 d apart) for season-long LDS control (Precision Laboratories, Inc., 2009). However, previous research has demonstrated that this timing does not provide season-long LDS control in a transition zone climate where LDS pressure is intense (Karcher et al., 2008). Successive applications of Cascade Plus later in the growing season may be necessary for season long control of LDS in transition zone and more southern climates. The objective of this research is to determine the effects of various application timings of Cascade Plus on season-long control of localized dry spot and turf quality on a sand-based putting green.

Materials and Methods

This experiment was conducted from May through October in 2008 at the Arkansas Agricultural Research and Extension Center in Fayetteville on a creeping bentgrass (*Agrostis stolonifera* cv. SR 1020) putting green built according to United States Golf Association specifications. The green was maintained under typical golf course conditions for the region (Table 1).

Cascade Plus application timing treatments consisted of the label timing, two experimental timings, and an untreated control (Table 2). Each treatment was applied to five replicate plots (6 by 6 ft) and irrigated with 0.25 inch of water following application. Initial treatments were applied on 9 May 2008 and all treatments were applied with a CO_2-powered boom sprayer.

Treatments were evaluated for LDS incidence and visual turf quality. Localized dry spot incidence was rated biweekly as a visual estimate of the percentage within each plot affected with LDS. Visual quality was rated biweekly using a 1 to 9 scale, where 9 represents ideal dark green, dense, uniform turf and 1 represents dead turf.

Results and Discussion

Localized dry spot. Treatments did not affect LDS incidence early in the growing season due to an abundance of rainfall at that time; however, treatments significantly affected LDS incidence from 31 July through the end of the trial (Fig. 1). On 31 July, there were no significant differences among treatments receiving a Cascade Plus application. From 14 August through 11 September, the 7 DAIT timing had significantly more LDS formation than the other two timing treatments (Fig. 1 and 2). On the final evaluation date (2 October), the 7 DAIT and 60 DAIT timing treatments were not significantly different from each other; however, the 7 DAIT treatment had significantly more LDS formation than the 7, 60, 90, and 120 DAIT timing on 2 October. Throughout the trial, there were no significant differences between the 60 DAIT and the 7, 60, 90, and 120 DAIT timing treatments with regard to LDS formation.

Turf quality. Turf quality was mostly affected by LDS formation; so treatment differences in turf quality were similar to those for LDS formation (Fig. 3). Treatments significantly affected turf quality from 31 July through the end of the trial. During that time, the control treatment had significantly lower turf quality than the other three treatments. From 14 August through the remainder of the trial, the 7 DAIT treatment had significantly lower quality than treatments receiving an application at 60 DAIT. Throughout the trial, there were no significant differences between the 60 DAIT and the 7, 60, 90, and 120 DAIT timing treatments with regard to visual turf quality. Cascade Plus applications did not result in severe phytotoxicity in this trial, even when applications were made later in the growing season. However, care was taken to apply treatments when temperatures were relatively cool (early in the morning) and irrigation was applied within 30 minutes of wetting agent application.

Conclusions

These results corroborate previous findings that Cascade Plus applications are likely necessary later in the growing season to provide season-long control of LDS. Applications at 90 and 120 DAIT did not significantly improve LDS control or turf quality compared to an application only at 60 DAIT. However, it is worth noting that the 2008 growing season was cooler and wetter than normal and that successive Cascade Plus applications at 90 and 120 DAIT may be more effective during more stressful growing seasons. Finally, late-season applications of Cascade Plus should be made during early morning hours or overcast conditions and then irrigated immediately to minimize phytotoxicity.

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Table 1. Maintenance of the experimental area.

Maintenance practice	Description
Mowing	Six times per week at a 0.125 inch mowing height.
Fertility	0.5, 0.1, and 0.5 lb of N, K_2O, and P_2O_5, respectively, per 1000 ft^2 per month of active growth. Other nutrients applied according to soil test recommendations.
Irrigation	As needed to prevent severe drought stress symptoms.
Growth regulation	Primo Maxx (trinexapac-ethyl) applied at 1/8 oz. per 1000 ft^2 per month of active growth.
Wetting agent application	Applied as treatment (see Table 2).
Cultivation	Hollow tine cultivation performed to affect 7% of the surface in the spring and fall.
Sand topdressing	Sand topdressing applied every 14 days throughout the growing season at an approximate rate of 4 ft^3 sand per 1000 ft^2.
Pesticides	Applied only on a curative basis.

Table 2. Summary of wetting agent treatments. DAIT = days after initial treatment.

Treatment ID	Description
Control	Untreated control
7 DAIT	Cascade Plus applied on 9 May and 16 May
60 DAIT	Cascade Plus applied on 9 May and 9 July
7, 60, 90, and 120 DAIT	Cascade Plus applied on 9 May, 16 May, 9 July, 9 Aug., and 9 Se pt.

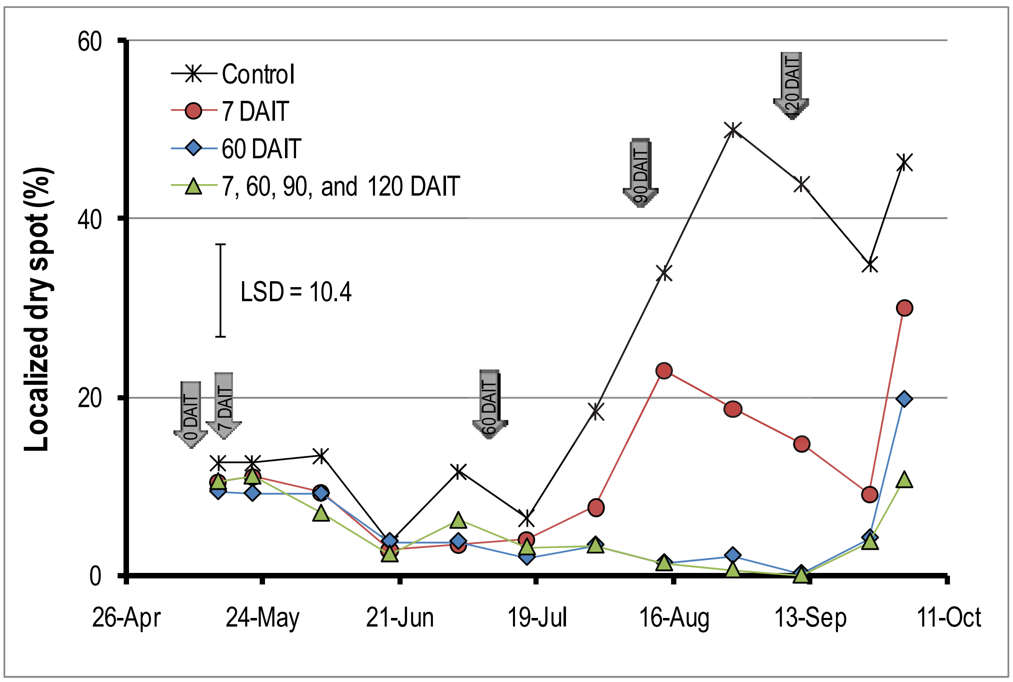

Fig. 1. Localized dry spot formation as affected by Cascade Plus timing treatment. Error bar represents Fisher's least significant difference value (α = 0.05). Arrows indicate treatment application dates. DAIT = days after initial treatment.

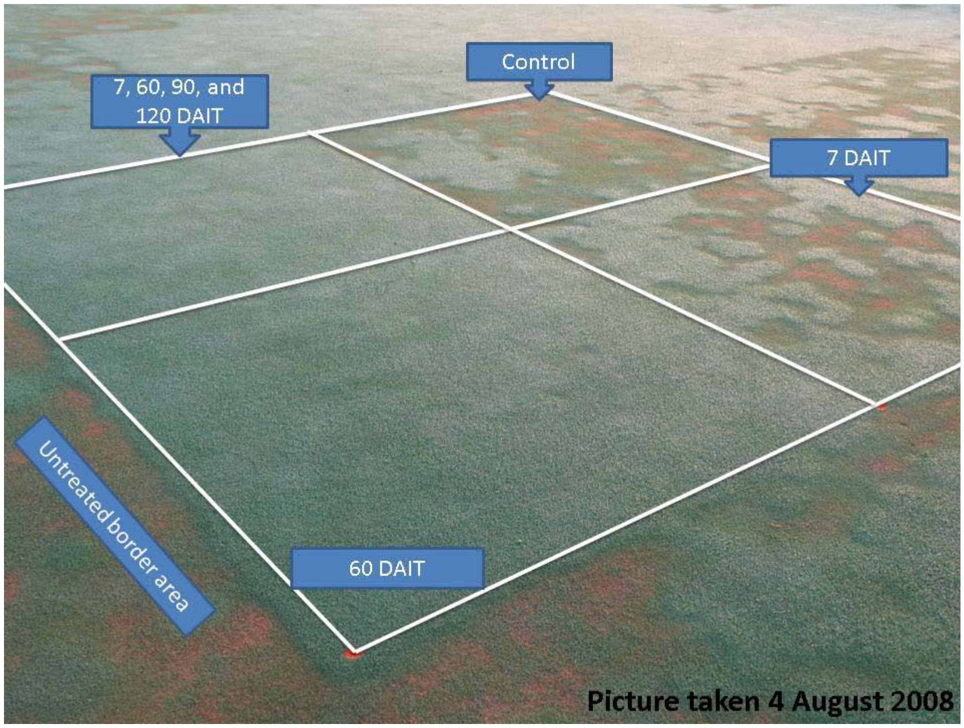

Fig. 2. Differences in localized dry spot formation among four plots with different application timings of Cascade Plus. Picture was taken early on the morning of 4 August 2008.

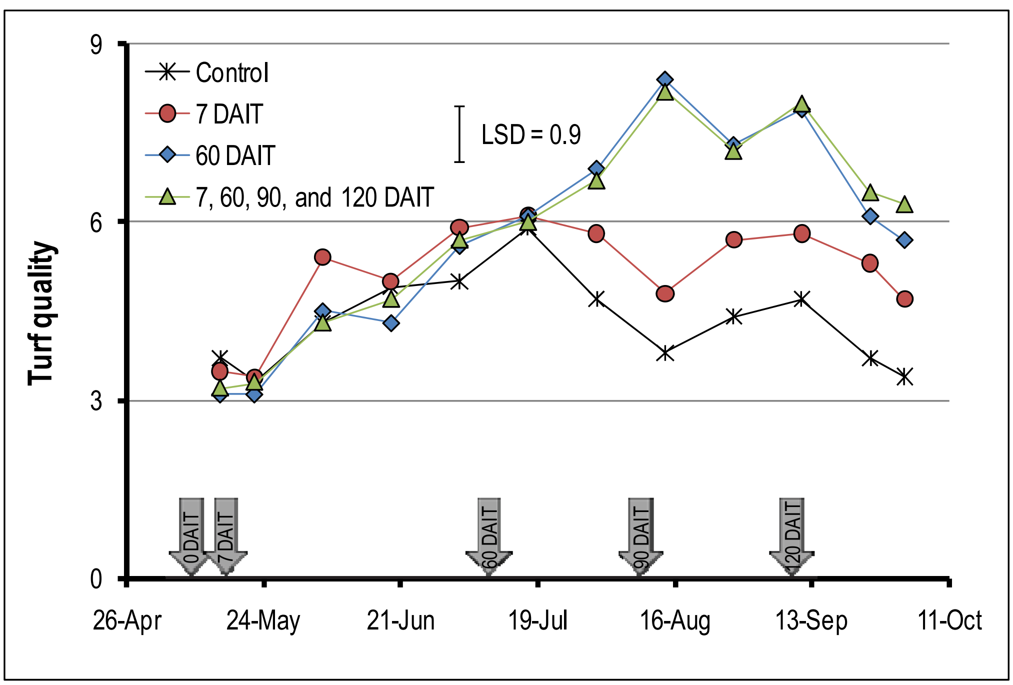

Fig. 3. Visual turf quality as affected by Cascade Plus timing treatment. Error bar represents Fisher's least significant difference value (α = 0.05). Arrows indicate treatment application dates. DAIT = days after initial treatment.

Wetting Agent Effects on Root-zone Moisture Distribution under Various Irrigation Regimes

Localized dry spot affecting putting green turf that was not treated with wetting agent

Photo by Doug Karcher

Doug Karcher[1], Mike Richardson[1], Aaron Patton[2], and Josh Summerford[1]

Additional index words: creeping bentgrass, time domain reflectometry, sand-based, putting green

Karcher, D., M. Richardson, A. Patton and J. Summerford. 2009. Wetting agent effects on rootzone moisture distribution under various irrigation regimes. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:34-39.

Summary. It is not clear how various wetting agent products affect moisture distribution throughout sand-based putting green rootzones. The objective of this research was to determine how localized dry spot (LDS) incidence, and soil moisture values and uniformity were affected by the application of five commercially available wetting agents. Wetting agents were applied during the 2008 growing season and evaluated under conditions of frequent, moderate, and infrequent irrigation application. All of the wetting agents tested in this study significantly reduced LDS formation compared to the untreated control. In addition, none of the wetting agents significantly increased soil moisture values during periods of frequent or moderate irrigation. All wetting agent products significantly increased soil moisture uniformity at a 3-inch depth compared to the untreated turf. These results suggest that specific wetting agents can be used to manage LDS without adversely affecting rootzone moisture distribution.

Abbreviations: LDS, localized dry spot; TDR, time domain reflectometry

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Previous research on wetting agent efficacy (when applied to sand-based putting greens) has focused primarily on evaluating water-drop penetration times or visual LDS symptoms. This research has demonstrated that most commercially available wetting agents are effective in reducing soil hydrophobicity and decreasing LDS symptoms. However, many golf course superintendents are also concerned about how wetting agent application affects soil moisture distribution throughout the putting green rootzone. It is often stated that some wetting agents move water rapidly through the rootzone while other products retain considerable moisture near the surface; but there are little data to substantiate such claims. Furthermore, there is variation in how irrigation practices are adjusted following wetting agent application, complicating the underlying cause of undesirable wetting agent effects. Some superintendents may not alter their irrigation practices, despite adding a wetting agent to their putting green management program. This may explain some of the anecdotal evidence that suggests wetting agent application contributes to excessive surface moisture and exacerbates summer bentgrass decline.

The objective of this research was to determine how commonly used wetting agents affect rootzone moisture distribution when applied to a sand-based putting green under wet, moderate, and dry irrigation regimes.

Materials and Methods

This experiment was conducted from June through August in 2008 at the Agricultural Research and Extension Center in Fayetteville on a creeping bentgrass (*Agrostis stolonifera* cv. L-93) putting green built according to United States Golf Association specifications. The green was mowed at a 0.125-inch height six days per wk and otherwise maintained under typical golf course conditions (Table 1).

Wetting agent treatments consisted of five commercially available wetting agent products plus an untreated control (Table 2). Treatments were applied according to manufacturer's label instructions and irrigated with 0.25 inch of water following application. Treatments were applied monthly from 10 June through 10 August, except for Cascade Plus, which was applied only on 10 June and 17 June. Each treatment was applied to four replicate plots, measuring 6 by 6 ft each. Irrigation was applied judiciously (daily), moderately (every 2-3 d), and sparingly (only under severe drought stress) following the June, July, and August treatment applications, respectively, to compare the wetting agents under a range of irrigation management regimes.

Treatments were evaluated for LDS incidence and soil moisture characteristics. Localized dry spot incidence was rated weekly as a visual estimate of the percentage within each plot affected with LDS. Volumetric soil moisture was evaluated twice monthly by taking 36 measurements on a 1-by-1 ft. grid at three sampling depths (3, 5, and 8 inches) within each plot with moisture probes (TDR 300, Spectrum Technologies, Plainfield, Ill., USA). From the moisture data, average rootzone moisture and average soil moisture variance (measured by standard deviation; n=36) were calculated for each wetting agent at each sampling depth.

Results and Discussion

LDS incidence. There was relatively little LDS formation in June and most of July when irrigation was applied judiciously and moderately, respectively (Fig. 1). Wetting agent treatment effects were significant in late July when weather conditions were hot and dry, and throughout August when irrigation was applied sparingly. When irrigation was applied sparingly, all of the wetting agent treatments resulted in turf with LDS incidence significantly less than the untreated control. There were minimal differences among wetting agent products with regard to LDS incidence.

Soil moisture values. Rootzone depth had a significant effect on soil moisture content, with average soil moisture content of 17.9, 13.7, and 10.8 % at the 3-, 5-, and 8-inch depths, respectively. When averaged across the season, the effect of wetting agent treatment on volumetric soil moisture was not significant. However, there was a significant wetting agent effect at the 3-inch depth on 28 August, the final evaluation date, which was after several weeks of infrequent irrigation (Fig. 2). Also, in late July, during a hot and dry period and under moderate irrigation frequency, wetting-agent treatment affected soil moisture at a 0.07 probability level (Fig 2). During periods of judicious irrigation, the wetting agent products resulted in soil moisture values similar to the untreated control. During dryer periods, Revolution and Cascade Plus resulted in higher soil moisture values than the untreated control (Fig 2).

Soil moisture variation. There was a significant wetting agent treatment x evaluation date interaction (Fig. 3) and wetting agent treatment x depth interaction (Fig. 4), with regard to soil moisture variation as measured by standard deviation. During hot and dry conditions in late July, and during infrequent irrigation applications in August, all wetting agents resulted in significantly more uniform soil moisture conditions (lower standard deviation values) compared to the control (Fig. 3). In addition, Primer Select had significantly higher moisture uniformity compared to the control during periods of judicious irrigation (Fig. 3). Wetting agent products did not differ significantly in soil moisture uniformity during infrequent irrigation application in August. At all three sampling depths, the control treatment had the least uniform soil moisture and was significantly more variable than all wetting agent treatments at the 3-inch depth (Fig. 4). Primer Select was the only wetting agent that resulted in significantly more uniform soil moisture compared to the untreated control at both the 5-inch and 8-inch depths.

Conclusions

Based on the 2008 data, all wetting agent products appear to effectively reduce LDS incidence and increase soil moisture uniformity at a 3-inch depth compared to the untreated turf. In addition, there is no evidence that these wetting agents significantly increase surface soil moisture during periods of frequent irrigation or rainfall. These results suggest that these commonly used wetting agents can be used to manage LDS without adversely affecting rootzone moisture distribution. This research is being funded by the Environmental Institute for Golf and will be repeated during the 2009 growing season.

Table 1. Maintenance of the experimental area.

Maintenance Practice	Description
Mowing	Six times per week at a 0.125 inch mowing height.
Fertility	0.5, 0.1, and 0.5 lb of N, K_2O, and P_2O_5, respectively, per 1000 ft^2 per month of active growth. Other nutrients applied according to soil test recommendations.
Irrigation	Frequent (June) – daily to prevent any drought stress symptoms. Moderate (July) – as needed to prevent moderate drought stress symptoms. Infrequent (August) – only to prevent extreme drought stress symptoms.
Growth regulation	Primo Maxx (trinexapac-ethyl) applied at 1/8 oz. per 1000 ft^2 per month of active growth.
Wetting agent application	Applied as treatment (see Table 2).
Cultivation	Hollow tine cultivation performed to affect 5% of the surface in the spring and fall.
Sand topdressing	Sand topdressing applied every 14 days throughout the growing season at an approximate rate of 4 ft^3 sand per 1000 ft^2.
Pesticides	Applied only on a curative basis.

Table 2. Wetting agent treatments.

Treatment		Description	Manufacturer
1.	Control	Untreated control	
2.	Cascade Plus	2 app's @ 8oz/ 1000 ft^2 (7 days apart)	Precision Labs, Inc. (Waukegan, IL)
3.	Magnus	4 oz/ 1000 ft^2 monthly	Precision Labs, Inc. (Waukegan, IL)
4.	TriCure AD	6 oz / 1000 ft^2 monthly	Mitchell Products (Millville, NJ)
5.	Revolution	6 oz / 1000 ft^2 monthly	Aquatrols, Inc (Paulsboro, NJ)
6.	Primer Select	4 oz / 1000 ft^2 monthly	Aquatrols, Inc (Paulsboro, NJ)

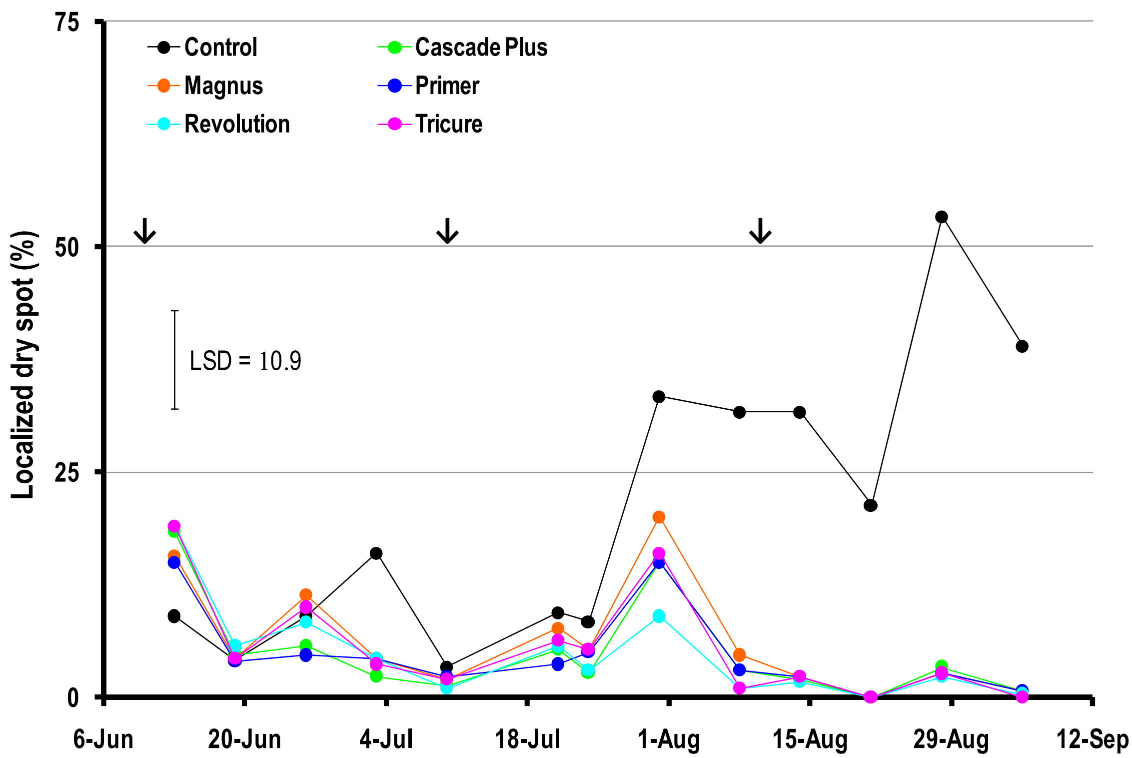

Fig. 1. Localized dry spot incidence as affected by wetting agent treatment. Arrows indicate treatment dates for all products, except for Cascade Plus which was applied only on 15 May and 22 May. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing wetting agent treatments within dates.

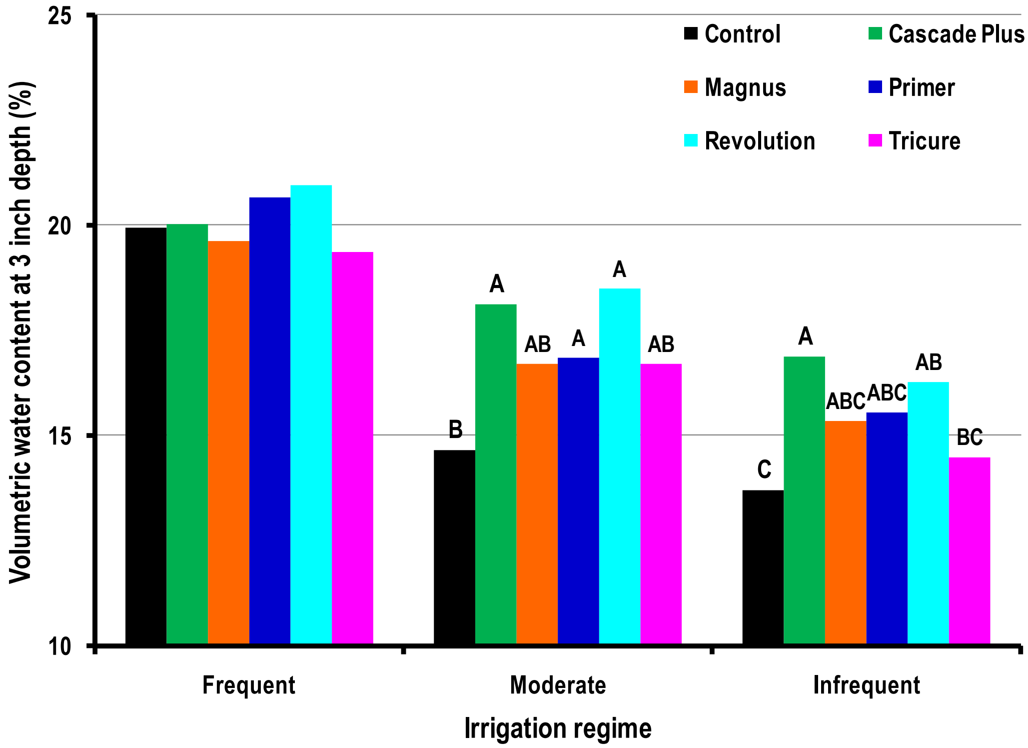

Fig. 2. Effect of wetting agent treatment on soil moisture content at the 3-inch depth, during June, July, and August, when irrigation was applied frequently, moderately, and infrequently, respectively. Within irrigation regimes, bars sharing a letter are not significantly different (α = 0.07).

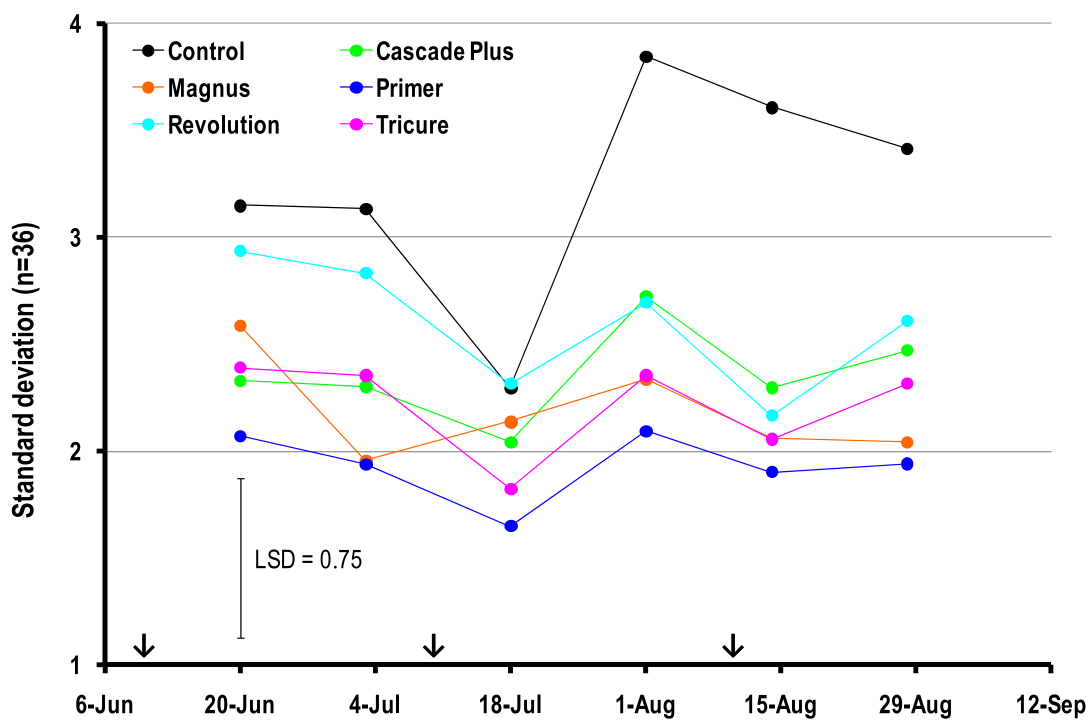

Fig. 3. Soil moisture variation as affected by wetting agent treatment and date. High standard deviation values correspond to less uniform soil moisture conditions. Arrows along the x axis indicate treatment dates for all products, except for Cascade Plus which was applied only on 15 May and 22 May. Error bar represents Fisher's least significant difference value for comparing wetting agent treatments within dates.

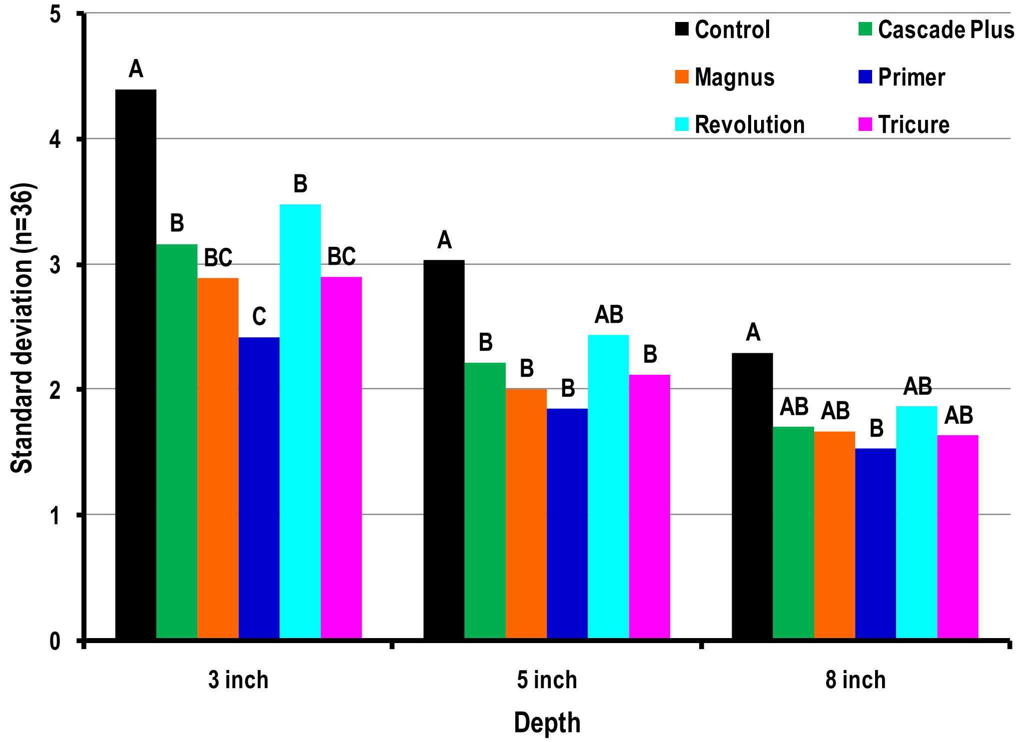

Fig. 4. Soil moisture variation as affected by wetting agent treatment and sampling depth. High standard deviation values correspond to less uniform soil moisture conditions. Within depths, bars not sharing a letter are significantly different according to Fisher's least significant difference value test (α = 0.05).

Segway and Golf Car Wear on Dormant Bermudagrass Fairways


Photo by Doug Karcher

Research comparing the tolerance of a bermudagrass fairway to Segway and golf cart traffic

John Kauffman[1], John Sorochan[1], Doug Karcher[2], and Tom Samples[1]

Additional index words: *Cynodon dactylon* × *C. traansvalensis*, traffic, greenup

Kauffman A., J. Sorochan, D. Karcher, and T. Samples. 2009. Segway and golf car wear on dormant bermudagrass fairways. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:40-44.

Summary. Recently, the Segway X2 personal transporter was introduced as an alternative to riding golf cars. Previous research compared the impact of these transporters on actively growing bermudagrass, but their impact on bermudagrass during winter dormancy is unknown. The objective of this research was to compare the effects of the Segway and traditional golf car on turf wear and spring green-up of 'Tifway' bermudagrass fairway turf trafficked during winter dormancy. In Tennessee, Segway traffic caused less wear on dormant bermudagrass turf than traditional golf car traffic and overall turning traffic caused more wear than stopping traffic, while spring green-up was not affected by vehicle type in Arkansas and Tennessee in 2008.

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Concentrated and repeated golf car traffic decreases turf quality by causing direct turfgrass injury and soil compaction. During dormancy, crown tissues of warm-season turfgrasses are more easily injured and dessicated, which often leads to decreased dormant turf cover and poor winter survival and spring greenup (Carrow and Johnson, 1996). Golf car traffic during the dormant period can further contribute to crown injury and a loss of turfgrass cover because of forces exerted on the outside portion of the tire during turns and the entire tire surface on starts and stops.

The Segway X2 personal transporter was recently introduced to the golf industry as an improvement on the Segway GT. Sorochan et al. (2006) reported that the Segway GT created less wear and soil compaction than traditional golf cars on actively growing bermudagrass (*Cynodon* spp.). Karcher and Landreth (2008) reported that both Segway units caused less turf loss and lower soil-surface hardness than a traditional golf car. The objective of this research was to compare the wear and spring green-up of both the Segway X2 and the traditional golf car on dormant bermudagrass fairway turf.

Materials and Methods

This study was conducted on 'Tifway' bermudagrass turf maintained under golf course fairway conditions at the University of Arkansas Research and Extension Center in Fayetteville and the East Tennessee Research and Education Center in Knoxville. Both sites were located on silt loam soils and mowed three times weekly at 0.5 inches.

At each site, traffic was applied using a Segway X2 and standard golf car (Tennessee – Club Car Model-DS Electric Golf Car; Arkansas – Model E-Z-GO TXT Electric Golf Car). From 12 February to 8 April 2008, each traffic treatment was applied at 10 passes weekly to simulate low traffic volume during winter play. Treatments were applied to four replicate plots in Arkansas and three replicate plots in Tennessee. Plots were arranged such that each had two fixed points: one point to simulate starting and stopping wear and the other point to simulate turning wear (Sorochan et al., 2006). A single pass consisted of starting the Segway or golf car at the start/stop point, completing a 180° turn around the turning point, then returning to and stopping at the start/stop point.

Vehicle start/stop and turning points for each plot were rated for turf quality, dormant turf cover, green turf cover, and surface hardness. Turf quality was evaluated using a 1 to 9 scale in which 9 represented ideal turf and 1 represented dead turf. A rating of 5 was assigned to indicate minimum acceptable turf quality. Dormant turf cover was also rated as the percentage of the plot covered by dormant turf, as opposed to bare ground, on a 0 to 100 scale. On emergence from dormancy, digital images were collected at both the inside and outside tire locations of the start/stop and turning points for each plot to determine the percent green turf cover, and analyzed using digital image analysis (Richardson et al., 2001).

Results and Discussion

In Tennessee, the Segway X2 showed higher turf-quality ratings than traditional golf car traffic after 26 February (Fig. 1). Golf car start/stop traffic took longer to reach acceptable turf quality than Segway traffic as turf emerged from dormancy (Fig. 1). At Arkansas, turning Segway traffic had significantly lower turf quality than all other vehicle and traffic types from 20 March to 23 April (Fig. 1). However, bermudagrass receiving turning Segway traffic increased visual quality slightly once plant growth resumed in the spring, while no other treatments advanced in quality.

In Tennessee, both types of Segway traffic had higher dormant turf cover than either type of golf car traffic. At the end of the dormancy period, turf trafficked with the Segway maintained no less than 83% dormant turf cover, while turf trafficked with the golf car had less than 70% dormant turf cover (Fig. 2).

In Arkansas, differences in vehicle and traffic type were significant only after 20 March, when dormant turf cover of all traffic and vehicle types was greater than turf cover of plots receiving turning Segway traffic. However, no differences in dormant turf cover were observed between either golf car traffic type and Segway start/stop traffic. At the end of the dormancy period, turf receiving Segway turning traffic maintained no more than 47% dormant turf cover, while turf receiving all other treatments maintained less than 65% dormant turf cover (Fig. 2).

No differences in green turf cover were observed in Tennessee until the last two evaluation dates, where both Segway traffic types and turning golf car traffic showed greater green turf cover and emerged from dormancy earlier than stopping golf car traffic, but did not differ amongst themselves (Fig. 3).

In Arkansas, neither vehicle type nor traffic type significantly impacted green turf cover until the final two evaluation dates, when Segway start/stop traffic showed greater green turf cover than all other traffic and vehicle types (Fig. 3). These results show that all forms of traffic during winter had little impact on emergence from dormancy.

Overall, the Segway X2 personal transporter produced no more wear on dormant bermudagrass than traditional golf car traffic and may produce less wear on dormant bermudagrass turf than traditional golf car traffic in some situations. Dormant and actively growing bermudagrass maintained higher turf quality when trafficked with the Segway rather than a golf car in Tennessee, but differences between the Segway and golf car were not consistent in Arkansas. Golf car traffic also reduced dormant turf cover over Segway traffic in Tennessee, but did not impact spring green-up. Use of the Segway X2 personal transporter as an alternative to traditional golf cars during dormant periods has the potential to increase winter aesthetics and preserve the quality of dormant surfaces for winter play.

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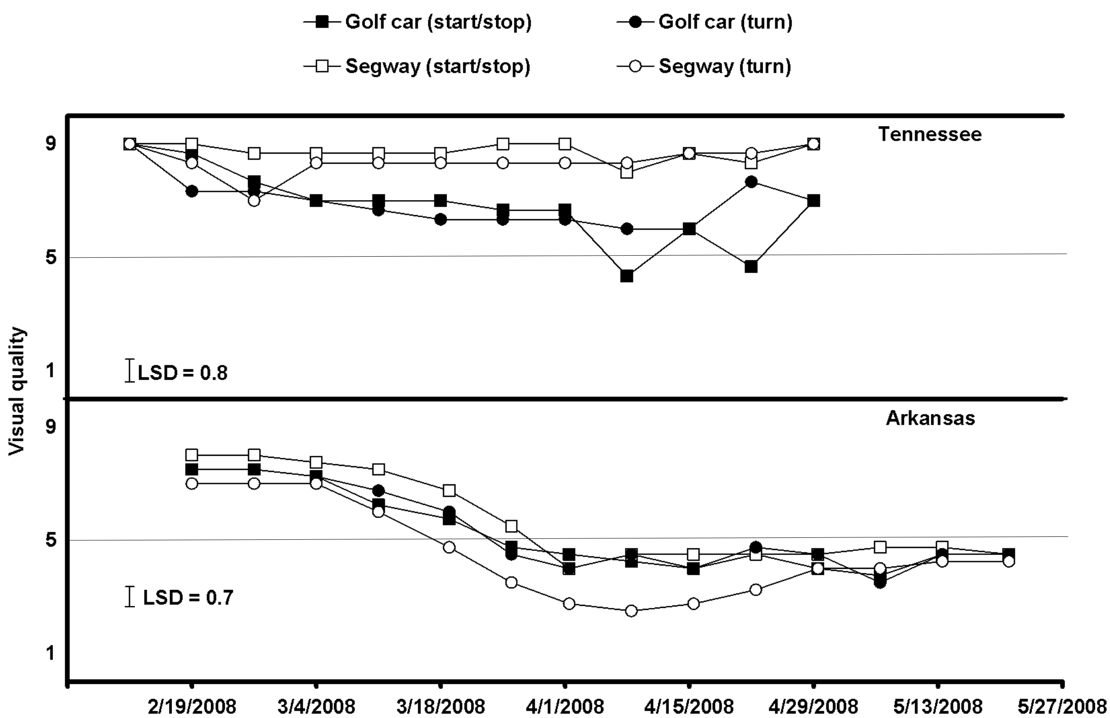

Fig. 1. Effect of traffic type x vehicle type interaction on turf quality at Tennessee and Arkansas. Rating of 1 indicates bare ground or dead turf, 5 indicates minimum acceptable quality, and 9 indicates ideal turf. Error bars represent $LSD_{0.05}$ values for separating treatment means within each date and location.

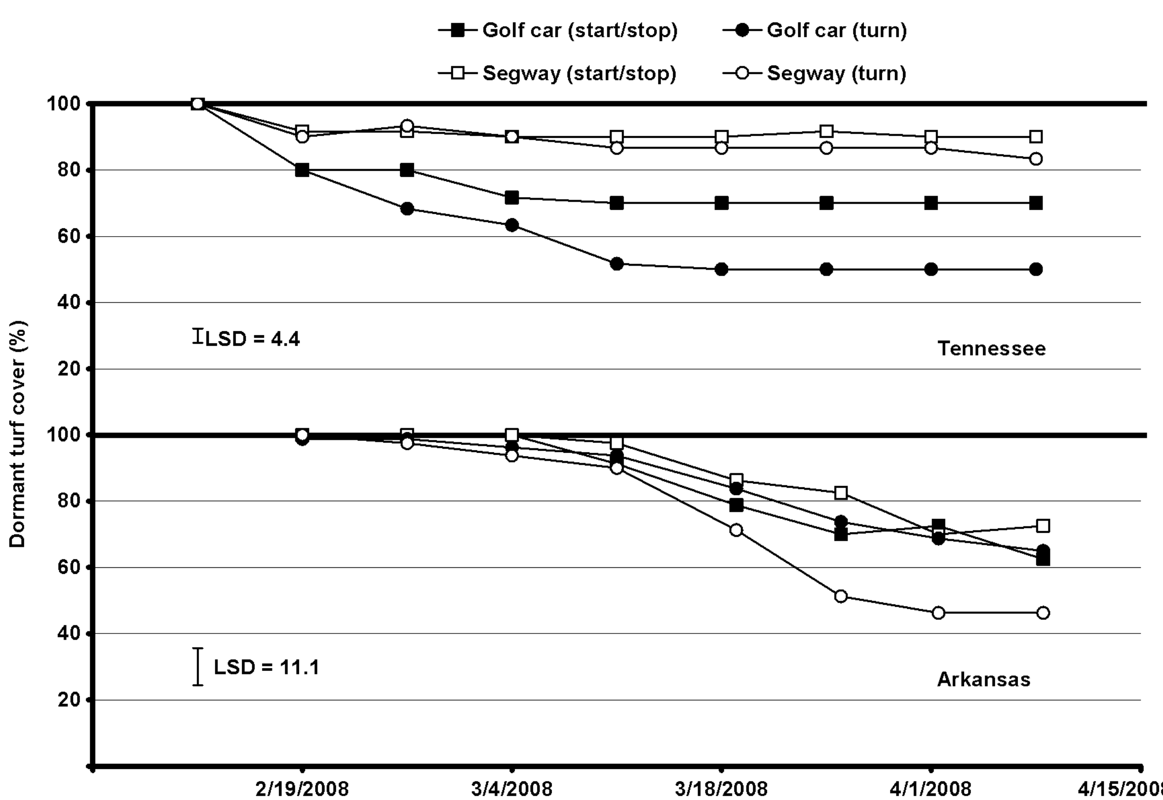

Fig. 2. Traffic type x vehicle interaction effect on the percentage dormant turf cover at Tennessee and Arkansas. Error bars represent $LSD_{0.05}$ values for separating treatment means within each date and location.

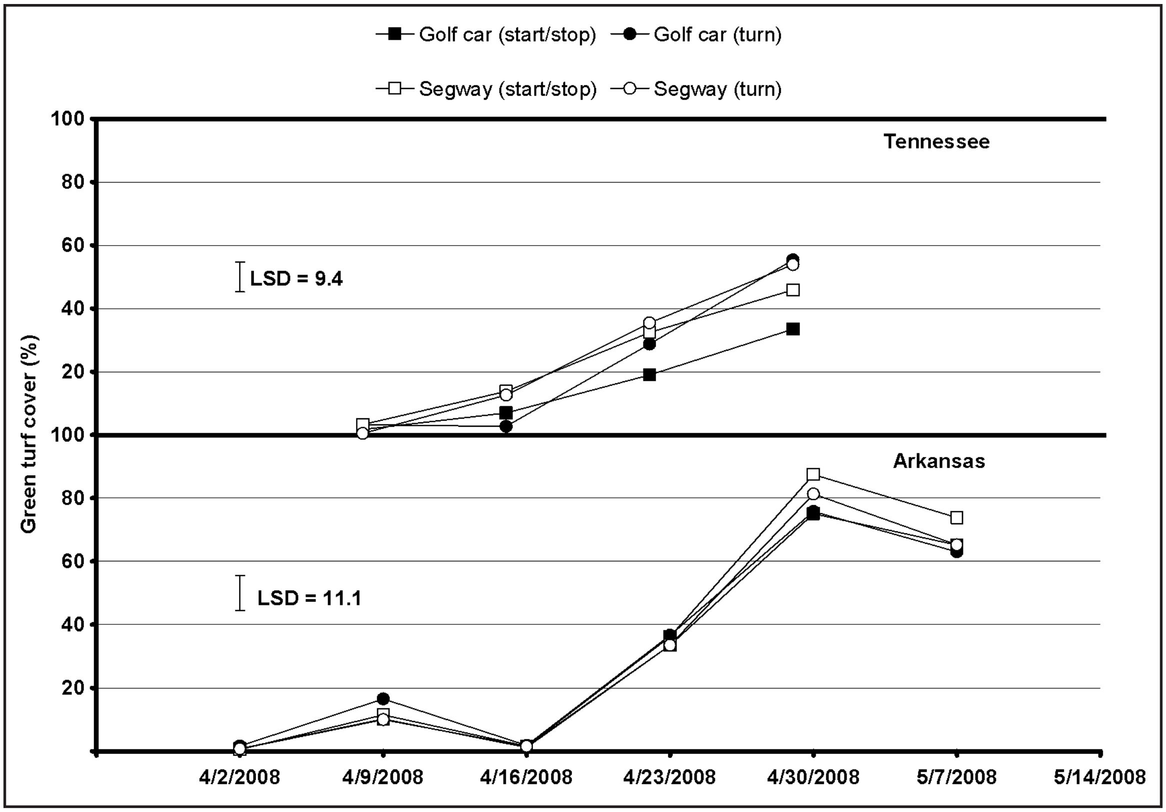

Fig. 3. Traffic type x vehicle interaction effect on the percentage green turf cover at Tennessee and Arkansas. Error bars represent $LSD_{0.05}$ values for separating treatment means within each date and location.

Effects of Mowing Height, Fertilizer, and Trinexapac-ethyl on Ball Lie of Tifsport Bermudagrass – 2008 Data

John McCalla[1], Mike Richardson[1], Doug Karcher[1], and Aaron Patton[2]

Additional index words: digital image analysis, Lie-N-Eye, nitrogen, fairway, rough

McCalla J., M. Richardson, D. Karcher, and A. Patton. 2009. Effects of mowing height, fertilizer, and trinexapac-ethyl on ball lie of Tifsport bermudagrass–2008 data. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:45-49.

Golfer striking a ball from a short-cut lie

Summary. Ball lie describes how a golf ball comes to rest in the turf canopy following a stroke. Ball lie is often considered uniform and adequate on the tee box or if it comes to rest in the fairway, but in the intermediate or deep rough, ball lie is variable. This 2-year project was conducted to investigate how different management techniques affect how a ball is positioned within the canopy of the turf. Different mowing heights, fertilizer rates, and trinexapac-ethyl (Primo) rates were applied to Tifsport bermudagrass and were evaluated to determine how they affected ball lie. On all rating dates, ball lie improved as mowing height decreased. There was an interaction between mowing height and Primo, with Primo having a positive effect on ball lie at higher mowing heights, but no effect at lower mowing heights. Nitrogen fertilization did not affect ball lie.

Abbreviations: TE, trinexapac-ethyl; DIA, digital image analysis

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A golf ball is more easily hit when the ball has a clean lie on the top of the canopy of closely cut, uniform turf. Golf ball lie is affected by several different factors, most importantly the height at which the turf is mown (Cella and Voigt, 2001). A golf ball's lie is often defined as the amount of the golf ball that remains above the turfgrass canopy after the ball comes to rest. The Lie-N-Eye is a device developed at the University of Illinois to evaluate the lie of a golf ball. The Lie-N-Eye uses a Vernier caliper attached to a base to measure the amount of ball above the canopy. This device was designed to measure turfgrass maintained between 0.75 and 1.0 inch. A second, similar device, called the Lie-N-Eye II, was developed to measure shorter cut turf between 0.375 and 0.625 inch (Cella et al., 2004). The Lie-N-Eye was initially tested with several different varieties of Kentucky bluegrass (*Poa pratensis*). It was successful in measuring differences in ball lie in varieties that were mowed at 0.875 inch (Cella and Voigt, 2001; Cella et al., 2005).

The use of digital image analysis (DIA) has changed the way data can be collected in turfgrass research. Recently, a device was designed and tested at the University of Arkansas that measures ball lie in turfgrass systems using DIA (Fig. 1, Richardson et al., 2007). With the development of this simplified technique, the opportunity to study cultivar differences and cultural practice effects on golf ball lie is now possible.

The objective of the current study was to determine the effect of mowing height, nitrogen rate, and trinexapac-ethyl (TE) on golf ball lie in Tifsport bermudagrass (*Cynodon dactylon* x *C. transvaalensis*).

Materials and Methods

This study was conducted over a two-year period at the University of Arkansas Agricultural Research and Extension Center in Fayetteville. Tifsport bermudagrass was established from sod in the spring of 2006 on a silt loam soil and cultural treatments were initiated in the fall of 2006. The experimental design was a strip-split-plot, with nitrogen rate and mowing height as strip factors and TE (Primo Maxx, Syngenta Professional Products, Greensboro, N.C.) as the split plot. Following establishment, three different mowing heights (0.5, 1.0, and 1.5 inch) were initiated and maintained by mowing three times weekly throughout the growing season with clippings returned. Three different nitrogen fertilizer rates (0.5, 1.0, and 1.5 lb N/1000 ft^2/month) were applied as urea (46-0-0) every two weeks at half the monthly rate. Trinexapac-ethyl was applied at three different rates, including 6 oz/A every four weeks, 3 oz/A every two weeks, and an untreated control. Application volume for TE was 30 gal/A and all treatments were applied with a CO_2-propelled backpack sprayer.

For analysis of golf ball lie, three golf balls were rolled onto each plot and digital images were taken of each ball using the device developed at the University of Arkansas, which measures the percentage of the golf ball that is above the canopy (Richardson et al., 2007). Ball lie data were collected on 19 July, 29 July, and 10 August in 2007, and 11 August and 8 September in 2008.

Results and Discussion

There was a significant mowing height effect on ball lie on all three evaluation dates in 2007 and both evaluation dates in 2008, and when averaged across dates within each year. In addition, there was also a significant TE × mowing height interaction on four of the five dates and when averaged across dates within each year.

As expected, shorter mowing heights improved ball lie on all evaluation dates (data not shown). These results follow a similar trend to what was seen by Hanna (2008). At the 0.5-inch mowing height, an average of 92.0% of the ball was above the canopy, while ball lie at the 1.0- and 1.5-inch mowing height was 89.1 and 77.1% above the canopy, respectively.

As reported earlier (McCalla et al., 2008), there was a significant TE × mowing height interaction on the first two evaluation dates in 2007 and when averaged across all three evaluation dates. At the 0.5-inch mowing height, there was no significance difference in ball lie between the

TE treatments (Table 1). However, when the mowing height was raised to either 1.0 or 1.5 inch, the TE-treated plots generally had more favorable ball lie compared to the untreated check (Table 2), which is likely due to the increased turfgrass density from TE treatments.

The data from the 2008 season were similar to the first, in that there was a significant TE x mowing height interaction on all dates and when averaged across dates. At the 0.5-inch mowing height, there was no significant difference between any of the TE treatments on either rating date or when both dates were averaged (Table 2). At the 1.0-inch mowing height, the untreated check produced a significantly worse ball lie than either the 3- or 6-oz TE treatments on the 11 August rating date. However, ball lie at the 1.0-inch mowing height was not improved by TE treatments on the 8 September date or when the two dates were averaged (Table 2). At the highest mowing height (1.5 inch), TE improved ball lie on both evaluation dates and when averaged across evaluation dates. As observed in the 2007 study (McCalla et al., 2008), there were no significant differences between any of the nitrogen treatments in relation to ball lie.

In summary, mowing height had a significant effect on ball lie across all rating dates, which is similar to results reported earlier on Kentucky bluegrass (Cella and Voigt, 2001) and in bermudagrass (McCalla et al., 2008). The growth regulator, TE, also improved ball lie, but only when the turf was maintained at a higher height of cut (1.0 or 1.5 inch). Increasing nitrogen fertilizer rate had no significant effect on ball lie in Tifsport bermudagrass. Therefore, golf course superintendents can improve golf ball lie on bermudagrass by maintaining low mowing heights or from applications of TE on intermediate and rough mowing heights (≥1.0 inch). More work is ongoing to see how cultivar and other cultural practices impact ball lie.

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Table 1. Interaction effect of mowing height and trinexapac-ethyl (TE) applications on ball lie in Tifsport bermudagrass in 2007.

Mowing height	TE	19 July	29 July	10 August	Avg.
(inch)	(oz product / A)	-----------------% of ball above canopy----------------			
0.5	0	96.3	91.4	88.3	92.0
	3	96.5	91.2	89.3	92.3
	6	96.2	90.3	88.3	91.6
LSD (0.05)[z]		ns[y]	ns	ns	ns
1.0	0	91.4	86.8	86.1	88.1
	3	94.1	89.1	86.2	89.8
	6	92.9	89.2	86.0	89.4
LSD (0.05)		ns	1.6	ns	1.3
1.5	0	75.9	69.4	76.7	74.0
	3	82.9	77.3	78.9	79.7
	6	78.1	77.0	77.4	77.5
LSD (0.05)		6.5	5.5	ns	4.0

[z] Least significant difference (P=0.05) for comparing means within a mowing height and date.

[y] ns, not significant.

Table 2. Interaction effect of mowing height and trinexapac-ethyl (TE) applications on ball lie in Tifsport bermudagrass in 2008.

Mowing height	TE	11 Aug.	8 Sept.	Avg.
(inch)	(oz product / A)	-----------------% of ball above canopy------------		
0.5	0	93.8	94.7	94.3
	3	95.2	93.9	94.5
	6	94.9	93.2	94.1
LSD (0.05)[z]		ns [y]	ns	ns
1.0	0	84.2	90.5	87.3
	3	88.9	89.6	89.3
	6	90.7	88.2	89.4
LSD (0.05)		3.6	ns	ns
1.5	0	39.6	40.8	40.2
	3	54.8	53.2	54.0
	6	54.1	54.2	54.2
LSD (0.05)		10.1	10.8	10.1

[z] Least significant difference (P=0.05) for comparing means within a mowing height and date.

[y] ns, not significant.

Effect of Mesotrione on Sod Quality of Tifway Bermudagrass

John McCalla[1], Mike Richardson[1], John Boyd[2], and Aaron Patton[1]

Additional index words: *Cynodon dactylon*

McCalla J., M. Richardson, J. Boyd, and A. Patton. 2009. Effect of mesotrione on sod quality of Tifway bermudagrass. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:50-53.


Photo by Mike Richardson

Sod harvested from mesotrione-treated plots

Summary. Commercial sod production has been taking place since the 1920's. Sod growers must have weed-free, high-quality sod to sell their product. The objective of this trial was to evaluate the effects of mesotrione, a relatively new herbicide in the turfgrass market, on sod regrowth after harvest and sod strength at the time of harvest. Tifway bermudagrass sod was harvested on 24 May 2008 and five different rates of mesotrione were applied at different timings during the regrowth of the sod. Herbicide injury and turfgrass cover were evaluated seven days after each herbicide application. Sod was harvested three weeks after final herbicide application (17 October 2008) and percent harvestable sod and sod strength were evaluated. There were no significant effects of mesotrione on turfgrass coverage for any of the application dates. There were no significant differences for herbicide injury except for the final application date, when the highest rates of mesotrione caused more severe injury than other rates. The highest rate (0.5 lb ai/A) of mesotrione applied at six and nine weeks after initial treatment had a negative effect on sod quality and produced less harvestable sod with weaker sod strength compared to most other treatments. There were no significant differences between any of the treatments at label rates (less than 0.5 lbs ai/A annually) in regard to sod strength.

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Commercial sod production began in the United States around 1920 (Mitchell and Dickens, 1979). High-quality sod is generally characterized as healthy, strong enough for handling, and weed free. Bermudagrass (*Cynodon* spp.) is the most widely-used grass for sod production in the southern United States and can often be harvested multiple times in a growing season. For producers to harvest two crops in a single season, growers must develop and follow stringent fertilizer and pesticide applications. Proper herbicide timing in sod production not only affects the appearance of the grass but may also affect the sod strength and rooting ability after harvest (Sharpe et. al, 1989).

Mesotrione (Tenacity) is a relatively new herbicide in turfgrass systems and has both pre- and post-emergence activity on broadleaf weeds and annual grasses (Gardner, 2008). Annual grassy weeds such as crabgrass are the most common in turf; mesotrione provides turf producers with another option to control these weeds. With the recent introduction of mesotrione to the turfgrass industry, studies are needed to evaluate its effectiveness on weed control and how it may adversely affect the grass in different situations such as sod production.

Bermudagrass in typically injured by mesotrione (Boyd, 2008). This phytotoxicity (injury) may be less problematic in certain situations such as sod farms, since the phytotoxicity is short-lived and the turf can recover from injury prior to harvesting and marketing the sod. However, there have been no studies to date to investigate the effects of mesotrione on bermudagrass sod production. The objective of this trial was to evaluate mesotrione for phytotoxicity and how it affects regrowth and sod strength of bermudagrass.

Materials and Methods

This study was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. on a hybrid bermudagrass (cultivar Tifway) area that was established with sprigs in the summer of 2003.

Sod was initially harvested from the entire experimental area using a Gandy Jr. sod cutter (18-inch width) on 24 May 2008 and 2-inch ribbons were left between the harvested strips. Herbicide applications were initiated 14 days after sod harvest. Mesotrione (2-[4-(methylsulfonyl)-2-nitrobenzoyl]-1,3-cyclohexanedione), was applied at five different rates, including an untreated control, across four different timings (Table 1). Herbicides were applied using a 4-ft boom sprayer with CO_2 as the propellant at a spray volume of 30 gal/A. Herbicide plot size was 5 × 25 ft. The turf was maintained at a lawn height of cut (2.0 inches) throughout the study. The plot area received 0.5 lb N/1000 ft^2 every 14 days until 100% cover was reached after harvesting and then once per month at 1.0 lb N/1000 ft^2 until sod harvest. There were four replications of each treatment.

Injury and cover ratings were taken seven days following each herbicide application. Injury was rated on a 1-9 (with 1 = no injury and 9 = dead turf) and turfgrass coverage was measured using digital image analysis (Richardson et al., 2001). A single strip of sod was harvested from each herbicide plot on 17 October 2008, which corresponded to three weeks after the final herbicide application date. Each plot yielded 10 pads of sod that were 18 inches wide by 30 inches long. Each piece of sod was lifted after harvest and determined to be a harvestable piece of sod if it did not break during the lifting. Percent harvestable sod was calculated from each plot as the number of pieces that could be lifted divided by ten. Five sod pads were sampled, if available, from each plot and measured for sod strength using a previously described sod stretcher (Sorochan et al., 1999; McCalla et al., 2008).

Results and Discussion

There was no significant injury from herbicide applications except on the final treatment date. At seven days after the final treatment application, the high rate of mesotrione (0.50 lb ai/A), caused significantly more injury than the 0.25-lb ai/A rate, which had significantly more injury than the other two rates and the untreated control (data not shown). There were no significant differences in turfgrass coverage between treatments following any of the herbicide applications. The experimental area had full turf coverage at eight weeks after the initial sod harvest.

The highest rate of mesotrione produced significantly less harvestable sod than all other treatments with the exception of the 0.156-lb ai/A treatment, with only 58% being harvestable (Table 2). There were no statistical differences in harvestable sod between 0.25, 0.125, and the untreated check. There were minimal statistical differences in sod strength among the treatments. However, the highest rate (0.5-lb ai/A) of mesotrione did have weaker sod strength than the 0.25-lb ai/A treatment. The sod strength results are similar to other studies that have evaluated the effects of herbicides on sod strength (Turner et al., 1990; Christians and Dant, 2002; and Sharpe et al., 1989). In those studies, herbicide applications did not adversely affect sod tensile strength when compared to the untreated check.

In summary, mesotrione had minimal effect on sod strength when compared to the untreated check, but the highest rate (2 applications of 0.50-lb ai/A) did reduce the amount of harvestable sod compared to other treatments. Mesotrione application is recommended to not exceed 0.50-lb ai/A per year, so the highest rate in this study exceeded label rates. For the label rates, the sod recovered and was ready for harvest approximately eight weeks after initial harvest and there was little to no injury resulting from herbicide applications. Collectively, these data suggest that mesotrione may be safely used in bermudagrass sod production at lower rates with minimal effects on sod quality and appearance. A second harvest is planned for early spring 2009.

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Table 1. Herbicide timings and rates used in the study. The initial mesotrione treatment was applied on 6 June 2008.

Treatment	Rate	Timing
	lbs. a.i. / acre	
Untreated		
Mesotrione	0.125	Initial treatment, 3 WAIT[z], 6 WAIT, and 9 WAIT
Mesotrione	0.156	3 WAIT, 6 WAIT, and 9 WAIT
Mesotrione	0.25	6 WAIT and 9 WAIT
Mesotrione	0.50	6 WAIT and 9 WAIT

[z]WAIT – weeks after initial treatment

Table 2. Harvestable sod and sod strength, as measured as the peak force to break the sod. Sod was harvested on 10 Oct. 2008.

Treatment	Rate	Harvest	Strength
	(lb. a.i. / acre)	%	force (lbs.)
Untreated		87.5	109.5
Mesotrione	0.125	97.5	106.4
Mesotrione	0.156	72.5	108.8
Mesotrione	0.25	85.0	121.2
Mesotrione	0.50	57.5	97.1
LSD(0.10)		22.5	18.4

2007 NTEP Bermudagrass Trial – Year 1 and 2 Results


Photo by Aaron Patton

Bermudagrass cultivar trial

Aaron Patton[1], Mike Richardson[2], Doug Karcher[2], and Jon Trappe[1]

Additional index words: *Cynodon dactylon, Cynodon dactylon x C. transvaalensis*, turfgrass, cultivars, quality, color, spring green-up, leaf texture, seed heads

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Summary. Bermudagrass continues to be the prevailing turfgrass species used in Arkansas for golf courses, sports fields, home lawns and utility turf situations. Identifying adapted cultivars for the region remains a central focus of the University of Arkansas turfgrass research program. The National Turfgrass Evaluation Program is the predominant means by which cultivars are tested throughout North America. A bermudagrass cultivar trial was planted in the summer of 2007 at Fayetteville, Ark. This trial was maintained under typical lawn conditions and data on spring green-up, overall quality, leaf color, leaf texture, and seed head formation were collected from summer 2007 through 2008. Average turf quality across months for the year was highest for OKC-1119, OKC-1134, PSG-9Y20, Tifgreen, Quickstand, RAD-CD1, GN-1, Premier, and SWI-1113. Turf quality for the year was least for PSG-91215, PSG-9BAN, PSG-94524, Sunsport, and Numex Sahara. Future evaluations over the next four years will provide a more complete picture of cultivars that perform best under these management and climate conditions.

Abbreviations: NTEP, National Turfgrass Evaluation Program.

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Bermudagrass (*Cynodon* spp.) remains the most commonly used turfgrass on golf courses, sports fields, and lawns in Arkansas and throughout southern and transition-zone environments. Bermudagrass has many positive attributes that have made it a successful turfgrass species, including good heat and drought tolerance, pest resistance, traffic tolerance, and tolerance to a wide range of soil types and water quality.

The National Turfgrass Evaluation Program (NTEP) is an organization within the U.S. Dept. of Agriculture that annually oversees turfgrass cultivar evaluation experiments at various sites throughout the U.S. and Canada. Each turfgrass species is tested on a four- to five-year cycle at sites throughout the growing region for that particular species. The University of Arkansas has been an active participant in the NTEP and has conducted several tests on bermudagrass cultivars since 1986. This report will describe the data collected in 2007 and 2008 for the 2007 NTEP bermudagrass trial at Fayetteville, Ark.

Materials and Methods

The majority of the bermudagrass entries in this trial were planted on 9 June 2007 at the University of Arkansas Research and Extension Center in Fayetteville. Some additional entries were planted in August for comparison over the life of the trial (Table 1). Plot size was 7 by 8 ft and there were three replications of each cultivar. Vegetative cultivars were planted as 2-inch diameter plugs on 12-inch spacings within the plots, while seeded cultivars were broadcast-planted at a seeding rate of 1.0 lb/1000 ft^2. Plots were maintained under lawn conditions, with a mowing height of 1.5 inch, and monthly applications of 1.0 lb N/1000 ft^2 during the growing season. Irrigation was applied as needed to promote germination and establishment and to prevent stress.

Overall turf quality was evaluated beginning in October 2007 and then monthly during the growing season in 2008. Quality was visually assessed on a 1 to 9 scale, with 9 representing ideal dark green, uniform, fine-textured turf and 1 representing dead turf. Seedling vigor was rated using a 1 to 9 scale, with 9 representing maximum vigor (quick germination and rapid growth) and 1 representing no germination. Turfgrass coverage was also monitored throughout the study as visual estimates. Turf genetic color was visually evaluated on a scale of 1 to 9, with 9 representing ideal, dark green turf and 1 representing tan or brown turf. Leaf texture was visually evaluated on a scale of 1 to 9, with 9 representing extremely fine turf texture and 1 representing extremely coarse texture. Cultivars were visually evaluated for spring green-up using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand. Density was rated on a scale of 1 to 9, with 9 representing maximum density. Seed head density was evaluated using a scale of 1 to 9, with 9 representing no visible seed heads.

Results and Discussion

There were significant differences in seedling vigor among cultivars (Table 1). Seedling vigor on 19 June 2007 was greatest for Sunsport, Numex Sahara, PSG-9BAN, SWI-1117, IS-CD10, SWI-1083, PSG-91215, PSG-94524, SWI-1113, PSG-9Y20, J-720, and SWI-1070. Seedling vigor on 25 July 2007 was greatest among Sunsport, Numex Sahara, SWI-1117, SWI-1083, PSG-91215, PSG-94524, and SWI-1113. Riviera, BAR-7CD5, Veracruz, and PST-R6FLT were among the cultivars with the least seedling vigor on 25 July 2007.

There were significant differences in turf coverage among cultivars on each rating date in 2007 (Table 1). At 51 days after planting (30 July), coverage was greatest for SWI-1083, SWI-1117, PSG 91215, J-720, SWI-1057, Numex Sahara, SWI-1113, SWI-1070, PSG-94524, OKS-2004-2, PSG-9BAN, IS-CD10, Sunsport, RAD-CD1, SWI-1122, and Princess 77, all of which were seeded entries (Table 1). Among the vegetative entries, Quickstand had the greatest coverage but was not significantly greater than other vegetative entries. Seventy-five days after planting (23 August), Quickstand coverage (91.7%) was greater than other vegetative entries. Premier, Celebration, and Patriot were the next quickest to establish with 75.0, 71.7, and 70.0% coverage, respectively.

Spring green-up was greater for vegetatively established cultivars compared to seeded cultivars when evaluated in April (Table 2). Spring green-up was greatest for Tifgreen and OKC-1119 and least for Veracruz, PST-R6LA, PST R6ON, Sunsport, PSG-91215, SWI-1083, SWI 1113, PST-R6FLT, SWI-1057, and Princess 77 on 7 April 2008. Spring green-up was greatest for Tifgreen, OKC-1134, OKC-1119, Tifsport, Tifway, Quickstand, and Tift-11 and least for Veracruz, Sunsport, SWI-1117, SWI 1113, PSG-91215, PSG-94524, SWI-1057, Numex Sahara, and Princess 77 on 30 April 2008.

Leaf texture was finest for cultivars established vegetatively compared to those established by seed (Table 2). Among individual cultivars, leaf texture was finest among OKC-1119, OKC-1134, and Premier and coarsest for Sunsport, PSG-94524, SWI-1081, PSG-9Y20, PSG-PROK, Quickstand, SWI-1117, SWI-1083, PSG-91215, BAR-7CD5, and Numex Sahara.

Turfgrass genetic color was darker for cultivars established vegetatively compared to those established by seed (Table 2). Among individual cultivars, turfgrass genetic color was darkest for Patriot, Premier, GN-1, SWI-1083, OKC-1119, Celebration, Tift-11, Tifway, and OKS-2004-2.

Turf density was densest for cultivars established vegetatively compared to those established by seed (Table 2). Turfgrass density was greatest for OKC-1119, OKC-1134, Tifway, Tifgreen, Tifsport, and Premier and least for SWI-1117, Sunsport, SWI-1083, PSG-91215, and Numex Sahara.

Seed heads were present in greatest quantities for PST-R6EY, Princess 77, and PST-R6LA. No seed heads were present in OKC 1134 and few seed heads were present in Patriot, OKC-1119, Premier, and GN-1 (Table 2). As expected, cultivars established by seed had more seed heads present than those established vegetatively (Table 2).

There were significant differences in turf quality among cultivars in October 2007 (Table 1). At that time, SWI-1113, PST R6LA, OKS 2004-2, PST-R6FLT, and SWI-1070 were among the top-rated cultivars for turfgrass quality.

On five of the six rating dates in 2008, turf quality was greatest for vegetatively established cultivars (Table 3). In September, however, turf quality was greatest for cultivars established by seed. Turf quality in 2008 varied for each cultivar by month. Average turf quality across months for the year was highest for OKC-1119, OKC-1134, PSG-9Y20, Tifgreen, Quickstand, RAD-CD1, GN-1, Premier, and SWI-1113. Turf quality for the year was least for PSG-91215, PSG-9BAN, PSG-94524, Sunsport, and Numex Sahara.

These early data should be interpreted with caution since they are only the average of a few rating dates, and plots were less than 16 months old when rated. Historically, there are shifts in cultivar performance as the plots age and are subjected to various stresses. Additionally, these plots are maintained at 1.5 inches, which is common for a home lawn or sports field and may not compare well to previous data collected at our location at a lower mowing height of 0.5 inch (Patton et al., 2008). Future evaluations over the next four years will provide a more complete picture of the cultivars that perform best under these management and climate conditions.

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Table 1. Seedling vigor ratings, coverage, and quality ratings for various bermudagrass cultivars in Fayetteville, Ark. Data are from 1 season (2007) after planting on 9 June, 2007.

	Seedling vigor[z]		Coverage				Turf quality[y]
Cultivar	June 19	July 25	June 19	July 30	Aug. 23	Sept. 18	Oct. 5
	rated on a 1-9 scale		-------------------------------%-------------------------------				rating 1-9
BAR 7CD5[x]	2.3	2.3	2.3	16.3	84.0	98.7	5.7
Celebration	.	.	6.0	12.7	71.7	98.3	5.3
GN-1[w]	.	.			8.7	40.0	2.7
IS-01-201[x]	2.7	4.0	3.3	64.3	98.3	99.0	6.0
IS-CD10[x]	4.7	6.0	9.3	82.3	98.0	99.7	6.7
J-720[x]	4.3	5.7	8.3	93.3	99.3	100.0	6.3
Midlawn	.	.	8.0	16.3	55.0	95.3	5.7
NuMex -Sahara[x]	5.7	8.0	21.7	93.0	99.7	100.0	6.0
OKC 1119	.	.	6.7	9.0	37.7	91.7	5.0
OKC 1134	.	.	7.7	10.7	43.3	94.0	5.3
OKS 2004-2[x]	3.3	5.0	6.7	85.7	98.0	99.0	7.0
Patriot	.	.	8.3	23.0	70.0	98.3	5.7
Premier	.	.	10.3	20.7	75.0	99.0	5.3
Princess 77[x]	3.7	5.0	8.0	68.7	99.0	100.0	6.3
PSG 91215[x]	4.7	6.7	13.3	94.7	99.7	100.0	6.0
PSG 94524[x]	4.7	7.0	15.0	89.7	100.0	100.0	6.0
PSG 9BAN[x]	5.0	6.0	11.7	84.3	98.0	100.0	6.3
PSG 9Y2O[x]	4.3	4.7	10.0	60.0	94.3	99.3	6.3
PSG PROK[x]	3.7	5.0	8.3	56.0	93.3	99.3	6.0
PST R6EY[x]	3.7	4.7	5.3	65.0	96.7	99.3	6.7
PST R6LA[x]	2.7	4.3	4.7	63.0	98.7	100.0	7.0
PST R6ON[x]	3.7	5.3	7.0	62.7	93.3	98.0	6.7
PST-R6FLT[x]	2.7	3.7	5.7	46.3	89.7	99.7	7.0
Quickstand	.	.	9.3	30.3	91.7	99.7	6.0
RAD-CD1[x]	3.7	5.0	7.3	78.7	99.7	99.7	6.7
Riviera[x]	2.7	3.7	4.0	53.0	97.0	99.0	6.7
Sunsport[x]	6.0	7.7	28.3	81.3	99.3	100.0	6.0
SWI-1057[x]	3.7	6.0	11.3	93.0	99.0	100.0	6.3
SWI-1070[x]	4.3	5.7	11.0	90.3	99.3	100.0	7.0
SWI-1081[x]	3.0	4.7	8.7	59.3	94.3	99.7	6.0
SWI-1083[x]	4.7	7.3	20.0	96.0	99.7	100.0	6.7
SWI-1113[x]	4.3	6.7	18.3	91.3	100.0	100.0	7.7
SWI-1117[x]	5.0	7.3	20.0	95.3	99.7	100.0	6.0
SWI-1122[x]	4.0	6.0	9.3	78.3	96.0	99.3	6.3
Tifgreen[w]	.	.			8.7	53.3	4.0
Tifsport[w]	.	.		6.3	26.7	71.7	4.0
Tift-11[w]	.	.		2.7	24.0	76.7	4.7
Tifway	.	.	11.3	11.3	28.3	66.7	3.0
Veracruz[x]	2.3	3.7	3.3	46.3	96.0	98.3	5.7
Yukon[x]	4.0	4.7	10.0	55.3	87.0	97.7	5.7
Average	3.9	5.4	9.2	54.7	81.2	94.3	5.9
LSD (P=0.05)	1.7	1.7	9.2	30.3	14.0	7.9	1.0

[z] Seedling vigor was rated using a 1 to 9 (9= maximum vigor (quick germination and rapid growth), 1= representing no germination).
[y] Turf quality rated on a scale of 1 to 9 (9= ideal dark green, uniform, dense, fine-textured turf, 1=dead).
[x] Seeded bermudagrass cultivar.
[w] Cultivars GN-1, Tifgreen, Tifway, Tifsport, and Tift-11 were not planted until August 2007.

Table 2. Spring green-up, texture, color, density, and seed head ratings in 2008 for various bermudagrass cultivars in Fayetteville, Ark.

	Spring green-up [z]		Texture [y]	Color [x]	Density [w]	Seed heads [v]
Cultivar	April 7	April 30	July 21	July 18	July 21	July 21
	----- visually rated on a 1-9 scale -----					
BAR 7CD5 [u]	2.3	5.7	3.7	6.0	5.0	6.3
Celebration	2.7	6.0	5.7	7.0	6.0	7.0
GN-1	4.3	6.2	5.3	7.3	6.3	8.0
IS-01-201 [u]	2.0	4.7	5.0	6.0	4.3	5.7
IS-CD10 [u]	2.0	4.7	5.0	6.0	4.7	6.2
J-720 [u]	2.0	5.0	5.0	6.3	4.7	6.0
Midlawn	2.7	6.0	6.0	6.0	6.7	7.3
NuMex -Sahara [u]	2.0	3.0	3.7	5.8	2.3	6.0
OKC 1119	4.7	7.0	8.0	7.0	8.0	8.3
OKC 1134	4.3	7.7	7.3	6.7	7.7	9.0
OKS 2004-2 [u]	2.3	5.7	5.3	6.8	5.0	6.0
Patriot	2.0	5.7	6.0	7.5	6.7	8.3
Premier	2.7	5.3	7.3	7.5	7.0	8.0
Princess 77 [u]	1.0	2.7	4.7	6.3	4.0	4.3
PSG 91215 [u]	1.7	3.3	4.0	6.0	3.0	6.3
PSG 94524 [u]	2.0	3.7	4.3	6.3	3.7	6.7
PSG 9BAN [u]	2.0	4.8	4.7	6.5	3.7	5.7
PSG 9Y2O [u]	3.0	5.3	4.3	6.7	4.3	6.3
PSG PROK [u]	2.0	4.7	4.0	6.7	3.7	6.0
PST R6EY [u]	2.0	5.3	5.0	6.3	3.7	4.0
PST R6LA [u]	1.7	4.8	5.0	6.3	5.0	5.3
PST R6ON [u]	1.7	5.0	5.3	6.3	4.7	4.7
PST-R6FLT [u]	1.3	4.3	5.3	6.2	5.0	5.3
Quickstand	4.0	6.7	4.0	5.7	5.0	7.0
RAD-CD1 [u]	2.0	4.7	5.0	6.3	4.3	6.3
Riviera [u]	3.0	6.3	5.0	6.7	4.0	5.7
Sunsport [u]	1.7	3.3	4.3	6.3	3.3	6.3
SWI-1057 [u]	1.0	3.0	5.0	6.0	4.3	5.3
SWI-1070 [u]	2.3	5.3	5.0	6.3	4.7	6.3
SWI-1081 [u]	2.0	5.0	4.3	6.3	4.5	6.3
SWI-1083 [u]	1.7	4.7	4.0	7.2	3.3	6.0
SWI-1113 [u]	1.3	3.0	5.3	6.3	5.0	6.3
SWI-1117 [u]	2.0	3.7	4.0	6.2	3.5	6.0
SWI-1122 [u]	2.0	4.7	4.7	6.3	4.0	6.0
Tifgreen	5.3	7.7	6.7	6.2	7.3	7.7
Tifsport	4.3	6.8	6.7	6.3	7.3	7.3
Tift-11	3.3	6.5	5.3	7.0	6.0	6.7
Tifway	4.0	6.8	6.3	7.0	7.7	7.3
Veracruz [u]	1.7	3.3	4.7	6.3	4.7	6.0
Yukon [u]	3.0	6.0	5.3	6.2	5.3	6.7
Average	2.5	5.1	5.1	6.5	5.0	6.4
LSD (P=0.05)	0.8	1.2	0.8	0.8	1.3	1.1
Propagation type						
Seeded	2.0	4.5	4.7	6.3	4.2	5.9
Vegetative	3.7	6.5	6.2	6.8	6.8	7.7
P – value	<0.0001	<0.0001	<0.0001	0.0019	<0.0001	<0.0001

[z] Spring green-up was visually evaluated for bermudagrass cultivars using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand.
[y] Leaf texture was visually evaluated on a scale of 1 to 9, with 9 representing extremely fine turf texture and 1 representing extremely coarse texture.
[x] Turf genetic color was visually evaluated on a scale of 1 to 9, with 9 representing ideal, dark green turf and 1 representing tan or brown turf.
[w] Density was rated on a scale of 1 to 9, with 9 representing maximum density.
[v] Seed head density was evaluated using a scale of 1 to 9, with 9 representing no visible seed heads.
[u] Seeded bermudagrass cultivar.

Table 3. Turf quality ratings in 2008 for various bermudagrass cultivars in Fayetteville, Ark.

	Turfgrass Quality [z]						
Cultivar	May	June	July	August	September	October	Average
	--------visually rated on a 1-9 scale--------						
BAR 7CD5 [y]	4.5	5.7	5.8	6.3	6.8	5.3	5.8
Celebration	5.3	5.5	5.7	6.0	5.7	5.3	5.6
GN-1	5.8	6.8	6.0	7.0	6.5	7.0	6.5
IS-01-201 [y]	4.7	5.5	5.3	6.2	7.2	5.7	5.8
IS-CD10 [y]	4.8	5.7	6.0	5.7	7.3	5.7	5.9
J-720 [y]	5.0	5.8	5.0	6.2	6.8	6.0	5.8
Midlawn	6.0	7.3	5.8	5.3	6.3	6.3	6.2
NuMex -Sahara [y]	3.7	4.7	4.5	5.0	6.0	5.0	4.8
OKC 1119	6.5	7.2	7.3	7.0	7.3	6.7	7.0
OKC 1134	7.0	7.5	6.5	6.5	6.2	7.3	6.8
OKS 2004-2 [y]	5.5	6.0	5.5	6.2	6.5	6.0	5.9
Patriot	5.0	7.0	6.2	6.7	6.3	5.3	6.1
Premier	5.8	6.3	6.7	6.7	6.8	6.7	6.5
Princess 77 [y]	4.5	4.8	5.3	6.8	6.7	6.3	5.8
PSG 91215 [y]	4.7	5.0	5.7	5.3	6.3	5.7	5.4
PSG 94524 [y]	4.0	5.2	5.5	5.3	6.8	5.7	5.4
PSG 9BAN [y]	4.3	5.0	5.0	6.2	6.7	5.3	5.4
PSG 9Y2O [y]	5.2	5.8	6.2	7.3	7.5	7.7	6.6
PSG PROK [y]	4.3	5.3	5.7	6.3	7.3	6.7	5.9
PST R6EY [y]	5.0	5.3	4.0	6.0	7.0	6.0	5.6
PST R6LA [y]	5.2	5.8	4.7	6.3	6.7	5.7	5.7
PST R6ON [y]	5.0	5.2	4.3	6.0	6.5	6.0	5.5
PST-R6FLT [y]	5.0	5.5	5.3	6.7	7.2	6.0	5.9
Quickstand	5.5	6.7	6.3	6.7	7.2	7.0	6.6
RAD-CD1 [y]	5.7	5.5	5.8	7.0	7.5	7.7	6.5
Riviera [y]	5.5	6.0	5.3	6.0	6.5	5.3	5.8
Sunsport [y]	3.7	4.5	5.2	5.3	7.0	5.7	5.2
SWI-1057 [y]	4.7	5.0	4.7	6.2	6.5	6.0	5.5
SWI-1070 [y]	4.5	6.0	6.2	6.0	7.2	6.3	6.0
SWI-1081 [y]	5.3	5.5	5.7	6.8	7.0	6.3	6.1
SWI-1083 [y]	4.8	5.0	5.3	6.0	7.0	5.3	5.6
SWI-1113 [y]	4.7	6.2	6.2	6.3	7.8	7.3	6.4
SWI-1117 [y]	4.0	4.7	5.5	5.8	7.0	6.0	5.5
SWI-1122 [y]	4.5	5.8	5.7	6.3	6.7	6.7	5.9
Tifgreen	6.0	6.8	6.0	7.0	7.2	6.7	6.6
Tifsport	5.7	6.7	5.7	6.8	6.3	6.3	6.3
Tift-11	6.2	5.8	5.8	7.0	6.7	6.0	6.3
Tifway	5.7	6.5	6.0	6.5	6.2	6.3	6.2
Veracruz [y]	5.2	5.7	5.7	6.5	7.3	7.0	6.2
Yukon [y]	5.2	6.2	6.0	6.3	6.8	5.7	6.0
Average	5.1	5.8	5.6	6.3	6.8	6.2	6.0
LSD (P=0.05)	1.2	0.9	1.0	1.1	0.9	1.4	0.7
Propagation type							
Seeded	4.8	5.4	5.4	6.2	6.9	6.1	5.8
Vegetative	5.9	6.7	6.2	6.6	6.6	6.4	6.6
P - value	<0.0001	<0.0001	<0.0001	0.0056	0.0059	0.0783	<0.0001

[z] Turf quality rated on a scale of 1 to 9 (9= ideal dark green, uniform, dense, fine-textured turf, 1=dead).
[y] Seeded bermudagrass cultivar.

2007 NTEP Seashore Paspalum Trial – Year 1 and 2 Results

Aaron Patton[1], Mike Richardson[2], Doug Karcher[2], and Jon Trappe[1]

Additional index words: *Paspalum vaginatum*, turfgrass, cultivars, quality, color, spring green-up, leaf texture, seed heads, salt

Photo by Aaron Patton

Seashore paspalum cultivar trial

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Summary. Seashore paspalum is a new turfgrass species being evaluated for use in Arkansas for golf courses or sports fields. Identifying adapted cultivars for the region remains a central focus of the University of Arkansas turfgrass research program. The National Turfgrass Evaluation Program is the predominant means by which cultivars are tested throughout North America. A seashore paspalum cultivar trial was planted in the summer of 2007 at Fayetteville, Ark. This trial is maintained under typical golf course fairway conditions and data on spring green-up, overall quality, leaf color, leaf texture, and seed head formation were collected from 2007 through 2008. Overall, 2008 turf quality was greatest for seashore paspalum cultivars UGA 7, UGA 22, and Sea Isle 1. Future rating over the next four years will provide a more complete picture of the cultivars that perform best under these management conditions in our climate.

Abbreviations: NTEP, National Turfgrass Evaluation Program

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A number of new seashore paspalum (*Paspalum vaginatum*) cultivars have appeared on the market in the past decade as several commercial and academic breeding programs have begun to identify and work with new germplasm. Seashore paspalum has excellent salinity tolerance, color, and mowing quality. Thus, the interest in and use of seashore paspalum has increased in recent years.

The National Turfgrass Evaluation Program (NTEP) is an organization within the U.S. Dept. of Agriculture that annually oversees turfgrass cultivar evaluation experiments at various sites throughout the U.S. and Canada. Each turfgrass species is tested on a four- to five-year cycle at sites throughout the growing region for that particular species. The University of Arkansas has been an active participant in the NTEP and has conducted several tests on other species since 1986. This report will describe the data collected in 2007 and 2008 for the 2007 NTEP Seashore Paspalum Trial at Fayetteville, Ark.

Materials and Methods

The entries were planted on 9 June 2007 at the University of Arkansas Research and Extension Center in Fayetteville. Plot size was 7 by 7 ft and there were three replications of each cultivar. Vegetative cultivars were planted as 2-inch diameter plugs on 12-inch spacings within the plots, while seeded cultivars were broadcast planted at a seeding rate of 1.0 lb/1000 ft^2. Plots were maintained under golf course fairway conditions, with a mowing height of 0.5 inch and monthly applications of 0.5 lb N/1000 ft^2 during the growing season. Irrigation was applied as needed to promote germination and establishment and to prevent stress.

Overall turf quality was evaluated monthly beginning October 2007. Quality was visually assessed on a 1 to 9 scale, with 9 representing ideal dark green, uniform, fine-textured turf and 1 representing dead turf. Seedling vigor was rated using a 1 to 9 scale, with 9 representing maximum vigor (quick germination and rapid growth) and 1 representing no germination. Turfgrass coverage was also monitored throughout the study as visual estimates. Turf genetic color was visually evaluated on a scale of 1 to 9, with 9 representing ideal, dark green turf and 1 representing tan or brown turf. Leaf texture was visually evaluated on a scale of 1 to 9, with 9 representing extremely fine turf texture and 1 representing extremely coarse texture. Cultivars were visually evaluated for spring green-up using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand. Density was rated on a scale of 1 to 9, with 9 representing maximum density. Seed head density was evaluated using a scale of 1 to 9, with 9 representing no visible seed heads.

Results and Discussion

There were no significant differences in seedling vigor among the two cultivars of seeded seashore paspalum planted in our trial (Table 1). There were few differences in turf coverage during establishment among the cultivars established in this trial, with the exception of one early date (30 July 2007) where seeded cultivars were less established initially and when Sea Isle 1 was less established than other vegetatively established cultivars (Table 1).

Spring green-up was greatest for UGA 22, Salam, and Sea Isle 1 (Table 2). Spring green-up was slowest for UGA 31, UGA 7, and SRX9HSCP. Among individual cultivars, leaf texture was finest among UGA 31, UGA 22, UGA 7, and Sea Isle 1. Turfgrass genetic color was darkest green for UGA 7 and UGA 31. Turfgrass density was greatest for UGA 7, Sea Isle 1, UGA 22, and UGA 31. Seed heads were present in greatest quantities for Salam and Sea Isle 1 in June and greatest for Sea Isle 1, Salam, and UGA 31 in July (Table 2).

There were no differences in turf quality among cultivars in October 2007 (Table 1). On two of the six rating dates in 2008, there were differences in turf quality (Table 3). In July, turf quality was greatest for UGA 7, Sea Isle 1, UGA 22, and SRX9HSCP. Turf quality was highest in September for UGA 7, UGA 22, Sea Spray, Sea

Isle 1, UGA 31, and SRX9HSCP with Salam having the lowest turf quality. Overall, 2008 turf quality means were greatest for UGA 7, UGA 22, and Sea Isle 1.

These early data should be interpreted with caution since they are only the mean of a few rating dates, and plots were less than 16 months old when rated. Historically, there are shifts in cultivar performance as plots age and are subjected to various stresses. Future rating over the next four years will provide a more complete picture of the cultivars that perform best under these management conditions in our climate.

Table 1. Seashore paspalum seedling vigor ratings, coverage, and quality ratings for various cultivars in Fayetteville, Ark. Data are from 1 season (2007) after planting on 9 June 2007.

	Seedling vigor[z]	Coverage				Turf quality[y]
Cultivar	July 25	July 30	August 23	Sept. 18	Oct. 5	Oct 5
	rating 1-9	----------------------------%------------------------------				rating 1-9
Salam		10.7	41.0	93.0	99.0	6.0
Sea Isle 1		6.7	31.0	92.3	98.3	6.0
Seaspray[x]	2.7	1.7	55.0	96.7	99.7	6.7
SRX9HSCP[x]	4.0	2.0	25.0	91.3	97.7	5.7
UGA 22		9.3	37.7	93.0	99.3	6.3
UGA 31		9.3	39.3	86.7	96.3	5.7
UGA 7		10.3	37.0	96.0	99.7	6.3
Mean	3.3	7.1	38.0	92.7	98.6	6.1
LSD (P=0.05)	NS	2.1	NS	NS	NS	NS

[z] Seedling vigor was rated using a 1 to 9 (9= maximum vigor (quick germination and rapid growth), 1= representing no germination).
[y] Turf quality rated on a scale of 1 to 9 (9= ideal dark green, uniform, dense, fine-textured turf, 1=dead).
[x] Seeded seashore paspalum cultivar.

Table 2. Seashore paspalum spring green-up, texture, color, density, and seed head ratings in 2008 for various cultivars in Fayetteville, Ark.

	Spring green-up		Texture	Color	Density	Seed heads	
Cultivar	April 7	April 30	July 21	July 18	July 21	June 23	July 21
	---------------------------------------visually rated on a 1-9 scale---------------------------------------						
Salam	5.0	7.0	7.0	6.8	6.8	6.3	4.3
Sea Isle 1	5.0	7.0	7.5	7.2	7.8	5.7	4.7
Seaspray [y]	4.3	7.2	7.2	6.3	6.5	4.7	3.3
SRX9HSCP [y]	4.0	7.0	7.2	7.0	6.8	3.7	3.0
UGA 22	5.0	7.5	7.7	7.0	7.3	4.3	2.7
UGA 31	3.7	7.0	7.7	7.8	7.2	4.0	4.0
UGA 7	4.0	7.2	8.0	7.8	8.0	2.0	2.7
Mean	4.4	7.1	7.5	7.1	7.2	4.4	3.5
LSD (P=0.05)	0.6	NS	0.5	0.4	0.9	1.2	1.2

[z] Cultivars were visually evaluated for spring green-up using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand. Leaf texture was visually evaluated on a scale of 1 to 9, with 9 representing extremely fine turf texture and 1 representing extremely coarse texture. Turf genetic color was visually evaluated on a scale of 1 to 9, with 9 representing ideal, dark green turf and 1 representing tan or brown turf. Density was rated on a scale of 1 to 9, with 9 representing maximum density. Seed head density was evaluated using a scale of 1 to 9, with 9 representing no visible seed heads.
[y] Seeded seashore paspalum cultivar.

Table 3. Seashore paspalum turf quality ratings in 2008 for various cultivars in Fayetteville, Ark.

	Turfgrass quality [z]						
Cultivar	May	June	July	August	September	October	Mean
	---------------------------------------visually rated on a 1-9 scale---------------------------------------						
Salam	6.0	6.0	6.8	5.7	6.0	6.0	6.1
Sea Isle 1	6.7	6.3	7.8	6.8	7.2	7.5	7.1
Seaspray [y]	6.0	5.7	7.0	6.0	7.0	7.5	6.5
SRX9HSCP [y]	6.0	6.7	7.5	6.3	7.2	7.0	6.8
UGA 22	6.7	6.0	7.7	7.0	7.8	7.8	7.2
UGA 31	5.3	6.3	7.2	6.8	7.7	7.3	6.8
UGA 7	6.7	7.7	8.2	7.7	8.0	8.2	7.7
Mean	6.2	6.4	7.5	6.6	7.3	7.3	6.9
LSD (P=0.05)	NS	NS	0.8	NS	0.9	NS	0.9

[z] Turf quality rated on a scale of 1 to 9 (9= ideal dark green, uniform, dense, fine-textured turf, 1=dead).
[y] Seeded seashore paspalum cultivar.

Herbicide Safety Varies on ‘Sea Spray’ Seashore Paspalum Seedlings


Photo by Aaron Patton

Herbicide damage on seashore paspalum seedlings

Aaron Patton[1], Jon Trappe[1], and Mike Richardson[2]

Additional index words: establishment, salt, *Paspalum vaginatum*, injury, coverage

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Summary. There are no reports of herbicide tolerance on seedling seashore paspalum, and currently only one herbicide is labeled for use on these seedlings. The objective of this study was to determine which herbicides cause the least amount of injury to seashore paspalum seedlings. Field studies were conducted in 2008 to assess the tolerance of seeded Sea Spray seashore paspalum to various herbicides. Treatments were applied two weeks after emergence of seedlings and compared to an untreated control and a salt water treatment. Greatest phytotoxicity and reduction in turfgrass coverage resulted from applications of Fusilade II, MSMA, Image 1.5 EC, Prograss, Velocity, Acclaim Extra, and Turflon Ester. Turfgrass coverage at two weeks after application was greatest for seashore paspalum treated with Lontrel, SedgeHammer, Blade, Drive 75DF, Quicksilver, salt water, Tourney, Pendulum Aquacap 3.8 AC, Dismiss, Barricade 4L, Ronstar G, Kerb, Trimec Classic, Trimec Southern, Spotlight, Certainty and the untreated check.

Abbreviations: NTEP, National Turfgrass Evaluation Program; DAA, days after application; WAA, weeks after application; WAE, weeks after emergence

[1] University of Arkansas, Cooperative Extension Service, Department of Horticulture, Fayetteville, Ark. 72701.
[2] University of Arkansas, Department of Horticulture, Fayetteville, Ark. 72701

A number of new seashore paspalum (*Paspalum vaginatum*) cultivars have appeared on the market in the past decade as several commercial and academic breeding programs have begun to identify and work with new germplasm. The interest in this species, which has excellent salinity tolerance, has increased and cultivars have been evaluated nationally since 2007 through the National Turfgrass Evaluation Program (NTEP), including a location in Fayetteville, Ark (Patton et al., 2009).

Seeded cultivars provide a quick, easy, and economical way to establish a high-quality seashore paspalum turf. As seeded cultivars are relatively new compared to vegetatively established cultivars of seashore paspalum, there are several factors that need to be investigated. Weed control is often very important in establishing turf from seed as effective weed control programs will decrease competition, increase establishment rate, and decrease the grow-in period.

The ability to control weeds during the first six to eight weeks after emergence is a key factor to the success of seeded warm-season grasses such as bermudagrass and zoysiagrass. Summer annual grasses such as crabgrass and goosegrass are very competitive with new seedlings and broadleaf weeds may also create problems through shading of young seedlings. Therefore, competition during the seedling stage could significantly prolong stand establishment and reduce overall stand density. Additionally, bermudagrass continues to be an aggressive weed in seashore paspalum swards. Little is known about effective herbicides that may be used during the establishment of seashore paspalum from seed.

There are no reports of herbicide tolerance on seedling seashore paspalum, and currently only Drive (quinclorac) is labeled for use on seashore paspalum seedlings. Most herbicide labels specify use only on established seashore paspalum. On established Salam seashore paspalum, Lontrel (clopyralid), Banvel (dicamba), SedgeHammer (halosulfuron), Image (imazaquin), Trimec Southern (mecoprop + 2,4-D + dicamba), Blade or Manor (metsulfuron), and Drive were found to cause little toxicity (Unruh et al., 2006). Duncan (1998) also identified that Kerb (pronamide), Ronstar (oxadiazon) and Pendulum (pendimethalin) could be used for preemergence control of weeds in seashore paspalum turf. Lastly, sea water has even been found to be an effective herbicide for postemergence control of weeds in Adalyad seashore paspalum (Wiecko, 2003). It is important to evaluate a range of herbicides to determine which are optimal during establishment from seed.

Currently, Dismiss (sulfentrazone), Quicksilver (carfentrazone), Lontrel, Speedzone Southern (2,4-D + mecoprop + dicamba + carfentrazone), SedgeHammer, Ronstar, Dimension (dithiopyr), and Barricade (prodiamine) are labeled for use on established seashore paspalum, but not on seedlings. The objective of this research study is to determine which herbicides are safe for use on Sea Spray seashore paspalum seedlings.

Materials and Methods

Research was conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville, Ark. Experiments were seeded on 13 June 2008 with 0.9 lb pure live seed 1000/ft^2 of 'Sea Spray' seashore paspalum in an area that was fumigated with methyl bromide in 2007. The experimental area was tilled and raked immediately prior to seeding. This provided a relatively weed-free site on which herbicide injury could be closely monitored. Additional weed germination was minimal, and those weeds were mechanically removed so as not to interfere with analysis. Plots were covered with a germination blanket until germination occurred to prevent the movement of seed. Experimental design was a randomized complete block with four replications of each herbicide treatment and an individual plot size of 20 ft^2. Plots were treated with various herbicides (Table 1) at two weeks after emergence (WAE). A fungicide, thought to be injurious to bermudagrass, was also included. Emergence occurred on 25 June 2008 and was defined as a uniform stand of one-leaf seedlings. A non-ionic surfactant (Latron AG-98, 0.25% v/v) was added to each herbicide prior to application on 8 July 2008. Herbicides were applied in 30 gal/A with a CO_2-pressurized sprayer at 30 psi. A salt water treatment was included and applied as 32,000 ppm (50 dS/m) in 288 gal/A per plot using NaCl. Salt water was applied on three consecutive days starting at 2 WAE. Five untreated plots were used as an untreated check for comparison. Plots were mown as needed at 0.5 inch when seedlings first reached 0.75 inch.

Digital image analysis was used to determine seashore paspalum coverage (Richardson et al., 2001) starting 1 week after herbicide application (WAA) and continued on until the majority of the plots reach 100% coverage. Herbicide injury was rated visually three times during the first 10 days after application (DAA) using a scale of 0 to 100 where 0 = no visible injury and 100 = brown turf.

Results and Discussion

There were significant differences in herbicide phytotoxicity and bermudagrass coverage following application. Greatest phytotoxicity and reduction in turfgrass coverage resulted from applications of Fusilade, MSMA, Image, Prograss, Velocity, Acclaim Extra, and Turflon Ester (Table 2). Turfgrass coverage at 2 WAA was greatest for seashore paspalum treated with Lontrel, SedgeHammer, Blade, Drive, Quicksilver, salt water, Tourney, Pendulum, Dismiss, Barricade, Ronstar, Kerb, Trimec Classic, Trimec Southern, Spotlight, Certainty, or the untreated check (Table 2). Coverage at 6 WAA was greatest for Dismiss, Quicksilver, Lontrel, Spotlight, Speedzone Southern, Trimec Classic, Trimec Southern, Drive, Blade, Certainty, SedgeHammer, Kerb, Ronstar, MSMA, Pendulum, Prograss, Dimension, Barricade, Tourney, Image, salt water treatment, and the untreated check (Table 2). Although Image, Prograss, and MSMA caused injury during the 2008 trial, turfgrass coverage in plots treated with these herbicides was not different than the untreated control at 6 WAA. Coverage at 6 WAA was lowest for Acclaim Extra, Tupersan, Turflon Ester, Fusilade II, and Velocity (Table 2). Based on first- and second-year results, Lontrel, SedgeHammer, Blade, Drive, Quicksilver, salt water treatment, and Tourney provided the greatest safety for applications to seedling seashore paspalum (Table 3). Other recommendations for more established seedlings as well as herbicides that should be avoided are provided in Table 3.

Acknowledgements

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Table 1. Herbicides or fungicide, trade names and application rates evaluated in 2008 for safety on 'Sea Spray' seedlings.

		Rate	
Trade name	Common name	pounds a.i. /A	oz product / A
Acclaim Extra	fenoxaprop-ethyl	0.089	20
Barricade 4L	prodiamine	1.5	48
Blade	metsulfuron	0.02	0.5
Certainty	sulfosulfuron	0.05	1.0
Certainty	sulfosulfuron	0.06	1.25
Dimension 2EW	dithiopyr	0.5	32
Dismiss 4L	sulfentrazone	0.25	8
Drive 75DF	quinclorac	0.75	16
Fusilade II	fluazifop-P-butyl	0.06	4
Image 1.5 EC	imazaquin	0.5	42.7
Kerb 50WP	pronamide	1.0	32
Lontrel 3L	clopyralid	0.37	16
MSMA 6	MSMA	2.0	42.6
Pendulum Aquacap 3.8 AC	pendimethalin	1.5	50
Prograss 1.5EC	ethofumesate	1.5	128
Quicksilver	carfentrazone	0.031	2.1
Ronstar G	oxadiazon	3.0	2,400
Sedge Hammer	halosulfuron	0.05	1.0
Speedzone Southern	carfentrazone + 2,4-D + MCPP + dicamba	0.01 + 0.13 + 0.05 + 0.01	32
Spotlight 1.5L	fluroxypyr	0.37	32
Tourney	metconazole	0.05	1
Trimec Classic	2,4-D + MCPP + dicamba	0.5 + 0.13 + 0.05	32
Trimec Southern	MCPP + 2,4-D + dicamba	0.33 + 0.36 + 0.07	32
Tupersan 50WP	siduron	4.0	128
Turflon Ester 4L	triclopyr	1.0	32
Velocity	bispyribac-sodium	0.1	9

Table 2. Herbicide or fungicide injury and Sea Spray seashore paspalum coverage at various timings after application in 2008.

Treatment	Herbicide or fungicide injury			Seashore paspalum coverage		
	3 [z]DAA	6 DAA	8 DAA	2 WAA	3 WAA	6 WAA
	--------	--------	--------	%	--------	--------
Acclaim Extra[y]	10.0 c-g [x]	78.8 a	89.3 a	3.2 f	18.8 e	66.4 b
Barricade	1.3 g	11.3 g-i	5.0 ij	97.4 a	97.4 a	97.0 a
Blade	0.0 g	6.7 h-i	6.7 h-i	98.1 a	99.0 a	98.0 a
Certainty (1.0 oz/A)	1.3 g	7.5 h-i	10.0 g-j	92.6 ab	98.2 a	97.6 a
Certainty (1.25 oz/A)	6.3 d-g	33.8 bcd	25.0 efg	80.7 bc	79.7 c	97.1 a
Dimension	2.5 fg	13.8 f-i	12.5 g-j	69.4 cd	76.8 c	98.1 a
Dismiss	41.3 ab	28.8 c-g	12.5 g-j	98.2 a	99.2 a	96.6a
Drive	7.5 d-g	18.8 d-i	8.8 h-i	98.6 a	98.6 a	98.6 a
Fusilade	15.0 cde	86.3 a	94.3 a	0.7 f	0.8 f	8.9 c
Image	15.0 cde	41.3 bc	52.5 cd	63.0 d	82.9 bc	99.8 a
Kerb	7.5 d-g	13.8 f-i	21.3 fgh	95.7 a	96.2 ab	99.1 a
Lontrel	2.5 fg	5.0 h-i	5.0 ij	99.2 a	99.2 a	98.1 a
MSMA	51.3 a	77.5 a	71.3 b	45.9 e	88.7 abc	98.1 a
Pendulum	1.3 g	2.5 i	0.0 j	99.2 a	98.9 a	96.9 a
Prograss	16.3 cd	47.5 b	55.0 c	6.6 f	36.1 d	86.7 a
Quicksilver	3.3 fg	13.3 f-i	0.0 j	98.3 a	99.1 a	96.0 a
Ronstar	1.7 g	15.0 e-i	20.0 ghi	96.6 a	98.6 a	97.3 a
Salt	5.0 efg	15.0 e-i	13.8 g-j	98.8 a	99.4 a	99.1 a
SedgeHammer	0.0 g	6.7 h-i	6.7 h-i	98.3 a	99.4 a	99.2 a
Speedzone Southern	10.0 c-g	18.8 d-i	7.5 h-i	98.5 a	99.4 a	98.6 a
Spotlight	12.5 c-f	21.3 d-h	21.3 fgh	87.7 ab	97.0 a	98.0 a
Tourney	5.0 efg	15.0 e-i	13.8 g-j	99.5 a	99.6 a	99.7 a
Trimec Classic	12.5 c-f	30.0 b-f	18.8 ghi	94.8 ab	97.7 a	99.2 a
Trimec Southern	31.3 b	41.3 bc	36.3 ef	91.1 ab	96.5 ab	97.9 a
Tupersan	0.0 g	32.5 b-e	37.5 de	1.9 f	2.6 f	34.0 c
Turflon	37.5 b	76.3 a	83.8 ab	4.5 f	8.4 ef	34.7 c
Velocity	20.0 c	85.5 a	90.8 a	0.5 f	1.2 f	7.9 c
Untreated check	3.1 fg	8.8 h-i	6.3 h-i	99.0 a	99.1 a	99.2 a

[z] DAA, days after application; WAA, weeks after application.
[y] Treatments sorted according to turfgrass coverage at 8 weeks after application (WAA).
[x] Values in a column followed by the same letter are not significantly different from one another (LSD, α=0.05).

Table 3. Recommendations for herbicide application to Sea Spray seashore paspalum seedlings based on two years of research.

Application timing	Herbicides
Recommended for use on seedlings 2 weeks after seedling emergence or later:	Lontrel, SedgeHammer, Manor/Blade, Drive 75DF, Quicksilver, salt water treatment, Tourney fungicide
Safe to use on seedlings at least one month after emergence (NOTE: this is a conservative recommendation, some of these products could be used earlier with little additional risk)	Dismiss, Spotlight, Speedzone southern, Trimec Classic, Trimec Southern, Certainty, Kerb, Ronstar, Pendulum, Dimension,and Barricade
Do not use on Sea Spray seedlings:	MSMA, Image, Tupersan, Turflon Ester, Fusilade, Acclaim Extra, Velocity, and Prograss

Seed Covers and Germination Blankets Influence Seeded Warm-Season Grass Establishment–Year 2

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Additional index words: bermudagrass, buffalograss, centipedegrass, seashore paspalum, zoysiagrass, *Cynodon dactylon, Buchloe dactyloides, Eremochloa ophiuroides, Zoysia japonica, Paspalum vaginatum*

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Photo by Aaron Patton

Various seed cover technologies

Summary. Covers and blankets are often used to reduce erosion, retain soil moisture, increase soil temperature, and enhance plant germination and establishment rates. There are reports of various effects of seed cover technology on the germination and establishment of warm-season grasses. The objective of this study was to determine how diverse seed covers influence the establishment of seeded bermudagrass, buffalograss, centipedegrass, seashore paspalum, and zoysiagrass. Plots were seeded on 9 June 2007 with various species and covered with seed-cover technologies including Curlex, Deluxe, Futerra, jute, poly jute, polypropylene, straw, straw blanket, thermal blanket, and an uncovered control. Overall, Curlex, Deluxe, Futerra products, jute, poly jute, straw blankets, thermal blankets and the untreated check allowed for the greatest establishment of these seeded warm-season grasses. Uncovered plots performed well in 2008 suggesting that seed covers are not always needed for successful establishment. Typically, most seed-cover technologies are useful for the establishment of warm-season grasses from seed, especially for reducing erosion during establishment.

Abbreviations: PLS (pure live seed)

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Covers and blankets are often used to protect turf during winter and spring, to warm the soil and increase germination rates, and also to reduce erosion. Seed germination blankets allow light penetration and gas exchange, facilitate soil warming, and increase soil moisture-holding capacity, all of which increase germination rates without the risk of excessive temperature build-up. It is known that germination of warm-season turfgrasses increases as temperatures rise, with maximum germination rate occurring between 86 and 95°F (Portz et al., 1981; Zuk et al., 2005).

Yu and Yeam (1967) reported that the germination rate of zoysiagrass (*Zoysia japonica*) seed could be doubled by using a polyethylene film, and Portz et al. (1993) found that clear polyethylene covers placed over the seedbed for 7 or 14 days after seeding increased germination and zoysiagrass coverage in Illinois and Maryland. Other materials tested such as straw (80 lb/1000 ft^2), did not enhance germination because they excluded light and reduced soil temperatures (Portz et al., 1993). Organic fiber mats increased establishment when used in non-irrigated areas, likely due to increased soil moisture retention, but did not increase establishment when used in irrigated plots (Hensler et al., 2001). Anecdotal evidence suggests that porous germination blankets could also be useful for increasing bermudagrass and zoysiagrass germination and coverage (Patton et al., 2004).

Overall, past research shows different effects from cover technologies, but no broad comparison has been made between different cover technologies. Additionally, no cover research has been done with seeded seashore paspalum (*Paspalum vaginatum*), and very little work with seeded bermudagrass (*Cynodon dactylon*), buffalograss (*Buchloe dactyloides*), and centipedegrass (*Eremochloa ophiuroides*). The objective of this study is to determine how various seed covers influence the germination and establishment of five seeded warm-season grasses.

Materials and Methods

Research was conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville, Ark. Experiments were seeded 1 July 2008 with bermudagrass at a rate of 1.0 lb. pure live seed (PLS)/1000 ft^2, zoysiagrass at a rate of 2.0 lb. PLS/1000 ft^2, seashore paspalum at a rate of 1.0 lb. PLS/1000 ft^2, centipedegrass at a rate of 0.5 lb. PLS/1000 ft^2, and buffalograss at a rate of 8.0 lb. PLS/1000 ft^2. Prior to seeding, the experimental area was tilled and raked to prepare the soil for seeding. The plot area was fumigated with methyl bromide in the spring of 2007, which provided a weed-free site on which establishment of various grasses could be closely monitored.

After seeding, plots were covered with various germination blanket technologies (Table 1). Plots were irrigated as needed to maintain a moist seed bed for four weeks after seeding based upon the frequency of natural rainfall. Temporary covers (Table 1) were removed 14 days after seeding. The experimental design was a split block with three replications. Both cover technology and species were applied as strips. Turfgrass coverage was determined by visual estimates.

Results and Discussion

There was a significant cover x species interaction and thus cover data will be presented separately by species. Bermudagrass coverage was greatest for plots covered with Deluxe, Futerra, Futerra netless, jute, poly jute, thermal blanket, and the untreated check. Bermudagrass coverage was least for straw-covered plots. These results are similar to those recorded in 2007 except for the uncovered check, which had less coverage than most cover technology treatments (Patton et al., 2008).

Buffalograss coverage was greatest for plots covered with Curlex, Deluxe, Futerra, Futerra netless, jute, poly jute, straw blanket, thermal blanket, and the untreated check. Buffalograss coverage was least in the polyethylene- and straw-covered plots. These results are similar to previous results except for the uncovered check and the thermal blanket, which had less coverage than most cover technology treatments in 2007 (Patton et al., 2008).

Centipedegrass coverage was greatest for plots covered with Curlex, Deluxe, Futerra, Futerra netless, Jute, Poly Jute, straw blanket, thermal blanket, and the untreated check. Centipedegrass coverage was least in the polyethylene- and straw-covered plots. These results are similar to previous results except for the uncovered check, Deluxe, and the thermal blanket, which had less coverage than most cover technology treatments in 2007 (Patton et al., 2008). Thus, polyethylene and straw are not recommended for centipedegrass establishment.

Seashore paspalum coverage was greatest for plots covered with Deluxe, Futerra, Jute, Poly Jute, and the untreated check. Seashore paspalum coverage was least for plots covered with Curlex, Futerra netless, polyethylene, straw, straw blanket, and the Thermal blanket. In 2007, seashore pasaplum establishment was least for Curlex, straw, straw blankets, and the uncovered check (Patton et al., 2008). Based on data for both years, avoid the use of straw, straw blanket, clear polyethylene (based on poor 2008 results), uncovered soil (poor results in 2007), and Curlex to establish seashore paspalum from seed, and instead use Futerra original, Futerra netless, poly jute, jute, or Deluxe to establish seashore paspalum from seed.

Zoysiagrass coverage was similar for all cover treatments except for straw-covered plots, which had significantly lower coverage. In both years, Futerra products and Curlex allowed for the most zoysiagrass establishment (Patton et al., 2007) and thus are recommended for use in establishing zoysiagrass, although other technologies will provide acceptable results.

Overall, Curlex, Deluxe, Futerra products, jute, poly jute, straw blanket, thermal blanket and the untreated check allowed for the greatest establishment of these seeded warm-season grasses in 2008. Across years, Deluxe, Futerra products, jute, poly jute, and thermal blanket allowed for the greatest establishment of these seeded warm-season grasses. Polyethylene-covered plots reduced coverage in 4 of the 5 species in 2008, which was likely due to temperature build-up under these covers (data not shown). Straw-covered plots reduced establishment in both years of the study, likely due to shading of seedlings. Uncovered plots performed well in 2008 and poorly in 2007, suggesting that seed covers are not always needed for successful establishment but that they are useful. Typically, most seed cover technologies are useful for the establishment of warm-season grasses from seed, especially for reducing erosion during establishment.

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Table 1. Cover technologies tested in the trial.

Cover technology	Cover construction	Cover type
Clear polyethylene cover 4 mil (0.1 mm, 4/1000")	Polyethylene	Temporary
Curlex, natural color	Curled excelsior aspen wood fiber mat	Permanent
Deluxe (0.5 oz crop protection fabric), Dewitt Company	[z]	Temporary
Futerra F4 Netless, natural color, Profile Products LLC (6.5' × 90')	[z]	Permanent
Futerra original, natural color, Profile Products LLC (82" × 135')	[z]	Permanent
Jute mesh erosion control mat (mesh fabric)	[z]	Permanent
Poly Jute erosion control blanket, Dewitt Company	Polypropylene multifilament yarn	Permanent
Straw [y], (Portz et al., 1993)	[z]	Permanent
Straw blanket with polypropylene netting	Straw and polypropylene	Permanent
Thermal blanket (3 oz.) Dewitt Company	Polypropylene	Temporary
Uncovered check		

[z] Information about the material used to construct the covers was not readily available on company websites.
[y] 80 lbs / 1000ft^2.

Table 2. Turfgrass coverage for various seeding blankets five weeks after planting.

Cover treatment	Species					Average
	Bermudagrass	Buffalograss	Centipedegrass	Seashore	Zoysiagrass	
	turfgrass coverage (%)					
Deluxe	92.6 a [z]	88.3 a	63.3 a	66.7 a	50.0 a	72.2
Jute	83.3 ab	83.3 ab	58.3 ab	53.3 abc	46.7 a	65.0
Uncovered check	86.6 ab	78.3 ab	53.3 ab	60.0 ab	41.7 a	64.0
Futerra	75.0 ab	73.3 abc	60.0 ab	51.7 abc	41.7 a	60.3
Poly Jute	85.0 ab	73.3 abc	41.7 ab	53.3 abc	33.3 ab	57.3
Thermal blanket	73.3 ab	71.7 abc	51.6 ab	40.0 bcd	48.3 a	57.0
Futerra F4 Netless	71.6 ab	68.3 abc	53.3 ab	41.7 bcd	41.7 a	55.3
Curlex	68.3 b	73.3 abc	58.3 ab	31.7 cd	40.0 ab	54.3
Straw blanket	65.0 b	78.3 ab	45.0 ab	28.3 d	31.7 ab	49.7
Polyethylene	68.3 b	53.3 c	18.3 c	28.3 d	46.7 a	43.0
Straw	35.0 c	61.7 bc	38.3 bc	20.0 d	18.3 b	34.7
Average	73.1	73.0	49.2	43.2	40.0	55.7

[z] Within columns, means followed by the same letter are not significantly different (LSD, α= 0.05).

Sulfonylurea Herbicide Safety on Sprigged Bermudagrass and Seashore Paspalum

Aaron Patton[1] and Jon Trappe[1]

Additional index words: Blade, Manor, Certainty, Monument, Revolver, SedgeHammer, metsulfuron, sulfosulfuron, trifloxysulfuron, foramsulfuron, halosulfuron, *Cynodon dactylon, C. dactylon × C. transvaalensis, Paspalum vaginatum*

Patton, A., and J. Trappe. 2009. Sulfonylurea herbicide safety on sprigged bermudagrass and seashore paspalum. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:73-81.


Photo by Aaron Patton

Planting of seashore paspalum sprigs

Summary. Sulfonylurea herbicides are a relatively new class of herbicides whose use is increasing on golf courses and athletic fields. Depending on the active ingredient, these herbicides can be used to control cool-season grasses, warm-season grasses, sedges, broadleaves, and other troublesome weeds. Many sulfonylurea herbicides are labeled for use on established bermudagrass, but their label recommendations on sprigged turf vary. Only two sulfonylurea herbicides are labeled for use on established seashore paspalum. The objective of this study was to determine the safety of various sulfonylurea herbicides on newly planted Tifway bermudagrass and Aloha seashore paspalum sprigs. There was no discernable herbicide injury to or reduction in 'Tifway' bermudagrass coverage at any point in the study regardless of herbicide, herbicide rate, or application timing, suggesting that all of these products could be used successfully to control weeds in newly sprigged bermudagrass. Blade or SedgeHammer applied at 2 or 4 weeks after sprigging (WAS), and Certainty applied at 4 WAS allowed maximum establishment of seashore paspalum from sprigs. Monument and Revolver reduced establishment of seashore paspalum more than other herbicides tested in this study.

Abbreviations: WAS (weeks after sprigging)

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Bermudagrass (*Cynodon* spp.) remains the most commonly used turfgrass on golf courses and sports fields in Arkansas and throughout southern and transition-zone environments. Bermudagrass has many positive attributes that have made it a successful turfgrass species, including good heat and drought tolerance, pest resistance, traffic tolerance, and tolerance to a wide range of soil types and water quality. Seashore paspalum (*Paspalum vaginatum*) is a new turfgrass species now being used on golf courses and sports fields and a number of new cultivars have appeared on the market in the past decade. Seashore paspalum has excellent salinity tolerance, color, and mowing quality. Thus, the interest in and use of seashore paspalum has increased in recent years. Both of these species are commonly planted using sprigs.

Sulfonylureas are a relatively new class of herbicides used by turfgrass managers (Yelverton, 2004). These herbicides can be used to selectively remove broadleaf weeds, grasses, sedges, and other problematic weeds. These herbicides effectively control weeds with low use rates, generally in ounces per acre. The commonly used sulfonylurea herbicides include chlorsulfuron (Corsair), foramsulfuron (Revolver), halosulfuron (SedgeHammer), metsulfuron (Manor or Blade), rimsulfuron (TranXit), sulfosulfuron (Certainty), and trifloxysulfuron (Monument).

There are little published data on the safety of sulfonylurea herbicides on newly sprigged turf, although there is a growing body of literature on the use of these herbicides in newly seeded turf. The general objective of this experiment was to determine the safety of sulfonylurea herbicides on newly sprigged bermudagrass and seashore paspalum turf with specific objectives to (1) identify differences in herbicide safety within bermudagrass and seashore paspalum, (2) identify the appropriate use rates of each herbicide based on labeled use rates, and (3) identify the optimal timing for applications after planting sprigs.

Materials and Methods

Research was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. Two separate experimental areas were each planted with one of the turfgrass species. Aloha seashore paspalum was sprigged on 15 July 2008 at 20 bushels/1000 ft^2 and another area was also sprigged on 15 July 2008 with Tifway bermudagrass at 12 bushels/1000 ft^2. Existing weeds were killed with glyphosate, the area tilled, and then raked to prepare the soil prior to sprigging. These areas were fumigated with methyl bromide in 2006. This provided a relatively weed-free site on which herbicide injury of various herbicides could be closely monitored. To limit additional weed pressure, oxadiazon (Ronstar G) was applied at 100 lbs/A (2.0 lbs a.i./A) on the day of sprigging to bermudagrass and 2 weeks after sprigging (WAS) on seashore paspalum. Prior to the first treatment application, plot areas with the most uniform establishment were selected for use. Experimental design was randomized complete block with four replications and an individual plot size of 4 by 5 ft. Each experimental area contained the same treatments but in a different randomization. Treatments were arranged as a 5 × 2 × 2 factorial with five herbicides, two herbicide rates (low and high), and two application timings at 2 or 4 WAS (Table 2).

A non-ionic surfactant (Latron AG-98, 0.25% v/v) was added to each herbicide prior to application on each date except for foramsulfuron (Revolver) since no additional surfactant was recommended by the pesticide label. Herbicides were applied in a spray volume of 30 gal/A using an XR8001VS Teejet nozzle with a CO_2-pressurized sprayer at 30 psi. An untreated check was included for comparison. Plots were mown as needed at 0.5 inch. Coverage of each species was determined using digital image analysis (Richardson et al., 2001). Herbicide injury was rated visually on a scale of 0 to 100 where 0 = no visible phytotoxicity and 100 = dead turf.

Results and Discussion

There was no herbicide injury to or reduction in Tifway bermudagrass coverage at any point in the study regardless of herbicide, herbicide rate, or application timing (data not shown). These results suggest that all of these sulfonylurea herbicides could be used successfully to control weeds in newly sprigged bermudagrass despite current label recommendations for some products, which recommend delaying use until the turf has reached full coverage or is one year old.

Herbicide injury on Aloha seashore paspalum varied by herbicide and application rate for the 2 WAS applications when rated on 5 August (Fig. 1). Monument caused the greatest injury to seashore paspalum. Revolver also caused significant injury to seashore paspalum, but was less injurious at the "low" recommended label rate. Certainty was injurious when applied at both rates, although the high rate in this study was a 2x label rate since only one rate (1.25 oz/A) is labeled for use in warm-season turf. Certainty applied at the labeled rate caused 22.5% injury. Blade was injurious at both rates, although maximum injury was only 10%. SedgeHammer herbicide injury was similar to the untreated check.

When herbicide injury was evaluated on 26 August for both application timings, there were significant herbicide-by-rate and herbicide-by-timing interactions (Figs. 2 and 3). Most herbicides performed similarly at both application rates with the exception of Revolver, which was less injurious at the "low" label application rate of 17.4 oz/A. Herbicide by timing interactions indicated differences in herbicide injury as affected by application timing (Fig. 3). Monument injury to seashore paspalum was initially less for the 4 WAS application timing compared to the 2 WAS application timing when rated on 26 August (Fig. 3), but this difference in injury between application timings was short lived as both application timings ultimately caused >99% herbicide injury (data not shown). Revolver injury was less for the 2 WAS application timing than for the 4 WAS application timing on 26 August (Fig. 3), but this was due to seashore paspalum recovery after the initial herbicide injury (data not shown).

There was a significant herbicide-by-rate-by-timing interaction on seashore paspalum coverage on 18 September (10 weeks after planting) (Fig. 4). Blade and SedgeHammer applications at either rate or timing allowed for maximum seashore paspalum establishment. Certainty applications at either application rate at 4 WAS also allowed for maximum seashore paspalum establishment. Certainty applications at the 2x rate and the 2 WAS application timing resulted in less seashore paspalum establishment than when applied at the label rate of 1.25 oz/A at the same timing. Revolver reduced establishment most when applied at the high rate at 4 WAS although seashore paspalum coverage was also unacceptable when Revolver was applied at the high rate at 2 WAS. Revolver applications at the low rate of 17.4 oz/A allowed for >80% coverage at either the 2 or 4 WAS application timing. Regardless of application rate or timing, Monument caused the greatest reduction in seashore paspalum establishment.

Blade or SedgeHammer applied at 2 or 4 WAS, and Certainty applied at 4 WAS allowed maximum establishment of Aloha seashore paspalum from sprigs. Both Monument and Revolver were the most injurious herbicides in this study and reduced seashore paspalum establishment more than other herbicides. Neither Monument nor Revolver are currently labeled for use in seashore paspalum but are labeled to control other *Paspalum* species, so these results were not completely unexpected. Blade is not labeled for use in seashore paspalum, but these results suggest that it could be used on Aloha seashore paspalum and possibly additional cultivars.

The Blade label recommends application to turf one year old or more, but this research suggests that it would be useful for controlling weeds in newly sprigged bermudagrass and seashore paspalum. The Certainty label is currently under revision and will likely include additional instructions regarding its use in newly sprigged areas. The Monument label recommends delaying applications to bermudagrass until "100% cover and root system is developed beyond 2-inch depth", but this research suggests it would be safe to use in newly sprigged bermudagrass. Our data were consistent with Revolver label recommendations that state not to apply within two weeks of sprigging bermudagrass. Our data for SedgeHammer suggest it would be safe to use in both newly sprigged bermudagrass and seashore paspalum. This is contrary to the SedgeHammer label which states to delay applications to sprigged turf until the turf is well established with a good root system. Overall, these results suggest that sulfuonylurea herbicides can be safely applied shortly after sprigging bermudagrass and that Blade, SedgeHammer, and Certainty could be useful herbicides when establishing seashore paspalum sprigs.

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Table 1. Herbicide trade name, common name, formulation, and label notes for each species denoting use instructions on sprigged turf.

Trade name	Common name	Formulation	Label notes about bermudagrass sprigging	Label notes about seashore paspalum sprigging
Blade	metsulfuron	60WDG	Do not apply to turf less than one year old	Not labeled for use[z]
Certainty	sulfosulfuron	75WDG	No instructions [y]	No instructions [y]
Monument	trifloxysulfuron	75WG	Delay applications until turf is at 100% cover and root system is developed beyond a 2-inch depth	Not labeled for use[z]
Revolver	foramsulfuron	0.19SC	Do not apply within two weeks of sprigging	Not labeled for use[z]
SedgeHammer	halosulfuron	75WDG	This product may be used on … sprigged turfgrass that is well established. Allow the turf to develop a good root system and uniform stand before application	This product may be used on … sprigged turfgrass that is well established. Allow the turf to develop a good root system and uniform stand before application

[z] Not labeled for use on sprigged turf at the time of this writing.
[y] Labeled for use on these species, but no application instructions on sprigged turf are provided based on label recommendations at the time of this writing.

Table 2. Herbicide trade name, common name, formulation, product application rate and timing.

Trt	Trade name	Common name	Formulation	oz. product/A	Rate	Application timing
1	Certainty	sulfosulfuron	75WDG	1.25	Low	2 WAS[z]
2	Certainty	sulfosulfuron	75WDG	2.50	High	2 WAS
3	Certainty	sulfosulfuron	75WDG	1.25	Low	4 WAS
4	Certainty	sulfosulfuron	75WDG	2.50	High	4 WAS
5	SedgeHammer	halosulfuron	75WDG	0.66	Low	2 WAS
6	SedgeHammer	halosulfuron	75WDG	1.33	High	2 WAS
7	SedgeHammer	halosulfuron	75WDG	0.66	Low	4 WAS
8	SedgeHammer	halosulfuron	75WDG	1.33	High	4 WAS
9	Monument	trifloxysulfuron	75WG	0.53	Low	2 WAS
10	Monument	trifloxysulfuron	75WG	1.06	High	2 WAS
11	Monument	trifloxysulfuron	75WG	0.53	Low	4 WAS
12	Monument	trifloxysulfuron	75WG	1.06	High	4 WAS
13	Blade	metsulfuron	60WDG	0.5	Low	2 WAS
14	Blade	metsulfuron	60WDG	1.0	High	2 WAS
15	Blade	metsulfuron	60WDG	0.5	Low	4 WAS
16	Blade	metsulfuron	60WDG	1.0	High	4 WAS
17	Revolver	foramsulfuron	0.19SC	17.4	Low	2 WAS
18	Revolver	foramsulfuron	0.19SC	35.2	High	2 WAS
19	Revolver	foramsulfuron	0.19SC	17.4	Low	4 WAS
20	Revolver	foramsulfuron	0.19SC	35.2	High	4 WAS
21	Untreated check					

[z] WAS, Weeks after sprigging.

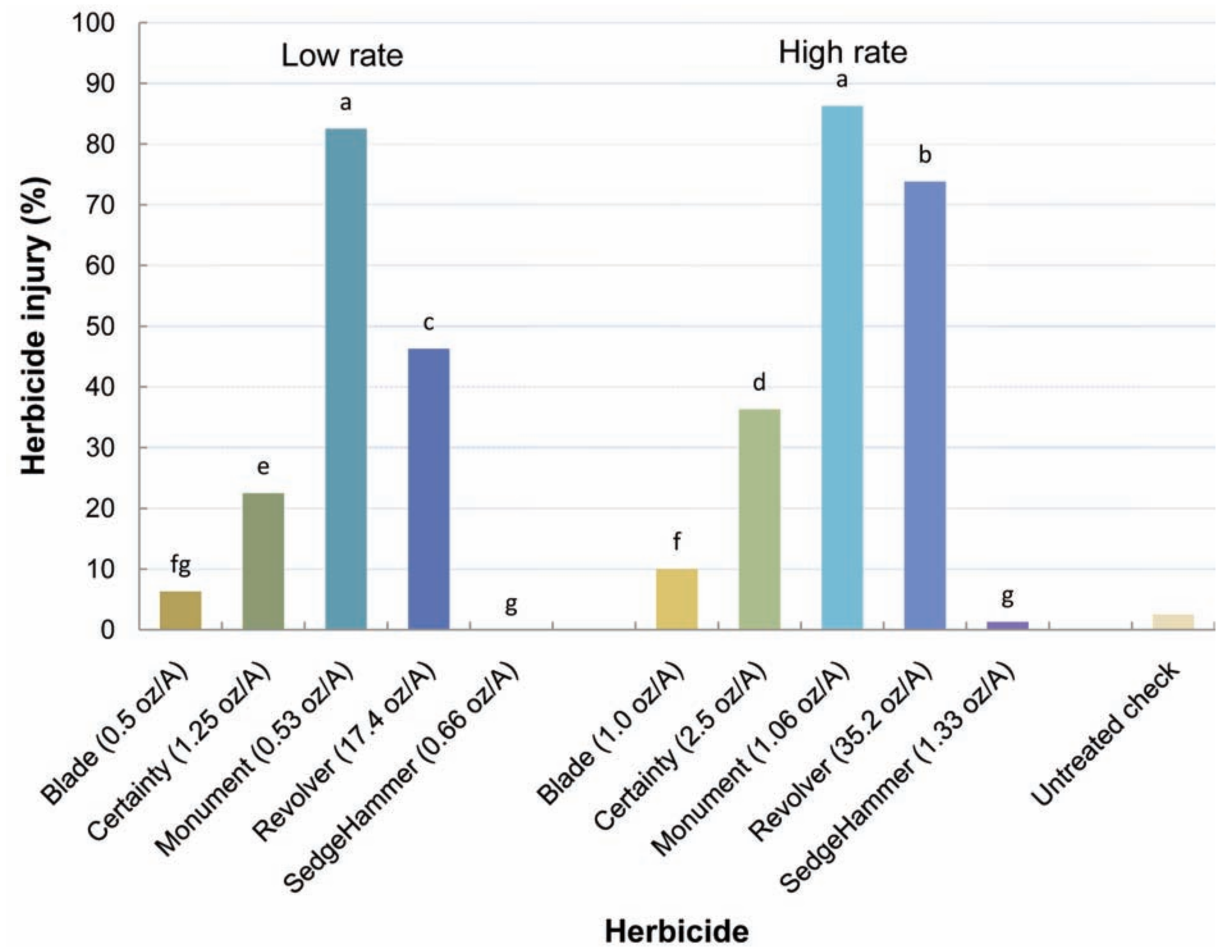

Fig. 1. Herbicide injury (5 August 2008) on Aloha seashore paspalum as influenced by applications of sulfonylurea herbicides at various rates 2 weeks after sprigging.

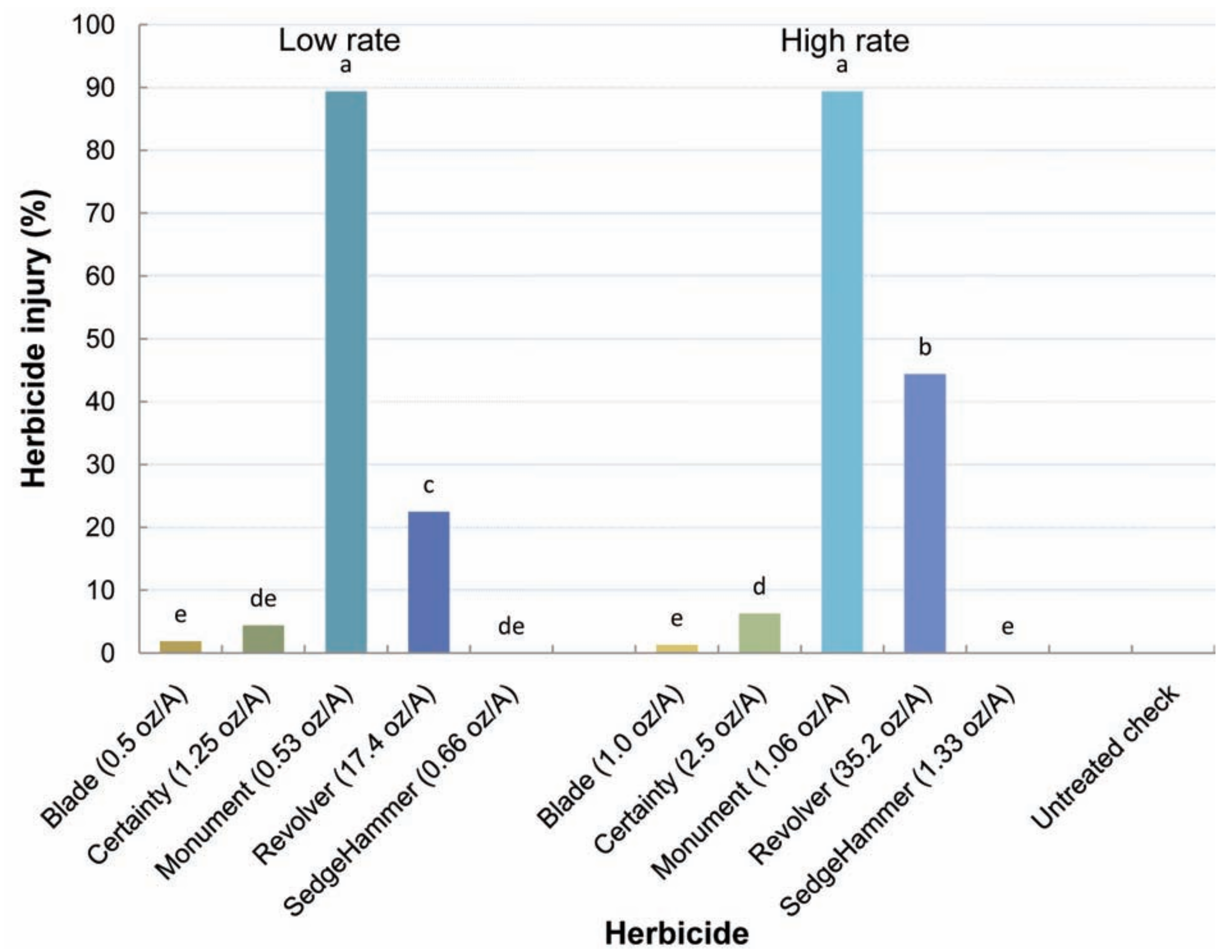

Fig. 2. Herbicide injury (26 August 2008) on Aloha seashore paspalum as influenced by applications of sulfonylurea herbicides at various rates across two timings (2 or 4 weeks after sprigging).

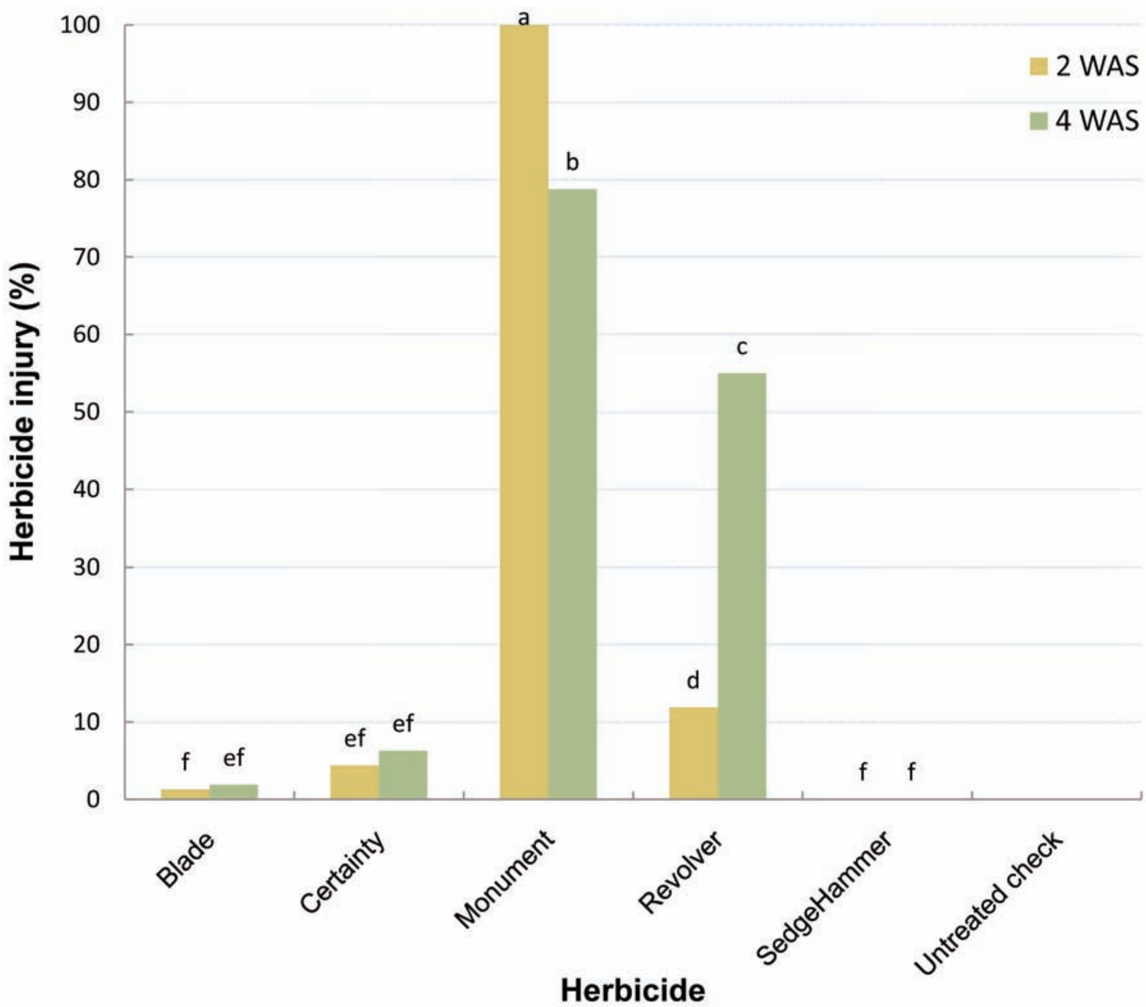

Fig. 3. Herbicide injury (26 August 2008) on Aloha seashore paspalum as influenced by applications of sulfonylurea herbicides at various rates and two timings (2 or 4 weeks after sprigging).

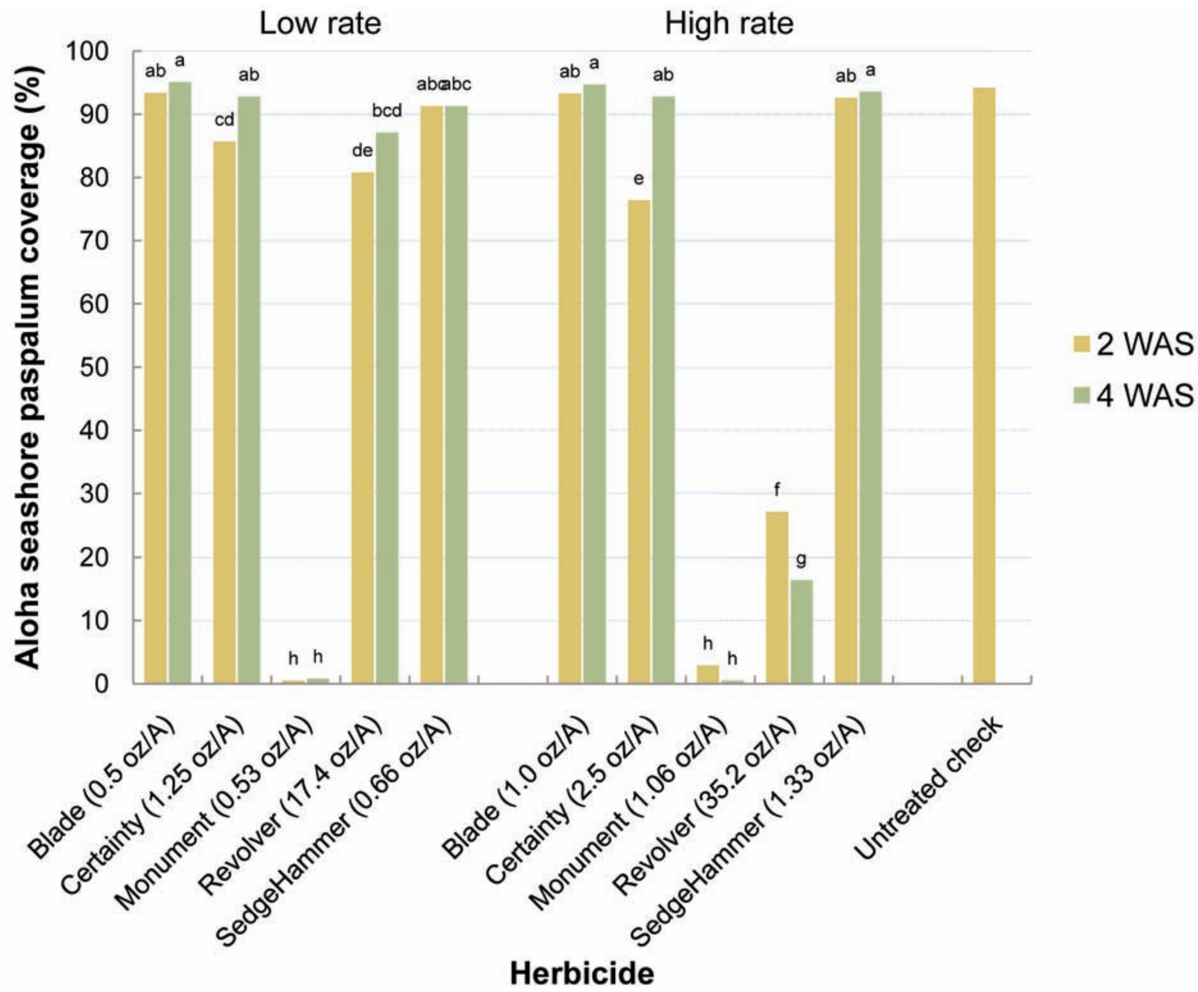

Fig. 4. Aloha seashore paspalum coverage on 18 September 2008 as influenced by applications of sulfonylurea herbicides at various rates and two timings (2 or 4 weeks after sprigging).

Weed Control During Zoysiagrass Establishment from Seed

Aaron Patton[1] and Jon Trappe[1]

Zoysiagrass seed

Photo by Aaron Patton

Additional index words: siduron, Tupersan, fenoxaprop, Acclaim, fluazifop, Fusilade, triclopyr, Turflon

Patton, A., and J. Trappe. 2009. Weed control during zoysiagrass establishment from seed. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:82-85.

Summary. Effective weed control is critical when establishing zoysiagrass from seed. The objective of this experiment was to identify herbicides and herbicide strategies that will reduce weed competition following planting without reducing zoysiagrass establishment. Half of the plots received an application of Tupersan (siduron) immediately following planting of Zenith zoysiagrass. Plots then were treated with Acclaim Extra (fenoxaprop), Fusilade (fluazifop), Turflon Ester (triclopyr), Acclaim Extra + Turflon Ester, or Fusilade + Turlon Ester at two different timings of either a single application at 2 weeks after emergence (WAE) or sequential applications at 2 + 6 WAE. Tupersan reduced zoysiagrass coverage between 8.0 to 9.1%. Injury caused by Acclaim Extra alone or Fusilade alone was decreased with the addition of Turflon Ester. Zoysiagrass coverage 6 WAE was lowest for Acclaim Extra alone or Fusliade alone while coverage was greatest for Turlon Ester, Acclaim Extra + Turflon, and Fusilade + Turlon Ester. Single or sequential applications of Acclaim Extra or Fusilade tank-mixed with Turflon Ester will reduce zoysiagrass injury, decrease weed coverage, and allow for improved zoysiagrass establishment compared to applications of Acclaim Extra alone or Fusilade alone.

Abbreviations: WAE (weeks after emergence)

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Weed control is necessary when establishing zoysiagrass (*Zoysia japonica*) from seed because of its slow germination and growth rate. Germinating summer annual grassy weeds or perennial weeds not controlled prior to planting reduces zoysiagrass establishment from seed (Patton et al., 2004a). Weeds that commonly reduce zoysiagrass establishment from seed include warm-season perennials like common bermudagrass (*Cynodon dactylon*) and warm-season annual grassy weeds such as crabgrass (*Digitaria* spp.) and goosegrass (*Eleusine indica*).

Previous research (Patton et al., 2004b) recommends applications of siduron at the time of seeding for control of summer annual grasses in zoysiagrass seedlings. Other herbicides useful for bermudagrass suppression in zoysiagrass, such as Acclaim Extra (fenoxaprop) and Fusliade (fluazifop), are known to injure zoysiagrass seedlings (Patton et al., 2007). Recently, McElroy and Breeden (2006) reported that Turflon Ester added to Acclaim Extra or Fusilade reduced herbicide injury on established zoysiagrass, but this effect has not been documented on zoysiagrass seedlings.

This research project examines the use of Tupersan (siduron), Turflon Ester, Fusilade, and Acclaim Extra for control of weeds during zoysiagrass establishment from seed. The objectives of this experiment were to (1) determine if adding Turflon Ester to Acclaim Extra or Fusilade would reduce herbicide injury on zoysiagrass seedlings, and (2) identify herbicides and herbicide strategies that would reduce weed competition following planting without reducing zoysiagrass establishment.

Materials and Methods

Research was conducted at the University of Arkansas Agricultural Research and Extension Center, Fayetteville, Ark. Plots were seeded on 26 June 2008 with 1.0 lbs pure live seed/1000 ft^2 of 'Zenith' zoysigrass. The experimental area was treated with three applications of glyphosate prior to planting, and was tilled and raked to prepare the soil for seeding. Plots were covered with a germination blanket until germination occurred to prevent the movement of seed. This experiment included four replications and an individual plot size of 5 by 5 ft. Half of each plot received an application of Tupersan at 12 lbs/A (6 lbs a.i./A of siduron) immediately following planting with the other half remaining untreated. Plots were treated with Acclaim Extra at 28 oz/A (0.125 lb a.i./A of fenoxaprop), Fusilade II at 6 oz/A (0.09 lb a.i./A of fluazifop), Turflon Ester at 16 oz/A (0.5 lb a.i./A of triclopyr), Acclaim Extra at 28 oz/A + Turflon Ester at 16 oz/A , or Fusilade II at 6 oz/A + Turflon Ester at 16 oz/A at two different timings of either a single application at 2 WAE or sequential applications at 2 + 6 WAE. Emergence occurred on 14 July 2008 and was defined as a uniform stand of one-leaf seedlings. A non-inonic surfactant (Latron AG-98, 0.25% v/v) was added to each herbicide, except Tupersan, prior to application. Herbicides were applied on 28 July 2008 and 26 August 2008 at 30 gal/A using an XR8001VS Teejet nozzle with a CO_2-pressurized sprayer at 30 psi. An untreated check was included for comparison. Plots were mown as needed at 0.5 inch when seedlings first reached 0.75 inch.

Zoysiagrass injury and coverage and weed coverage were visually estimated. A final rating of turf coverage was collected using a modified grid. A 3 by 4 ft frame with an internal filament grid of 88 intersections was placed in the center of each plot. The total number of times that zoysiagrass was present under an intersection was recorded for each plot. Percent coverage using the grid was calculated by dividing the number of times zoysiagrass occurred under a filament intersection by 88.

Results and Discussion

Herbicide injury was greatest when rated on 12 August (15 days after application) in plots treated with Acclaim Extra (Table 1). With the exception of Turflon Ester alone, all other herbicides caused more injury than the untreated check, but less injury than Acclaim Extra alone. Injury caused by Acclaim Extra alone or Fusilade alone was decreased with the addition of Turflon Ester, which is consistent with reports on established zoysiagrass (McElroy and Breeden, 2006) and reports on seedling turf (McElroy and Lewis, 2008; Rutledge and Reicher, 2008).

Early in the experiment (12 August), weed coverage was predominated by carpetweed (*Mollugo verticillata*). When weed coverage was rated on 24 September, prostrate spurge (*Chamaesyce humistrata*) was the predominant weed with some crabgrass and goosegrass also present. On all dates, weed coverage was reduced from applications of Tupersan at seeding (Table 1). Weed coverage was also reduced from single and sequential applications of Turflon Ester or herbicides tank-mixed with Turflon Ester more so than from single or sequential applications of Acclaim Extra alone or Fusilade alone. Applications of Acclaim Extra alone or Fusilade alone would likely provide better weed control than reported in this experiment if the predominant weeds were grasses instead of the broadleaf weeds present in our experiment.

Unlike previous reports (Patton et al., 2004b; McElroy and Lewis, 2008), Tupersan reduced zoysiagrass coverage between 8.0 to 9.1% on each of the rating dates (Table 1). Tupersan did not reduce coverage when zoysiagrass coverage was estimated using the grid intersection method. McElroy and Lewis (2008) reported a 51% increase in zoysiagrass coverage when Tupersan was applied at seeding, which was likely due to the reduction in crabgrass coverage in their experiment. Although Tupersan did reduce zoysiagrass coverage in our experiment, the beneficial reduction in weed coverage would likely be more helpful than harmful.

On only one occasion did herbicide selection impact zoysiagrass coverage. Zoysiagrass coverage on 26 August was lowest for Acclaim Extra alone (41.0%) or Fusilade alone (44.7%) while coverage was greatest for the untreated check (70.1%) and from single applications of Turflon Ester (66.6%), Acclaim Extra + Turflon Ester (58.1%), and Fusilade + Turflon Ester (59.9%). These results are similar to previous reports, where applications of Acclaim Extra alone or Fusilade alone should be avoided on seedling zoysiagrass (Patton et al., 2007; Rutledge and Reicher, 2008).

Differences in treatments on zoysiagrass coverage were significant at $P < 0.10$ probability levels on 24 September. The analysis of zoysiagrass coverage resulted in few treatment differences despite large differences in treatment means likely because of the variability in establishment across the experimental area. However, trends in zoysiagrass coverage as affected by various herbicides were similar for later rating dates to those seen on 26 August. Zoysiagrass coverage means were lowest for Acclaim Extra alone or Fusilade alone with single or sequential applications. Zoysiagrass coverage means were greatest for the untreated check and from single and sequential applications of Turflon Ester or herbicides tank-mixed with Turflon Ester.

It is crucial to select herbicides that cause the least injury while providing the best weed control to maximize zoysiagrass establishment. Exact herbicide strategy will depend on the primary weed species present. Tupersan applied immediately following seeding reduced zoysiagrass coverage in our study, but in other studies it did not reduce coverage (Patton et al., 2004b) and increased zoysiagrass coverage by suppressing weeds (McElroy and Lewis, 2008). Therefore, Tupersan is recommended for use immediately following zoysiagrass seeding since it will reduce weed coverage with little to no reduction in zoysiagrass coverage. Single or sequential applications of Acclaim Extra or Fusilade tank-mixed with Turflon Ester will reduce zoysiagrass injury, decrease weed coverage, and allow for improved zoysiagrass establishment compared to applications of Acclaim Extra alone or Fusilade alone.

Acknowledgements

This research was also replicated in 2007 and 2008 by Mr. Dustin Lewis at the University of Tennessee, Knoxville, under the guidance of Dr. Scott McElroy, Auburn University as well as at Purdue University by Mr. James Rutledge, under the guidance of Dr. Zac Reicher. Special thanks to them for their cooperation and assistance in the development and implementation of this project. Special thanks also to Mr. Antonio Pompeiano for assistance in the maintenance of the plots at the University of Arkansas.

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Table 1. Herbicide injury, weed control, and zoysiagrass coverage as influenced by applications of Tupersan, Acclaim Extra, Fusilade II, Turflon Ester, and their combinations.

		Herbicide injury[z]	Weed coverage			Zoysiagrass coverage				Zoysiagrass grid[y]
Herbicide	Application timing	12 Aug.	1 Aug.	12 Aug.	24 Sept.	12 Aug.	26 Aug.	5 Sept.	24 Sept.	24 Sept.
	WAE[x]	----------	----------	----------	----------	%	----------	----------	----------	----------
Acclaim Extra	2	48 a	14 a	26 a	2.9 ab	40	41 b	40	57	68
Fusilade II	2	35 b	12 a	23 a	1.6 c	37	45 b	56	80	91
Turflon Ester	2	7 d	8 b	1 b	0.3 bc	58	67 a	77	91	98
Acclaim Extra + Turflon Ester	2	31 b	7 b	1 b	0.6 bc	48	58 a	64	88	96
Fusilade II + Turflon Ester	2	18 c	10 ab	1 b	0.5 bc	53	60 a	64	86	96
Acclaim Extra	2 + 6				4.5 a			47	70	83
Fusilade II	2 + 6				3.0 a			37	63	84
Turflon Ester	2 + 6				0.0 c			70	91	96
Acclaim Extra + Turflon Ester	2 + 6				0.1 c			68	89	97
Fusilade II + Turflon Ester	2 + 6				0.0 c			64	87	96
untreated check		5 d	14 a	20 a	2.1 abc	64	70 a	77	95	98
Tupersan	at seeding	28	7 b	9 b	0.6 b	43 b	50 b	56 b	77 b	89
no Tupersan		27	14 a	12 a	2.2 a	52 a	58 a	64 a	86 a	93

[z] Injury was rated as 100% = dead turf and 0% no visible injury.
[y] Zoysiagrass grid counts were performed. The number of times that zoysiagrass was present under a grid with 88 intersections was determined and that value was divided by 88 for each plot to calculate the percent zoysiagrass coverage.
[x] WAE, weeks after emergence. Seedling emergence occurred on 14 July.
[w] Values in a column followed by the same letter are not significantly different from one another (LSD, α=0.05).

Mowing Height, Mowing Frequency, and Rolling Frequency Affect Putting Green Speed

Photo by Mike Richardson

Application of rolling treatments

Jay Richards[1], Doug Karcher[1], Thom Nikolai[2], Mike Richardson[1], Aaron Patton[3], and Josh Summerford[1]

Additional index words: ball roll distance, Pelzmeter, turf quality, transition zone, USGA rootzone, 'L-93' creeping bentgrass

Richards, J., D. Karcher, T. Nikolai, M. Richardson, A. Patton and J. Summerford. 2009. Mowing height, mowing frequency, and rolling frequency affect putting green speed. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:86-92.

Summary. Rolling putting greens may allow turf managers to decrease mowing frequency or increase mowing height without losing green speed. Such mowing practice adjustments could be beneficial in minimizing summer stress on creeping bentgrass putting greens in Arkansas and throughout the transition zone. The objective of this study was to determine the effects of mowing and rolling frequency and mowing height on turf quality, green speed (ball roll distance), water infiltration, and the susceptibility to algae on a sand-based putting green. This study contained eight combinations of mowing and rolling treatments, which were applied over an entire growing season. Turf quality was rated weekly, water infiltration measurements and algae ratings were conducted twice during the season, and ball roll distance was measured twice weekly. Rolling treatments increased ball roll distance, while causing very little harm to the putting surface. With rolling treatments, golf course superintendents can mow less frequently or at a higher height to minimize summer stress and maintain desired green speeds.

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Light-weight rolling of putting greens is a cultural practice that dates back over 100 years. However, in the 1920s rolling practices declined due to fears that putting green soils would compact, resulting in drainage and aeration problems (Piper and Oakley, 1921). The practice of rolling greens was mostly abandoned for the next 70 years. However, in the early 1990s, when the demand for faster greens grew, rolling putting greens re-emerged as a viable cultural practice (Nikolai, 2002). Most new putting greens are built according to either United States Golf Association (USGA) specifications (USGA, 1993) or with other techniques that include a predominantly sand rootzone, which makes them less susceptible to compaction than previous soil-based putting green rootzones. The technology of rollers has also improved significantly and new rollers are designed particularly for rolling golf course putting greens.

A recent putting green rolling study concluded that most greens rollers increase green speed by over one foot on the day rolling is applied and retain over 6 inches of that increase the day after rolling (Nikolai, 2003). If greens rolling can improve green speeds for as long as 48 hours, daily mowing may not be necessary. This could reduce stress to the putting green surface, especially during hot, humid conditions. The objective of this research is to determine the effects of various combinations of mowing and rolling frequency and mowing height on a USGA putting green with regard to ball roll distance, overall quality, water infiltration, and algae incidence.

Materials and Methods

This research was conducted at the Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. on a 6-yr-old ‘L93’ creeping bentgrass (*Agrostis stolonifera*) putting green that was constructed according to USGA specifications (USGA, 1993). Fertilizer, growth regulator and pesticide application, aerification, irrigation, and topdressing were uniform across the experimental area throughout the study and were consistent with typical golf course putting green management practices.

In this study, there were eight different mowing and rolling treatments, each replicated three times for a total of 24 plots (4.5 by 18 ft). The treatments, summarized in Table 1, were chosen to compare the effects caused by different mowing heights, mowing frequencies, and rolling frequencies on putting green speed and turf quality. Treatment applications began 14 April 2008 and continued until 7 Nov 2008. All mowing treatments were applied using a walk-behind greens mower (Toro Greensmaster 1000, Toro Company, Bloomington, Minn.). After the plots were mowed, rolling treatments were applied using a commercially available greens roller (RS48-11C Golf Roll ‘n’ Spike, Tru-Turf Rollers, Ernest Junction, Queensland, Australia). Rolling was applied as a single pass across appropriate plots. Putting green speed was evaluated by measuring ball roll distance with a Pelzmeter (Nikolai, 2005). On each plot, three golf balls were rolled in opposite directions and the six resultant ball roll distances were averaged. Ball roll measurements were collected twice per week, once on a day in which all rolling treatments were applied and once on a day when only plots that were rolled six times per week were treated. Turf quality was measured weekly by rating each plot on a scale from 1-9, with 1 being poor, 6 being minimum acceptable quality, and 9 being exceptional. Water infiltration measurements were done on 25 June 2008 and 12 November 2008 using a double-ring infiltrometer (Turf-Tec Double-Ring Infiltrometer, Turf-Tec International, Tallahassee, Fla.) and a mariotte siphon (Gregory, 2005). The mariotte siphon was used to maintain constant pressure in the center ring of the infiltrometer. Algae ratings were done on 10 July 2008 and 9 September 2008 following heavy rain periods that produced algae outbreaks across the experimental area. Each plot was rated on a scale from 1-9, with 1 being no algae and 9 being completely infested with algae.

Results and Discussion

Ball roll distance data were averaged over the 2008 growing season, for both the day-of-rolling and day-after-rolling evaluations (Fig. 1). Turf mowed at 1/8 inch produced significantly faster green speeds compared to plots mowed at 5/32 inch when rolling was not applied. Decreasing the mowing height from 5/32 to 1/8 inch increased green speed by an average of eight inches. This increase is marginally greater than the increase at which the average golfer can detect differences in speed on adjacent putting greens (6 inches) (Karcher et al., 2001). Therefore, decreasing the mowing height from 5/32 inch to 1/8 inch produced noticeably faster green speeds.

Rolling three times per week resulted in an increase in ball roll distance of approximately one foot on the day all rolling treatments were applied compared to the non-rolled plots. On the day after rolling treatments were applied, there was an increase of 5 to 6 inches, compared to the non-rolled plots, demonstrating that rolling did have a residual effect on green speed (Fig. 1). Plots that were rolled six times per week had significant increases in green speed over those rolled three times per week. Plots mowed at 1/8 inch and rolled six times per week resulted in an additional increase in green speed of approximately six inches on the day all rolling treatments were applied and 14 inches on the day only daily (6x) rolling treatments were applied, compared to those plots rolled three times per week (Fig. 1). At the 5/32-inch mowing height, plots that were rolled six times per week had ball roll distances 6 to 8 inches longer than plots rolled three times per week on days that all plots were rolled. And on days when only six-times-per-week rolling was applied, the daily rolling plots had ball roll distances of approximately 1 ft greater than plots rolled three times per week (Fig. 1). In summary, plots mowed at 5/32 inch and rolled every other day had green speeds just as fast as the 1/8-inch, non-rolled plots. Additionally, plots mowed at 5/32 inch and rolled daily produced faster green speeds than the 1/8-inch, non-rolled treatment. Collectively, these data demonstrate that lightweight rolling does improve putting green speed, but the amount of increased speed is related to the amount of additional rolling.

At the 1/8-inch mowing height, decreasing mowing frequency to three times per week increased ball roll distance 6 inches when plots were rolled on alternate days and by 1 ft when plots were rolled every day compared to the 1/8-inch mowing height control, which received no rolling (Fig. 1). Therefore, when mowing at 1/8 inch, it is possible to mow every other day and increase green speeds with regular rolling compared to mowing every day with no rolling.

Turf quality data were averaged over the 2008 growing season (Fig. 2). All turf quality ratings for each treatment stayed above the minimum acceptable quality rating of 6. Plots mowed daily at 1/8 inch that received a rolling treatment had lower quality than treatments mowed at 5/32 inch; however, they remained above an acceptable level.

Water infiltration evaluations were conducted in June and November (Fig. 3). On the June evaluation date, there were no statistical treatment differences at the 0.05 probability level; however, treatments that were rolled 6 times per week and the 1/8-inch treatment rolled 3 times per week had lower infiltration rates than treatments with no rolling ($P = 0.07$). In addition, it was apparent during a heavy rain event that water infiltrated into the rootzone slower on the plots receiving daily rolling treatments compared to control plots that received no rolling (Fig. 4). On the November evaluation date, there were still no significant treatment differences, but the infiltration rates were much slower compared to the rates from the June evaluations (Fig. 3). The November infiltration rates were marginally acceptable for a USGA sand-based putting green (>6 inches per hour) (USGA, 1993). On the November evaluation date, the experimental area had not been core aerified for seven months. These results suggest that regular core aerification is important on sand-based putting greens, even when the turf is not rolled regularly, to manage organic matter accumulation and maintain acceptable water infiltration rates.

Treatments mowed at 1/8 inch had significantly more algae than treatments mowed at 5/32 inch (Fig. 5). This is likely due to the healthier and denser canopy found on plots with the higher mowing height. The implementation of rolling did not increase the prevalence of algae. In some instances, less algae were seen on rolled plots compared to control plots that were not rolled.

In summary, rolling treatments were effective at increasing putting green speed. In fact, ball roll distances measured on plots mowed at 1/8 inch that received no rolling were reached and surpassed when plots at 5/32 inch were rolled at three and six times per week. So, faster green speeds may be achieved without lowering the mowing height. In addition, green speeds were increased by rolling even when mowing frequency was reduced to every other day. Therefore, during the hot, humid periods of a transition zone summer, golf course managers may be able to mow less frequently or at a higher height to minimize summer stress and also maintain the desired green speeds.

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Table 1. Summary of mowing and rolling treatments.

Treatment no.	Mowing frequency	Mowing height	Rolling frequency	Treatment ID
	(days / wk)	(in)	(days / wk)	
1	6	1/8	6	1/8
2	6	5/32	6	5/32
3	3	1/8	6	1/8 R3x
4	6	1/8	3	1/8 3x R6x
5	3	1/8	3	1/8 3x R3x
6	6	1/8	6	1/8 R6x
7	6	5/32	6	5/32 R6x
8	3	5/32	6	5/32 R3x

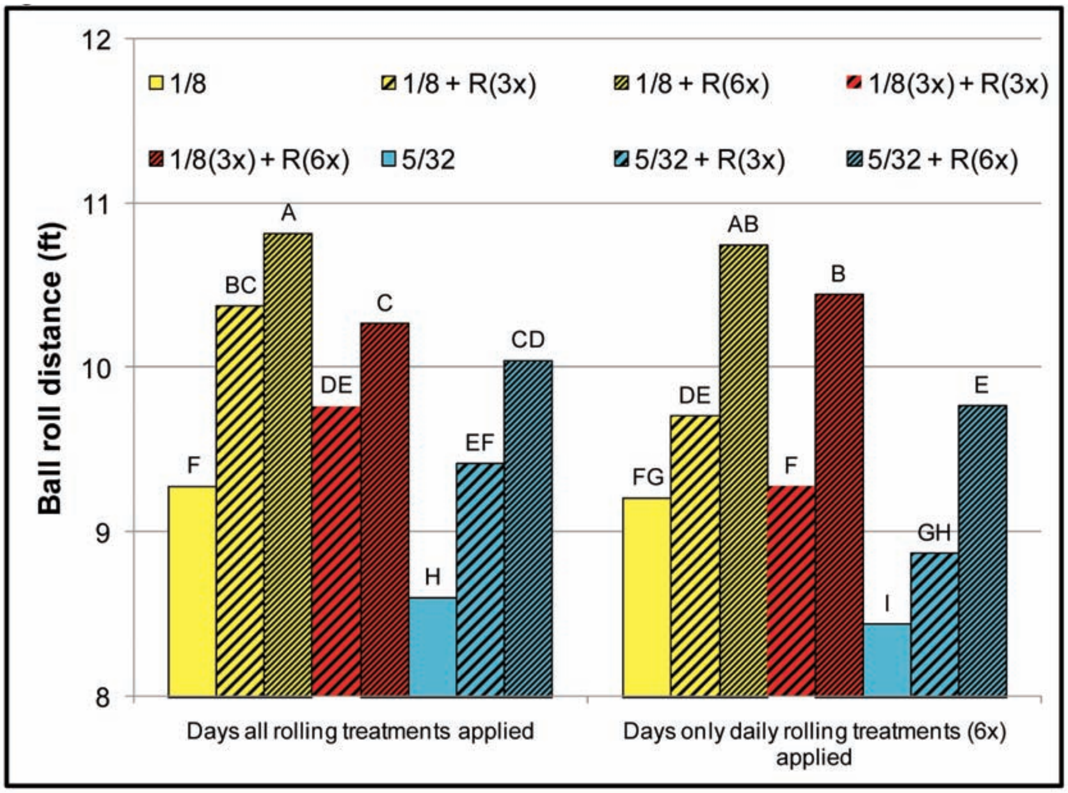


Fig. 1. Effect of mowing and rolling treatments on ball roll distance on days all plots were rolled and on days that plots rolled six times per week were rolled. Within days, bars sharing a letter are not significantly different according to Fisher's least significant difference test (α = 0.05).

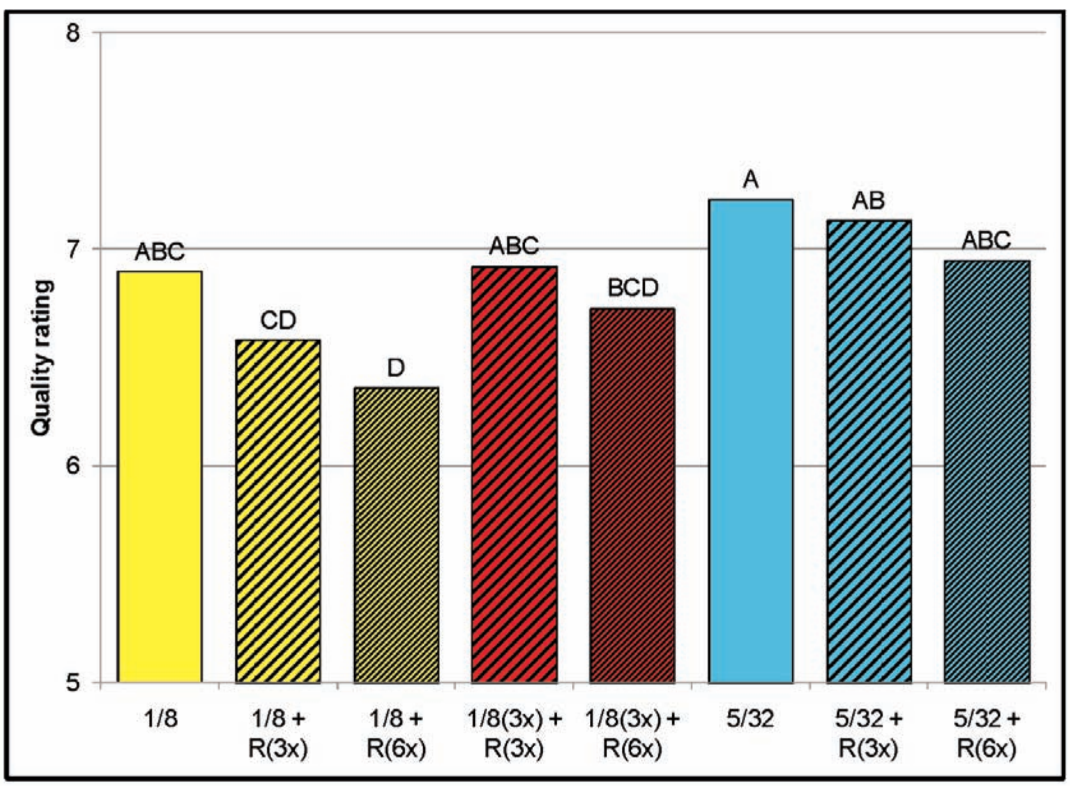


Fig. 2. Effect of mowing and rolling treatments on visual turf quality, averaged across the 2008 growing season. Bars sharing a letter are not significantly different according to Fisher's least significant difference test (α = 0.05).

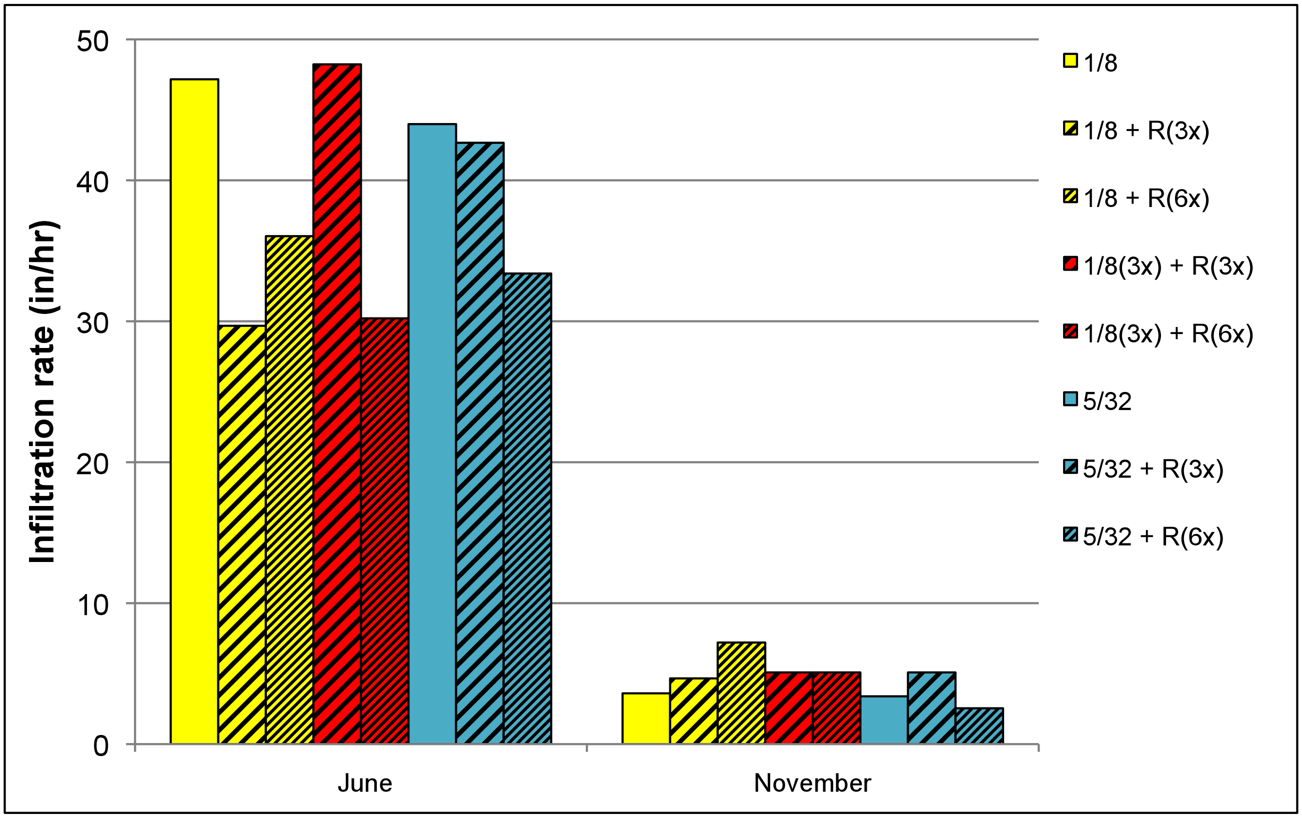


Fig. 3. Effect of mowing and rolling treatments on water infiltration rate in June and November of 2008.

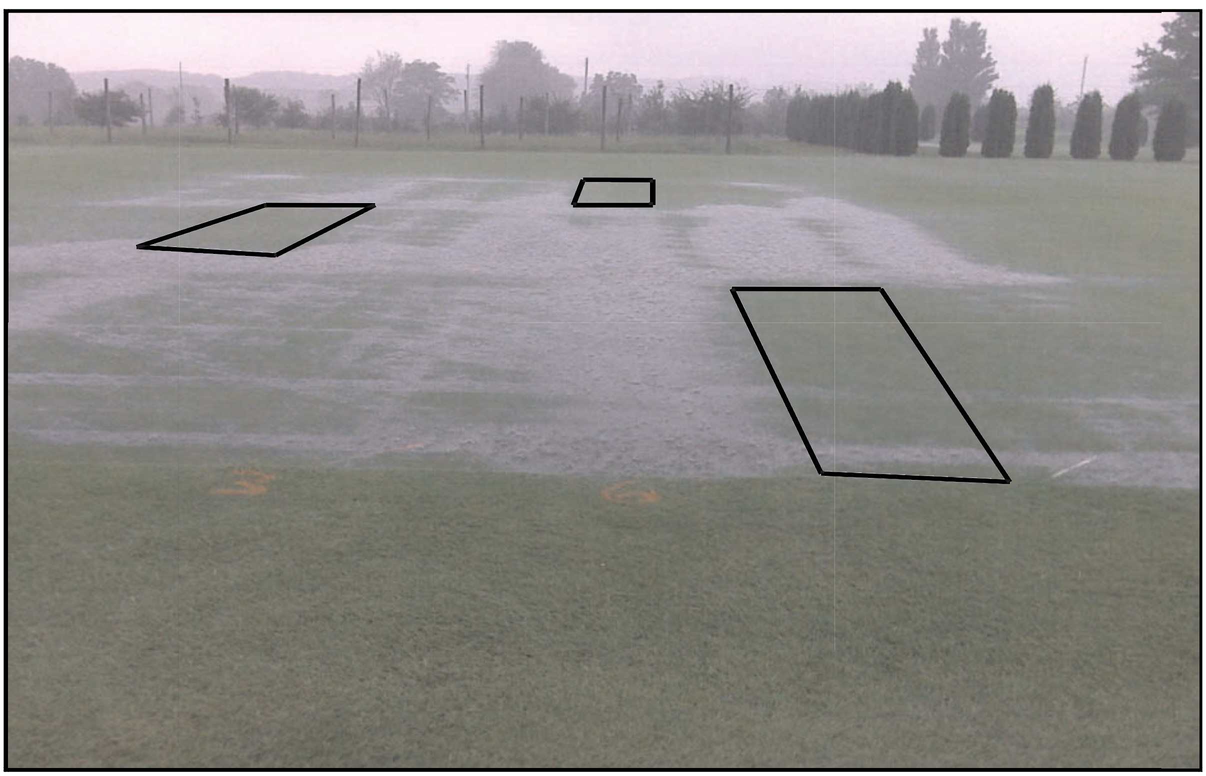


Fig. 4. Experimental area during an intense rain event in August of 2008. Three plots that did not receive rolling treatments and had more rapid water infiltration are highlighted.

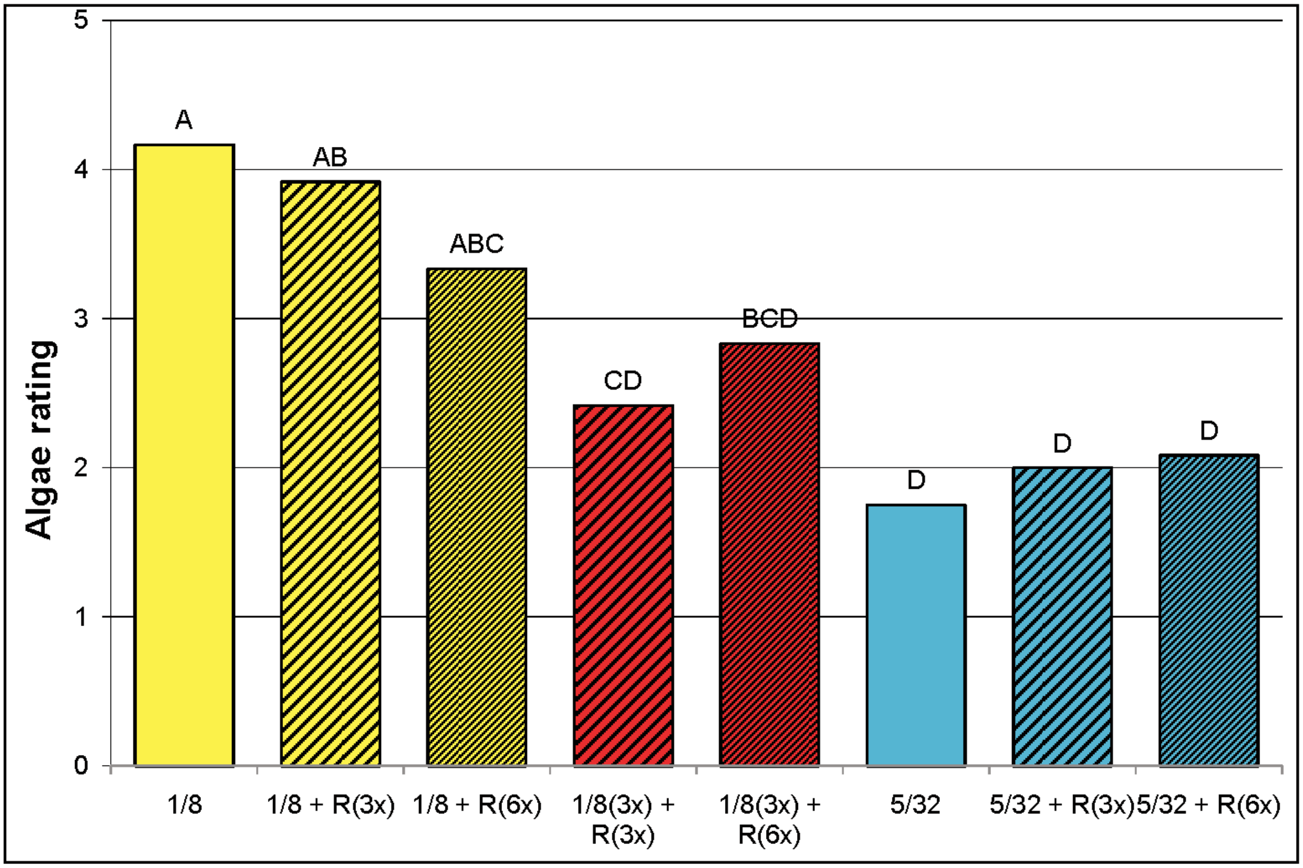
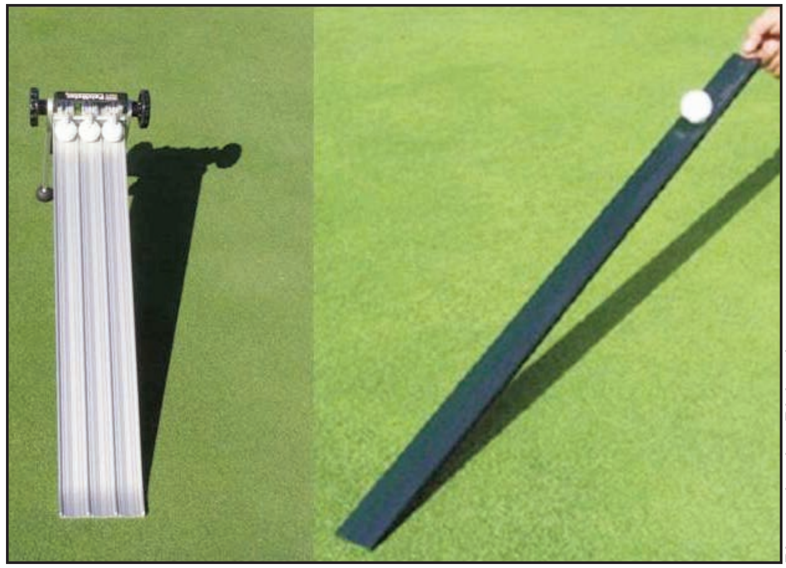


Fig. 5. Effect of mowing and rolling treatments on visual algae incidence, averaged across two evaluation dates in 2008. Bars sharing a letter are not significantly different according to Fisher's least significant difference test (α = 0.05).

Comparing Two Devices Used to Measure Green Speed on Golf Course Putting Greens

Jay Richards[1], Doug Karcher[1],
Josh Summerford[1], Thom Nikolai[2],
Jason Henderson[3], and
John Sorochan[4]



Photos by Jay Richards

Devices used for measuring putting green speed. Pelzmeter (left) and Stimpmeter (right).

Additional index words: Stimpmeter, Pelzmeter, ball roll distance, *Agrostis stolonifera*, *Poa annua*

Richards, J., D. Karcher, J. Summerford, T. Nikolai, J. Henderson, and J. Sorochan. 2009. Comparing two devices used to measure green speed on golf course putting greens. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:93-99.

Summary. The Stimpmeter and Pelzmeter are two devices to measure putting green speed, but it is unclear how these meters compare for measuring putting green speed. The research objective was to compare the measurement variability of the two devices when measuring putting green speed and to determine if the meters give similar results on the same putting surface. This study was conducted at four sites: the University of Arkansas (Fayetteville, Ark.), the University of Tennessee (Knoxville, Tenn.), the University of Connecticut (Storrs, Conn.), and Michigan State University (East Lansing, Mich.). At each site, multiple evaluators used each device to measure putting green speed on plots with varying green speeds. There were few differences in putting green speed values between the Pelzmeter and the Stimpmeter when measuring the same turf. Measurement repeatability (as measured by standard deviation) was similar between the two devices when different evaluators measured the same plot. Golf course superintendents and turf researchers can choose the green speed measuring device that fits their situation best because both meters produced similar results.

Abbreviations: ARK (University of Arkansas), CONN (University of Connecticut), MSU (Michigan State University), TENN (University of Tennessee), USGA (United States Golf Association)

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Putting green speed is an important aspect of a putting green's overall quality. Putting green speed is the distance a ball travels after being released from an inclined plane, such as a Stimpmeter, or after being struck with a putter. According to a Golf Course Superintendents Association of America survey, golfers are more concerned about the speed of the putting greens than any other aspect of the golf course (Umminger, 2002). In the 1970s, the United States Golf Association (USGA) recognized that green speed was an important aspect of the game of golf and commissioned for the development of an instrument that could be used to measure the speed of a putting green. Though the Stimpmeter was developed by Eddie Stimpson in the 1930s, an improved design of the Stimpmeter was released in 1977 and today is the only tool accepted by the USGA for measuring putting green speed (Thomas, 1983). The Stimpmeter is a tool that provides a way to measure putting green consistency throughout the golf course (Fig. 1b). The Stimpmeter has been the prominent tool used in turfgrass research where putting green speed is evaluated. Past studies used the Stimpmeter to measure putting green speed as affected by nitrogen fertilization and the growth regulator trinexapec-ethyl (McCullough, 2006); bermudagrass (*Cynodon* spp.) genotypes (Busey, 1997); overseeding 'Tifdwarf' bermudagrass (*Cynodon trasvaalensis*) putting greens (Grossi, 2008); different mowing equipment (Jang, 2004); and lightweight rolling (Hartwiger, 2001). In fact, until recently, the Stimpmeter was the only tool used for research to measure putting green speed.

In 2004, a new apparatus, the Pelzmeter, was released for measuring putting green speed (Fig. 1a). The Pelzmeter was designed to reduce the variability associated with the Stimpmeter by implementing a bubble-level system to ensure the ball is released from a consistent height, and a tapered ramp, which releases the ball horizontally onto the green to minimize ball bounce. The Pelzmeter's three side-by-side grooves help to minimize ball tracking effects (Pelzmeter User Manual, 2004). Because it is relatively new to the turf industry and is not endorsed by the USGA, the Pelzmeter has been used much less than the Stimpmeter for putting green speed research. However, recent studies have used the Pelzmeter to determine the effect that various mowing treatments and rolling treatments had on putting green speed (Richards, 2008), and the Pelzmeter was also used to determine the speed of nine putting greens that were mowed using various bedknife thicknesses (Carson, 2007).

Research using the Stimpmeter and the Pelzmeter to measure green speed is currently being conducted. Therefore, it is important to know how to compare putting green speed measurements from the two devices. Also, there is a need to substantiate claims that the Pelzmeter reduces measurement variability that is associated with the Stimpmeter. The objective of this study is to determine which device measures putting green speed with the least variability and to determine if the meters give similar results on the same putting surface.

Materials and Methods

Experimental area. This study was conducted at four sites: the University of Arkansas (ARK), Fayetteville, Ark., the University of Tennessee (TENN), Knoxville, Tenn., the University of Connecticut (CONN), Storrs, Conn., and Michigan State University (MSU), East Lansing, Mich. The experimental area at each site is summarized in Table 1. Putting green root zones and species varied across sites. At ARK and TENN, putting greens were built on a USGA specification rootzone (USGA, 1993). However, at CONN and MSU, putting greens were built on native soil.

Meter evaluations. This study contained two main treatment factors: the device for measuring putting green speed (Pelzmeter and Stimpmeter) and the evaluator using the device (three evaluators at each site). At each site, ball roll distance was measured by each evaluator with each device on each of eight plots varying in green speed. A range of green speeds was present on the plots at each location as the result of a concurrent study comparing the effects of different mowing heights, mowing frequencies, and rolling frequencies on putting green speed and turf quality (Richards, 2008, 2009).

Putting green speed was determined by measuring ball roll distance using the Pelzmeter and the Stimpmeter according to standard procedures (Pelzmeter Manual 2004; Hoos, 1982). On each plot, three evaluators were assigned to use each device three times in a random order. However, at MSU, each evaluator used each device only once per plot.

Statistical analysis. Regression analysis was computed using PROC REG in SAS (SAS Institute Inc., Cary, N.C.) to compare the putting green speeds as measured by the Pelzmeter to those measured by the Stimpmeter. For each device, standard deviations (with 95% confidence intervals) were calculated to determine measurement repeatability with each device. Standard deviations were calculated for the variation among different evaluators when measuring the same plot with the same device and for the variation within a single evaluator when repeatedly measuring the same plot with the same device.

Results and Discussion

Regression analysis revealed a strong linear relationship ($R^2 = 0.94$) between the Stimpmeter and the Pelzmeter across a wide range of ball roll distances (8.7 to 11.8 ft) (Fig. 2). A strong linear relationship with a slope near 1.0 (0.96) was present across all four experimental sites, which included a variety of grass species and soil types (Table 1). This indicates that green speed measurements taken with the Pelzmeter can be expected to be very similar to those measured with the Stimpmeter. Therefore, ball roll distances from previous research with the Stimpmeter can be compared to studies that use the Pelzmeter.

Little difference in measurement variability was found between the Stimpmeter and the Pelzmeter when different evaluators measured the same plot (Fig. 3). There was evidence that the Pelzmeter reduces measurement variability among evaluators at the CONN site (Fig. 3). However, there were no significant differences among the meters at the other three sites. Measurement variation was higher at MSU than at the other sites (Fig. 3). This is likely due to evaluator ball roll distances being calculated from a single sample at MSU, whereas three subsamples were averaged per evaluator at the other three sites. Considering these results, variation in green speed measurements on the same turf should not be attributed to the device or the evaluator, as long as standard operating procedures for each device are followed. Variation is most likely the result of other factors, such as varying wind speed and direction during measurement, nonuniform surface conditions, and differences in turf orientation due to grain or mowing patterns.

Both of these instruments are suitable for measuring green speed if they are used properly, and each provides certain advantages and disadvantages for the user. The Stimpmeter is less expensive and easier to handle and transport, but may have a greater potential for operator error. Evaluators in this trial had previous experience using the Stimpmeter; so the chance of operator error was minimized. However, untrained operators are more likely to cause errors by raising the Stimpmeter with a rapid motion or by not holding the ramp steady as the golf ball is rolling off. The Pelzmeter takes longer to set up; however, operator error is minimized. Therefore, golf course superintendents and turf researchers can choose the green speed measuring device that best fits their situation. The strong linear relationship that exists between the two devices should provide researchers and golf course superintendents with confidence that the Pelzmeter and the Stimpmeter are similarly effective for evaluating putting green speed.

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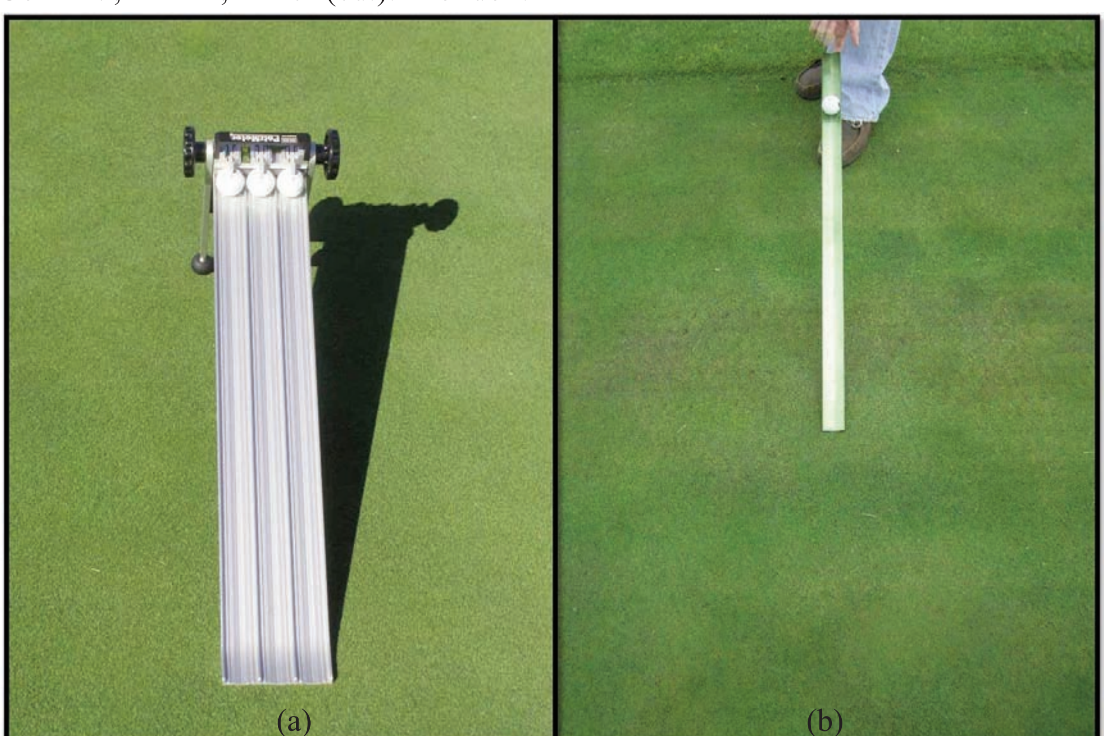

Fig. 1. Turf researchers using the Pelzmeter (a) and the Stimpmeter (b) to measure putting green speed.

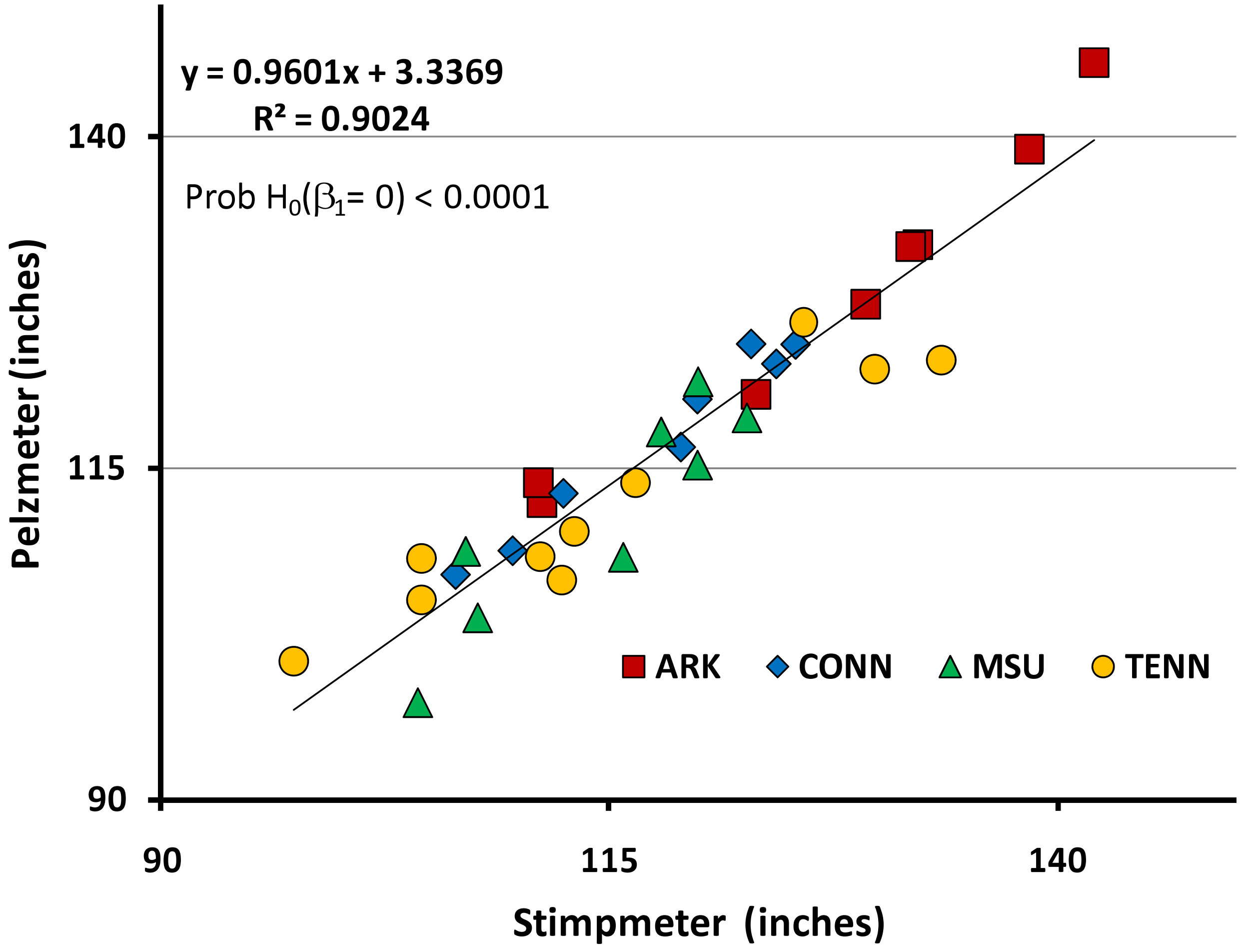

Fig. 2. Regression analysis comparing putting green speeds measured by the Pelzmeter to those measured by the Stimpmeter.

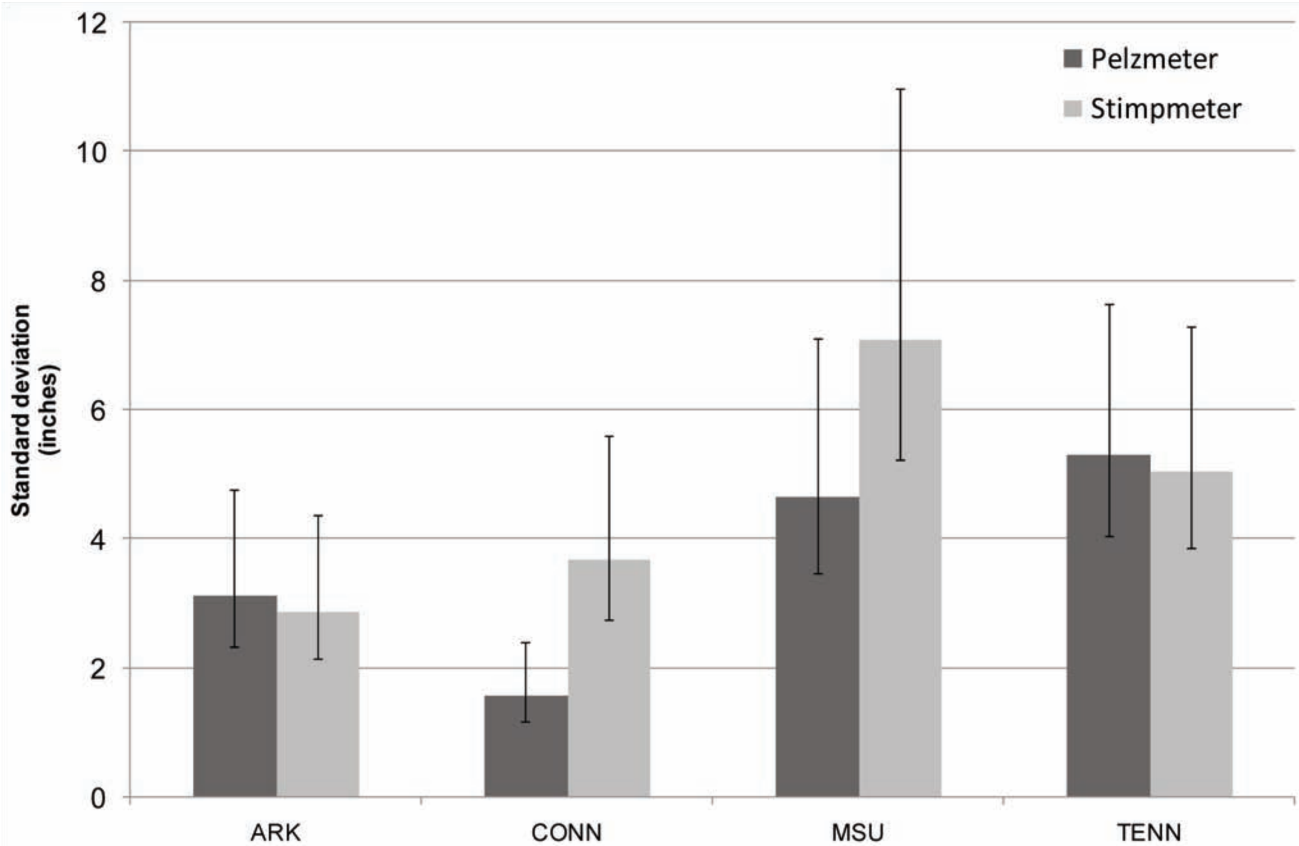

Fig. 3. Comparison of measurement repeatability of each device in determining putting green speed measurements taken at ARK, CONN, MSU, and TENN using the Pelzmeter and the Stimpmeter.

Table 1. Experimental areas at each research site.

	UARK	TENN	UCONN	MSU
Facility	Arkansas Agricultural Research and Extension Center	University of Tennessee East Tennessee Research and Education Center	University of Connecticut Plant Science Research and Education Facility, Storrs, CT	Hancock Turfgrass Research Center
Grass species	*Agrostis stolonifera*	*Agrostis stolonifera*	*Agrostis stolonifera*	*Poa annua*
Cultivar	'L93'	Dominant South Providence & SR 1119	'A-4'	'Reptans'
Soil Type	USGA sand based†	USGA sand based	Sandy Loam	Push-up
Age of Green	5 years	2 years	1 year	20+ years
Irrigation frequency	deep 2-3x wk^{-1}	deep 2-3x wk^{-1}	deep 2x mo^{-1}	minimal to prevent dry spots
Topdressing Frequency	every 2 weeks	every 2 weeks	every 3-4 weeks	every 2-3 weeks
Pesticide practices	Applied on curative basis	Applied on curative basis	Applied on a curative basis	Applied on curative basis
Annual N rate (lb. N M^{-2} yr^{-1})	4.0	6.0	4.0	4.0
Plot size (ft)	4.6 x 18.0	3.9 x 17.7	4.6 x 16	5.9 x 16
Mower	Toro Greensmaster 1000	Toro Flex 21	Jacobsen PGM 22	Toro Greensmaster 1000

† Constructed according to USGA specifications (USGA, 1993).

High-Frequency Light Weight Rolling Affects Putting Green Speed and Quality

Jay Richards[1], Doug Karcher[1], Thom Nikolai[2], Mike Richardson[1], Aaron Patton[3], and Josh Summerford[1]

Mower-mounted vibratory putting green rollers

Additional index words: Pelzmeter, USGA rootzone, 'G2' creeping bentgrass

Richards, J., D. Karcher, T. Nikolai, M. Richardson, A. Patton, and J. Summerford. 2009. High-frequency light weight rolling affects putting green speed and quality. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:100-104.

Summary. Rolling putting greens is a cultural practice that many golf course superintendents are using to increase putting green speed. Research shows that putting greens constructed according to United States Golf Association (USGA) specifications can be rolled six times per week and result in no decline in overall turf quality. However, the effects of rolling putting greens more than 6 times per week are unclear. Therefore, the objective of this study is to determine if rolling the putting surface more than six times a week to increase ball roll distance produces a decline in turf quality or water infiltration. Three different rolling treatments (applied two times per day, four times per day, and eight times per day) were chosen to evaluate the effects they would have on putting green speed, turf quality, and water infiltration. Plots rolled eight times per day produced significantly faster green speeds compared to plots rolled two and four times per day. Plots rolled two times per day consistently had the highest quality, and though there were some small differences in water infiltration, all remained above the acceptable infiltration rate for a sand-based putting green.

Abbreviations: USGA (United States Golf Association)

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Light-weight rolling of putting greens is a cultural practice that is continuing to gain popularity among golf course superintendents wishing to increase putting green speed. A recent study concluded that putting greens constructed according to USGA specifications (USGA, 1993) can be rolled six times per week and result in no decline in turf quality (Richards, 2008, 2009). However, there are occasions when a rolling frequency of more than six times per week may be desired. Many golf course superintendents go to great lengths to improve putting green speeds for tournament play, and therefore, may consider a more aggressive rolling program that exceeds six times per week. There has been little research performed to determine how often the putting surface can be rolled to improve green speed without causing a decline in turf quality. Therefore, the objective of this study is to determine the effects that high-frequency rolling on putting greens has on ball roll distance, turf quality, and water infiltration.

Materials and Methods

This research was conducted at the Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. on a 6-yr-old 'G2' creeping bentgrass (*Agrostis stolonifera*) putting green that was constructed according to USGA specifications (USGA, 1993). Mowing, fertilizer, growth regulator, and pesticide application, aerification, irrigation, and topdressing were uniform across the experimental area throughout the study and were consistent with typical golf course putting-green management practices.

The study consisted of three different rolling treatments: two times per day, four times per day, and eight times per day. Each treatment was applied six days per week and replicated four times for a total of 12 plots (5 by 60 ft). Treatment application began 30 June 2008 and continued for six weeks until 7 August 2008. Rolling treatments were applied using a commercially available greens roller (True Surface Vibe V Vibratory Greens Rollers, Turfline, Inc., Moscow Mills, Mo.) mounted on a triplex greens mower (John Deere 2500B, John Deere Co., Moline, Ill.). Putting green speed and turf quality were evaluated once per week. Green speed was determined by measuring ball roll distance with a Pelzmeter (Nikolai, 2005). On each plot, three golf balls were rolled in opposite directions and the six resultant ball roll distances were averaged. Turf quality was determined by rating each plot on a scale from 1-9, with 1 being poor, 6 being minimal acceptable quality, and 9 being exceptional. Six weeks after the first rolling treatment was applied, water infiltration measurements were conducted using a double-ring infiltrometer (Turf-Tec Double-Ring Infiltrometer, Turf-Tec International, Tallahassee, Fla.) and a mariotte siphon (Gregory, 2005). The mariotte siphon was used to maintain constant head pressure in the center ring of the infiltrometer. Infiltration was measured to assess the compaction of the surface layer of the putting green.

Results and Discussion

Ball roll distance. There were no significant differences between plots rolled two times per day and those rolled four times per day with regard to ball roll distance (Fig. 1). However, plots that were rolled eight times per day produced green speeds, on average, 10 inches faster than those rolled two or four times per day. Differences in green speeds between plots existed after just one week of applying treatments. After three days of rolling applications, plots rolled eight times per day produced green speeds 14 inches longer than plots rolled two times per day and 12 inches longer than plots rolled four times per day (data not shown). This increase in green speed was likely a result of the thinning of the turf that occurred on the plots rolled eight times per day rather than a smoother putting surface.

Turf quality. Treatments consisting of rolling two times per day provided better quality than those rolled four times per day, which produced better quality ratings than plots rolled eight times per day (Fig. 2). Overall quality for all treatments remained acceptable (>6.0) until day 16 (Fig. 2). At this point, turf quality began decreasing for all three treatments. Plots rolled four and eight times per day began producing unacceptable quality ratings. All plots rolled two times per day remained above minimal acceptable quality throughout the study. The reduction in turf quality on plots rolled four or eight times daily was mostly attributed to thinning of the turf. However, plots rolled four times per day did remain acceptable throughout the study. Because this study was conducted in the middle of the summer, thin areas were very susceptible to becoming very hot during the day thus causing them to decline even more rapidly.

Water infiltration. Though there were no significant treatment differences, all three treatments possessed water infiltration rates higher than 36 inches per hour (data not shown), which exceeded rates that are acceptable for a USGA sand-based putting green (USGA, 1993). Over a 1-2 month period, a light-weight roller like the Tru Surface Greens Roller will not likely cause surface compaction, especially in situations where the rolling frequency is only three to six times per week.

This study shows that rolling can be done as often as four times per day for two weeks without a decline in turf quality. Over a six-week period, high-frequency rolling of up to eight times per day did not negatively affect water infiltration, but rolling eight times per day had a detrimental effect on turf quality after two weeks. Therefore, golf course superintendents can implement high-frequency rolling programs on their putting greens for short periods of time and see no detrimental effects on overall turf quality or water infiltration.

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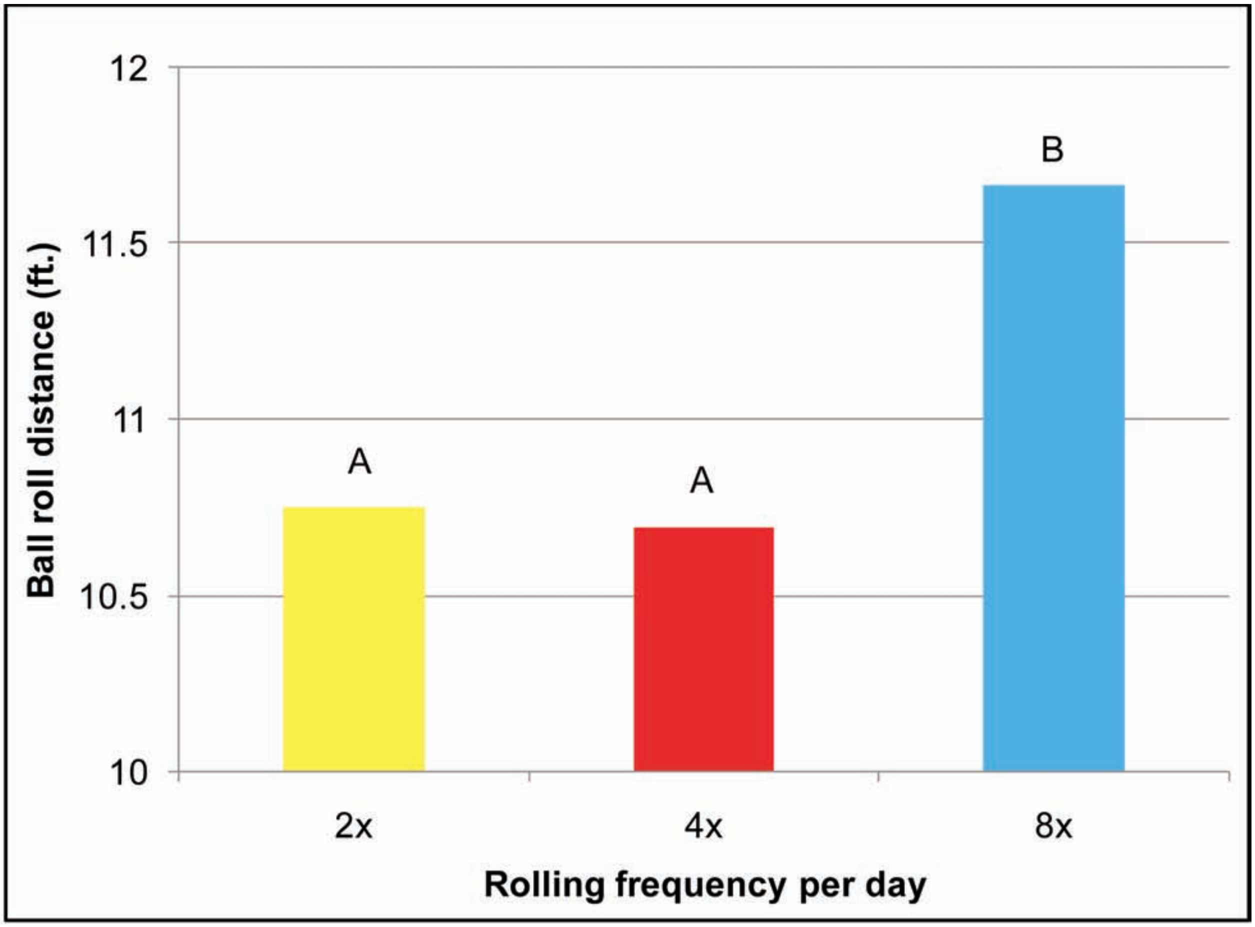

Fig. 1. Effect of rolling frequency on ball roll distance. Bars not sharing a letter are significantly different according to Fisher's least significant difference test (α = 0.05).

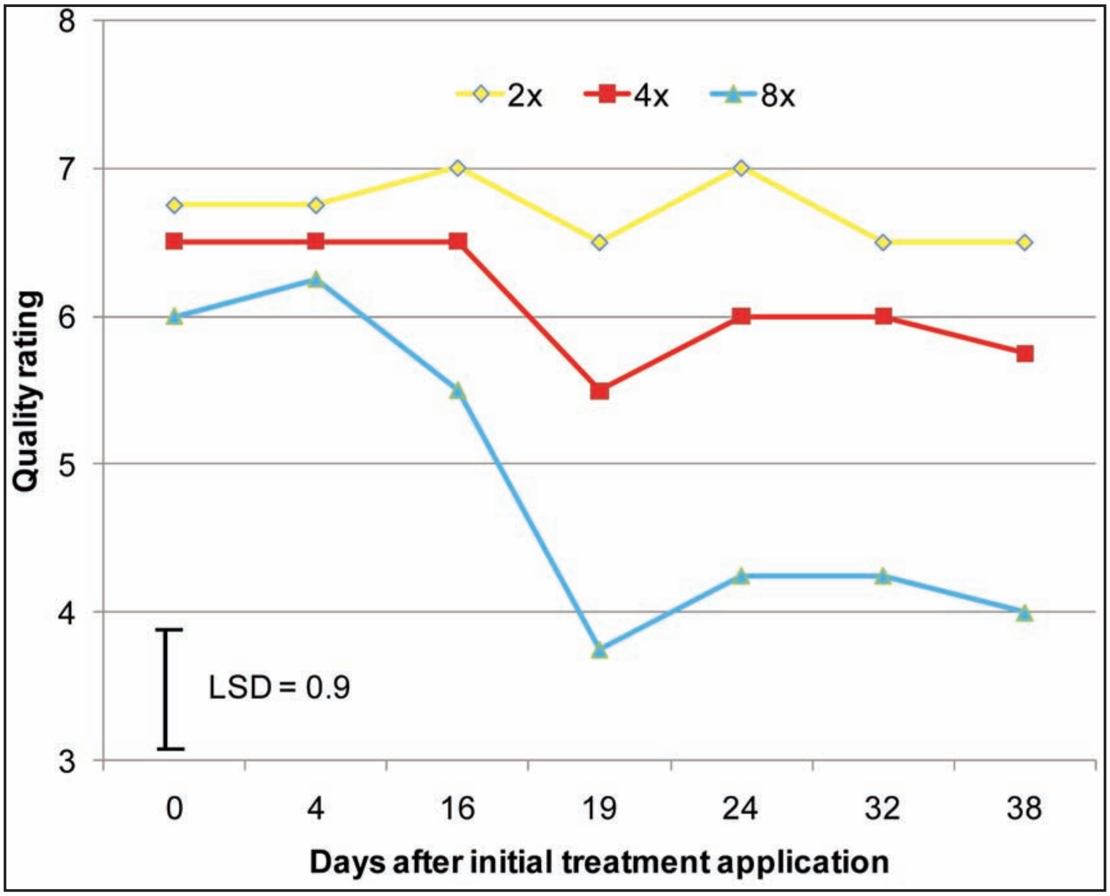

Fig. 2. Putting green quality as affected by rolling frequency over time. Error bar represents Fisher's least significant difference value (α = 0.05).

Report From the 2006 NTEP Tall Fescue Trial–2007-2008 Data

Mike Richardson[1], John McCalla[1] Doug Karcher[1], and Aaron Patton[2]

Additional index words: *Festuca arundinacea*, turfgrass, cultivars, quality, color, brown patch

Richardson, M., J. McCalla, D. Karcher, and A. Patton 2009. Report from the 2006 NTEP tall fescue trial–2007-2008 data. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:105-109.


Photo by Mike Richardson

Data collection using digital image analysis.

Summary. Tall fescue is a very popular grass for lawn areas in northern Arkansas and throughout the transition zone. Identifying adapted cultivars for the region remains a central focus of the University of Arkansas turfgrass research program. The National Turfgrass Evaluation Program is the predominant means by which cultivars are tested throughout North America. A tall fescue cultivar trial, containing 113 entries, of which 45 are now commercially available cultivars, was planted in the fall of 2006 at Fayetteville, Arkansas. Cultivars were rated for turf color, overall turf quality, and incidence of brown patch. The cultivars that have rated highest for overall turfgrass quality during the first two growing seasons included Toccoa, Fat Cat, Mustang 4, Rhambler SRP, Plato, Rocket, Jamboree, Raptor II, Traverse SPR, Turbo, and Van Gogh. The cultivars with the worst overall quality throughout 2008 were Falcon IV, Cezanne RZ, Einstein, and Ky-31. There were significant differences among cultivars in brown patch severity during both 2007 and 2008. Cultivars with good tolerance of brown patch included Ky-31, Rhambler SRP, Talladega, Speedway, and Mustang 4.

Abbreviations: NTEP, National Turfgrass Evaluation Program

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Tall fescue (*Festuca arundinacea*) is one of the most popular cool-season turfgrasses in the transition-zone regions of the United States and is widely used in lawns, sports fields, and on utility turf in the region. Tall fescue is known for its superior drought tolerance, good shade tolerance, and ability to grow on poor soils relative to other cool-season grasses. Breeding efforts in the past three decades have made tremendous strides in improving the overall quality of this species.

The National Turfgrass Evaluation Program (NTEP) is an organization within the U.S. Department of Agriculture that annually oversees turfgrass cultivar evaluation experiments at various sites throughout the U.S. and Canada. Each turfgrass species is tested on a four- to five-year cycle at sites throughout the growing region for that particular species. The University of Arkansas has been an active participant in the NTEP and has conducted several tests on tall fescue cultivars over the past 20 years. This report summarizes the 2007 and 2008 performance data, including turfgrass color, turfgrass quality, and brown patch for the NTEP 2006 National Tall Fescue Test at Fayetteville, Arkansas.

Materials and Methods

This cultivar experiment is being conducted at the Arkansas Agricultural Research and Extension Center in Fayetteville. The plot size was 4 by 5 ft and there were three replications of each cultivar. Prior to seeding, the entire trial area was fumigated with methyl bromide and a preplant fertilizer (10-20-20) was applied at 10 lb/1000 ft^2 prior to seeding. One-hundred-thirteen tall fescue cultivars and experimental lines were broadcast planted on 2 October 2006 at a seeding rate of 6 lb/1000 ft^2. Plots were maintained under lawn conditions throughout the duration of the study. Mowing height was maintained at 1.5 inches throughout the season with clippings returned. Four nitrogen applications were made during each growing season with 2.0 lb N/1000 ft^2 applied in November and 1.0 lb N/1000 ft^2 applied in April, June, and September. All N applications were made as urea (46-0-0). Irrigation was supplied as needed to promote establishment, maintain vigorous growth, and prevent drought stress.

Overall turf quality was evaluated monthly from March through November in 2007, but is presented as the seasonal average in this paper. Quality was visually assessed on a 1 to 9 scale, with 9 representing ideal dark-green, uniform, fine-textured turf and 1 representing dead turf. Turfgrass color was evaluated monthly from March through November and is presented as the seasonal average in this paper. Color was visually assessed on a 1 to 9 scale, with 9 representing ideal dark-green color and 1 representing chlorotic conditions. Brown patch (*Rhizoctonia solani*) was evaluated on 15 August 2007 and 9 July 2008 and was visually rated as both disease incidence (% of plot infected) and as disease intensity (1 to 9 scale, with 1 representing no damage to turf from disease and 9 representing completely dead turf in diseased areas). An overall rating of disease severity was calculated by multiplying disease incidence by disease intensity. For this report, the only data that will be presented and discussed are from those cultivars (45 total) that were commercially available at the time this paper was published.

Results and Discussion

The 2008 growing season was noteworthy in that Fayetteville experienced extremely wet and cool conditions both early in the summer and then again in the late summer and early fall (Richardson and Stiegler, 2009). Significant differences in turf quality were present among cultivars on every rating date in 2007 and 2008 (data not shown), but quality was also significantly different when averaged over the entire season and both seasons (Table 1). Some of the cultivars with the highest turf quality over the first two growing seasons included Toccoa, Fat Cat, Mustang 4, Rhambler SRP, Plato, Rocket, Jamboree, Raptor II, Traverse SPR, Turbo, and Van Gogh, while the cultivars with the worst overall quality over the two seasons were Falcon IV, Cezanne RZ, Einstein, and Ky-31 (Table 1). Significant differences in turfgrass color have also been documented in this trial, with cultivars such as Toccia, Fat Cat, Hunter, and Darlington having the darkest green genetic color, while Ky-31 had the lightest color (Table 1).

Brown patch disease was active in the experimental area for only a couple of weeks in July of 2008 due to the unseasonably cool weather. Average rating values for disease incidence in 2008 ranged from 5% up to 23%, which is considerably lower than what was observed in 2007 (Table 1). In 2008, cultivars with the lowest brown patch severity ratings included Ky-31, Rhambler SRP, Talladega, Speedway, and Mustang 4, although there were numerous cultivars in the trial that were not statistically different from Ky-31 with regards to brown patch severity. The Ky-31 and Rhambler cultivars also demonstrated the best resistance to brown patch in the 2007 trials, as reported earlier (Richardson et al., 2008).

These data represent initial evaluations of tall fescue cultivars that will be marketed in this region in the coming years. Data will continue to be collected on these varieties through the 2010 growing season. Yearly summaries of the data from this site and all sites around the United States will be published by NTEP and be available at their website (www.ntep.org).

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Richardson, M. and C. Stiegler. 2009. 2008 weather summary for Fayetteville, Arkansas. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:110-111.

Table 1. Turfgrass color and seasonal turfgrass quality at Fayetteville, Ark., for 45 commercially available tall fescue entries in the NTEP 2006 National Tall Fescue Test. Cultivars are arranged by average turf quality ratings across both the 2007 and 2008 season.

Cultivar	Turf color 2007-2008	------------- Turf quality ------------- 2007	2008	Average
	---------- 1-9, with 9 = best color or quality --------			
Toccoa	7.3	7.5	7.4	7.5
Fat Cat	7.3	7.4	7.2	7.3
Mustang 4	7.0	7.3	7.2	7.2
Rhambler SRP	6.6	7.2	7.1	7.2
Plato	6.3	7.2	7.1	7.2
Rocket	6.5	7.2	7.1	7.1
Jamboree	6.9	7.2	7.0	7.1
Raptor II	7.1	7.2	7.0	7.1
Traverse SPR	6.7	7.2	7.0	7.1
Turbo	7.0	7.2	7.0	7.1
Van Gogh	6.7	7.2	6.9	7.1
Aggressor	6.9	7.2	6.9	7.0
Biltmore	6.8	7.1	6.9	7.0
Aristotle	6.7	7.1	6.9	7.0
Hunter	7.2	7.1	6.9	7.0
Bullseye	6.9	7.1	6.8	7.0
Talladega	6.8	7.1	6.9	7.0
SR 8650	7.1	7.1	6.8	7.0
Firenza	6.8	7.1	6.8	7.0
Spyder LS	7.0	7.1	6.8	7.0
Darlington	7.5	7.0	6.9	7.0
Speedway	6.9	7.1	6.7	6.9
Titanium LS	6.6	7.0	6.8	6.9
Escalade	6.4	7.0	6.8	6.9
Lindbergh	6.6	7.0	6.7	6.9
Firecracker LS	6.6	7.0	6.7	6.9
Tulsa Time	6.9	7.0	6.7	6.9
Monet	6.6	7.0	6.7	6.9
Wolfpack II	6.8	7.0	6.7	6.8
Hemi	6.8	7.0	6.7	6.8
Tahoe II	7.0	6.9	6.7	6.8
Justice	6.5	6.9	6.7	6.8
Magellan	6.8	7.0	6.7	6.8
Essential	6.6	7.1	6.5	6.8
Turbo RZ	6.9	6.9	6.6	6.8
Silverado	5.8	6.8	6.8	6.8
Millennium SRP	6.7	7.0	6.5	6.8
Rembrandt	6.5	6.9	6.6	6.7
Padre	6.5	6.9	6.5	6.7
Rebel IV	6.6	6.9	6.5	6.7
Skyline	6.8	6.8	6.5	6.7
Falcon IV	6.6	6.9	6.4	6.6
Cezanne RZ	6.6	6.9	6.3	6.6
Einstein	6.5	6.9	6.3	6.6
Ky-31	4.9	6.4	6.1	6.3
LSD(0.05)	0.4	0.3	0.5	0.4

Table 2. Brown patch evaluations at Fayetteville, Ark., for 45 commercially available tall fescue entries in the NTEP 2006 National Tall Fescue Test. Cultivars are arranged by average brown patch severity ratings across both the 2007 and 2008 season.

	2007			2008			Average		
Cultivar	Incidence[z]	Intensity[y]	Severity[x]	Incidence	Intensity	Severity	Incidence	Intensity	Severity
	%	1-9		%	1-9		%	1-9	
Ky-31	6.7	1.0	6.7	6.7	1.0	6.7	6.7	1.0	6.7
Rhambler SRP	6.7	1.0	6.7	5.0	1.3	6.7	5.8	1.2	6.7
Talladega	10.0	1.0	10.0	5.0	1.7	8.3	7.5	1.3	9.3
Speedway	5.0	1.7	11.7	5.0	1.3	6.7	5.0	1.5	9.3
Mustang 4	8.3	1.3	11.7	5.0	1.3	6.7	6.7	1.3	9.7
Jamboree	10.0	1.3	15.0	5.0	1.7	8.3	7.5	1.5	11.7
Titanium LS	10.0	1.3	13.3	6.7	1.7	10.0	8.3	1.5	11.7
Aggressor	8.3	1.3	11.7	6.7	2.0	13.3	7.5	1.7	12.7
Plato	11.7	1.3	18.3	8.3	1.7	15.0	10.0	1.5	16.7
Bullseye	11.7	1.3	15.0	8.3	1.7	18.3	10.0	1.5	17.0
Spyder LS	11.7	1.7	21.7	6.7	2.0	13.3	9.2	1.8	17.7
Justice	6.7	2.3	20.0	6.7	2.3	15.0	6.7	2.3	17.7
Wolfpack II	8.3	1.7	18.3	10.0	1.3	16.7	9.2	1.5	18.0
Toccoa	11.7	2.0	23.3	5.0	2.7	13.3	8.3	2.3	18.7
Tahoe II	11.7	2.0	26.7	5.0	2.3	11.7	8.3	2.2	19.3
Rembrandt	15.0	1.3	25.0	8.3	2.0	16.7	11.7	1.7	21.0
Magellan	18.3	1.7	33.3	5.0	2.0	10.0	11.7	1.8	22.0
Raptor II	16.7	1.7	30.0	11.7	1.7	15.0	14.2	1.7	22.7
Hemi	15.0	1.7	26.7	8.3	2.3	20.0	11.7	2.0	23.3
Turbo	16.7	2.0	33.3	5.0	2.7	13.3	10.8	2.3	23.7
Turbo RZ	15.0	1.7	35.0	8.3	2.3	21.7	11.7	2.0	28.7
Cezanne RZ	13.3	1.7	33.3	13.3	1.7	25.0	13.3	1.7	29.3
SR 8650	16.7	2.0	43.3	6.7	2.7	20.0	11.7	2.3	32.0
Biltmore	20.0	2.7	53.3	6.7	2.0	11.7	13.3	2.3	32.7
Millennium SRP	21.7	1.7	41.7	10.0	2.3	25.0	15.8	2.0	33.7
Firenza	20.0	2.0	46.7	6.7	2.7	20.0	13.3	2.3	33.7
Van Gogh	21.7	2.0	48.3	8.3	2.7	25.0	15.0	2.3	36.7
Traverse SPR	21.7	3.0	66.7	6.7	2.3	16.7	14.2	2.7	41.7
Falcon IV	26.7	2.3	73.3	5.0	2.7	13.3	15.8	2.5	43.7
Lindbergh	20.0	2.3	56.7	11.7	2.7	33.3	15.8	2.5	45.3
Monet	30.0	2.0	63.3	15.0	2.0	30.0	22.5	2.0	47.0
Darlington	23.3	2.3	71.7	8.3	3.0	23.3	15.8	2.7	47.7
Essential	30.0	2.7	83.3	6.7	2.3	15.0	18.3	2.5	49.3
Padre	35.0	2.3	83.3	8.3	2.0	16.7	21.7	2.2	50.3
Aristotle	31.7	2.0	76.7	11.7	3.0	36.7	21.7	2.5	56.7
Rocket	38.3	2.0	80.0	16.7	2.7	36.7	27.5	2.3	58.3
Einstein	36.7	2.7	100.0	10.0	2.3	21.7	23.3	2.5	61.0
Rebel IV	33.3	2.7	93.3	10.0	3.0	28.3	21.7	2.8	61.0
Escalade	36.7	2.7	103.3	8.3	2.7	20.0	22.5	2.7	62.0
Firecracker LS	26.7	3.0	95.0	10.0	2.7	28.3	18.3	2.8	62.0
Fat Cat	28.3	3.0	116.7	5.0	3.0	15.0	16.7	3.0	66.0
Skyline	38.3	3.3	120.0	13.3	3.3	41.7	25.8	3.3	81.0
Tulsa Time	36.7	3.3	140.0	11.7	3.7	43.3	24.2	3.5	91.7
Hunter	45.0	3.3	180.0	20.0	3.0	68.3	32.5	3.2	124.3
Silverado	60.0	3.3	205.0	23.3	3.3	83.3	41.7	3.3	144.3
LSD (0.05)	25.6	1.5	95.1	9.7	1.4	31.5	15.9	1.4	58.0

[z] Disease incidence was visually rated on a scale of 0-100% of the plot area infected.
[y] Disease intensity was rated on a 1-9 scale, with 1=no damage and 9=severe damage.
[x] Disease severity was calculated as disease incidence (%) x disease intensity (1-9).

Nitrogen Rate and Season Influence Ammonia Volatilization Following Foliar Application of Urea to Putting Green Turf


Photo by Chris Stiegler

NH_3 volatilzation traps installed on plots

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Additional index words: creeping bentgrass, ultradwarf bermudagrass, fertilization, boric acid trap

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Summary. Foliar nitrogen (N) fertilization continues to gain popularity with golf course superintendents, especially in regard to putting green nutrition. However, little is currently known about the efficiency of this practice in the field, or the significance of the possible N-loss mechanisms associated with foliar applications. This project was conducted to document the extent of ammonia volatilization from turfgrasses managed as putting greens, following the applications of foliar N using urea (46-0-0), over a 24 h period. Two different foliar fertilizer rates (0.10 1b N/1000ft^2 and 0.25 lb N/1000ft^2) were applied once monthly (May through September) to established putting greens of 'Penn A-1' creeping bentgrass and 'Tifeagle' ultradwarf bermudagrass. This study was initiated in 2007 and repeated in 2008. Ammonia volatilization over a 24-h period was measured via boric-acid trapping. Month of year and N rate both had a significant effect on the amount of N volatilized from the turfgrass canopy. The results from our field trial suggest that foliar urea-N applications to putting green turf can be made to actively growing plant tissue throughout the season without concern for substantial N loss via this pathway.

Abbreviations: NH_3 (ammonium), NH_4^+ (ammonium), UAN (urea-ammonium nitrate), H_3BO_3 (boric acid), H_2SO_4 (sulfuric acid)

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Foliar fertilization is a common practice on today's intensively managed golf courses. A recent survey of golf course superintendents in Arkansas indicated that all respondents are using foliar fertilization on their putting greens and many superintendents apply over half of the nutrients to greens in this fashion (data not shown).

Urea and/or urea-ammonium nitrate (UAN) are common sources of nitrogen (N) included in foliar fertilizer products and when applied to the plant surface, there is risk of considerable N loss to the atmosphere as ammonia (NH_3) with these N sources. The presence of the urease enzyme, both on the leaf surface and within most plants (Witte et al., 2002), underlies NH_3 (ammonia) volatilization N-loss potential. Urease catalyzes the hydrolysis of urea into NH_3 and carbon dioxide. Under most conditions, the NH_3 then undergoes protonation ($NH_3 + H^+ \leftrightarrow NH_4^+$). While this is a highly important process for plants to assimilate urea-N into a plant-available form of ammonium (NH_4^+), NH_3 gas may also escape from the system (volatilize) during the process. Factors known to favor NH_3 volatilization include increased soil pH; increased surface temperature, moisture, or relative humidity; and wind speed (Joo, 1987; Knight et al., 2007).

Atmospheric losses of N as NH_3 gas, following the application of N fertilizers, have been well studied in agricultural research, while this same N-loss pathway from turfgrass stands has received considerably less research attention. Though several investigations into NH_3 volatilization from turfgrass stands have been reported, as shown in Turner and Hummel (1992), no such studies are known to be specific to N loss from the putting green turfgrass canopy following foliar-applied urea-N. Characteristics of foliar fertilization, such as soluble urea treatments made directly over the top of the plant canopy with low carrier rates, should negate the possibility of denitrification and/or leaching losses, as these are strictly soil/rootzone phenomena. Therefore, NH_3 volatilization should be the most important N-loss mechanism associated with typical foliar-N fertilization practices (McCarty, 2005). However, no studies to date have attempted to measure volatilization of NH_3 from golf course putting greens following foliar-N applications. Given this current lack of turfgrass scientific clarity, the objective of this study was to document the extent of N-loss from seasonal foliar applications of urea to a putting green turfgrass canopy.

Materials and Methods

This field research study was conducted at the University of Arkansas Research and Extension Center in Fayetteville, Arkansas. Experimental areas of 'Penn A1' creeping bentgrass (*Agrostis stolonifera*) and 'Tifeagle' ultradwarf bermudagrass (*Cynodon dactylon* x *Cynodon transvaalensis*) were established on a sand-based putting green (USGA, 1993) and maintained according to typical putting green management practices for the region. Within the experimental areas, four replicated plots were designated for each sampling date and each turfgrass species.

Applications of foliar urea-N were made once-monthly using urea (46-0-0), May through September 2007, to 2 by 4 ft plots with 6 inch borders. Treatments were repeated in the same months during 2008. Foliar-N was applied in a spray volume of 58 gal/A with the aid of a spray shield and a single nozzle CO_2-pressurized sprayer. A Teejet® (TX-VS2) hollow-cone spray nozzle was selected to produce a fine, atomized spray pattern for even, thorough plot coverage facilitating foliar uptake. Application rates of 0.10 and 0.25 lb N/1000ft^2 were used and designated as a low and high rate, respectively. These correspond with foliar-N application rates commonly used by golf course superintendents. For a 24-h period after treatment, plots received no irrigation or rainfall to limit all N absorption to the foliar uptake pathway.

Estimates of NH_3 volatilization were obtained through the use of an acid collection trap (4% H_3BO_3 solution with pH color indicator) housed in a small Petri dish, suspended within a bottomless 1-pint Mason jar (Fig. 1). Immediately after foliar-N treatments were applied, these apparatuses were directly inserted into the putting green turf, completely enclosing a portion of the plot previously treated with urea fertilizer solution. These air-tight traps were modified in form and function but were designed after original specification details outlined by Mulvaney et al. (1997). The chambers were deployed for a period of 24 h after N application, then acid traps were collected, stabilized in-field, and transported to the laboratory for analysis. As described in Mulvaney et al. (1997), acidimetric titration with 0.01 M H_2SO_4 back to the original end point pH of the boric acid solution allowed for an indirect measurement of N loss via NH_3 volatilization.

Results and Discussion

Percentages of N applied and lost via NH_3 volatilization were influenced by N rate and month of urea-N application on both species. In addition, there were a few higher-order interactions between the two species. There were significant ($P < 0.05$) two-way interactions of month × rate and year × month on Tifeagle bermudagrass, while Penn A1 creeping bentgrass data exhibited a three-way interaction of year × month × rate. Figures 2 and 3 represent these respective interactions and discussion for each species will be focused on these graphs.

Ammonia volatilization from the Tifeagle bermudagrass putting green surface ranged from a pooled maximum of 10.4% (May 2008) to a pooled minimum value of 0.5% (June-low N rate). During all application months, the higher N application rate created volatile N losses that were numerically higher than those achieved with the lower N rate and in some cases this difference was significant (Fig. 2). This is not unexpected based on principles of enzyme kinetics. Increased urea (substrate) concentration on turfgrass leaves should result in increased urease enzyme activity, and a subsequently higher amount of NH_3/NH_4 (product) conversion coupled with an increased likelihood for volatile loss as NH_3.

In 2007, when foliar urea-N was applied to Penn A1 creeping bentgrass, NH_3 volatilization losses expressed as a percentage of applied N ranged from a maximum of 1.4% (September-low N rate) to a minimum value of 0.2% (several monthly sampling dates and both N rates). On the last two experimental dates in August and September, the low foliar-N-rate plots had significantly more N loss via NH_3 volatilization than was observed in plots receiving a higher N rate (Fig. 3). This is dissimilar to what was seen on Tifeagle bermudagrass and is not easily explained based on the previously applied enzyme kinetic approach. It could simply be an aberration that arose due to the extremely low percentage of applied N generally lost from Penn A1 creeping bentgrass via NH_3 volatilization (Fig. 3). While, statistically, there was enough difference between the low and high rate during August and September to indicate significance, the numerical differences of 0.3 % and 0.6 % for these months, respectively, are not likely agronomically significant.

Acid-trap estimated volatilization of NH_3–N, resulting from 2008 monthly applications to Penn A1 creeping bentgrass, was also negligible. Comparatively, these numbers were even lower than were seen in 2007 with a maximum mean of 0.5% N loss (July-high rate) and a minimum of 0.0% (September-low rate). An N-rate effect was again observed in year 2 of the study with the May application date showing a significant difference between the high and low rate (Fig. 3). However, as discussed previously, finding statistical significance between two values less than 1% of the applied N holds no real practical significance to golf course superintendents.

Our data suggest that NH_3 volatilization from foliar urea-N application may not be a significant N-loss mechanism. Due to the design and use of our measurement devices (Fig. 1), much higher than normal ambient air/plant surface temperatures and a 100% relative humidity environment were inevitable within our NH_3 volatilization chambers. This should have created a worst-case scenario in regard to volatile losses of N. Despite this fact, the largest mean N loss observed in 2007 was 7.1% of the N applied, while in 2008 this number reached 13.7%. In both years, this abnormally high percent of N loss was seen with the high N rate when applied to Tifeagle bermudagrass in May. It should be noted that in both instances, this particular experimental area had yet to achieve full green-up. This altered state of turfgrass growth and activity could have rendered the Tifeagle bermudagrass canopy less receptive to foliar uptake and resulted in greater than normal NH_3 volatilization. Indeed, subsequent observations on Tifeagle were vastly lower than this first month (Fig. 2), and this trend was consistent for both years.

Comparing our results to NH_3 volatilization loss previously reported using foliar applications of urea (Wesely, 1987), we observed much lower numbers with our methodology and experimental parameters. The substantially lower N rates used in this study, which are inherent to putting green foliar-fertilizer applications, could be the reason for this discrepancy. Another possible explanation for this could be that the high-density plant community created by the low mowing heights of putting green turfgrass culture makes for an ultrareceptive environment for foliar absorption of urea. This is a premise that we are currently investigating with a co-related foliar nutrient uptake study using ^{15}N-labeled urea on the same experimental areas. The ability of plant leaves to absorb the urea molecule shortly after foliar fertilization application (Wittwer et al., 1963) also has the capacity to limit NH_3 volatilization, since urea hydrolysis could take place inside the plant, rather than on the leaf surface.

Despite turfgrass literature reference to NH_3-N loss via volatilization being a disadvantage when using foliar fertilization (McCarty, 2005), our two-year research study does not support this statement. Rather, the results from our field trial suggest that foliar urea-N applications to putting green turf can be made to actively growing plant tissue throughout the season without concern for substantial N-loss via this pathway.

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Fig. 1. Apparatus used for in-field ammonia volatilization estimates.

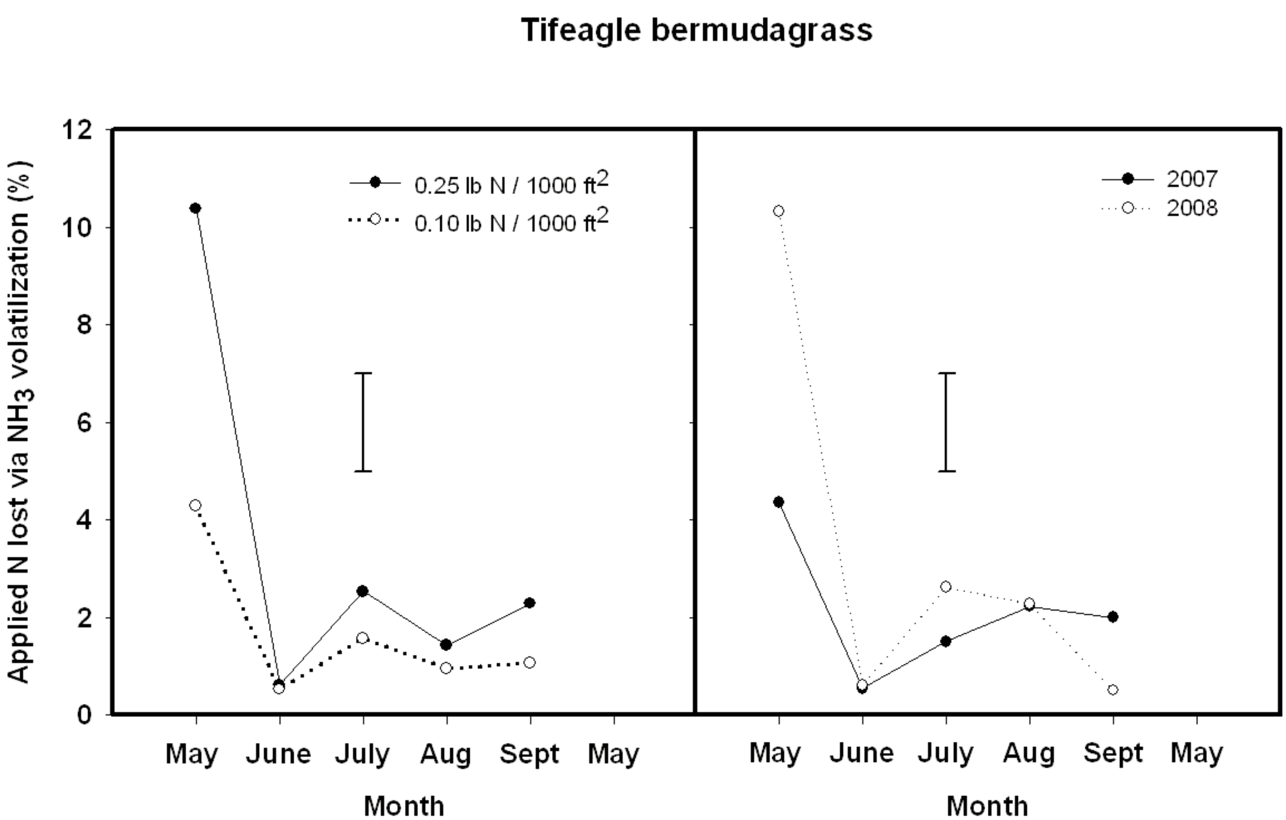

Fig. 2. Ammonia volatilization as affected by the following: (left) foliar urea application rate and sampling month; (right) year and sampling month. (LSD bar indicates significance at the 0.05 probability level).

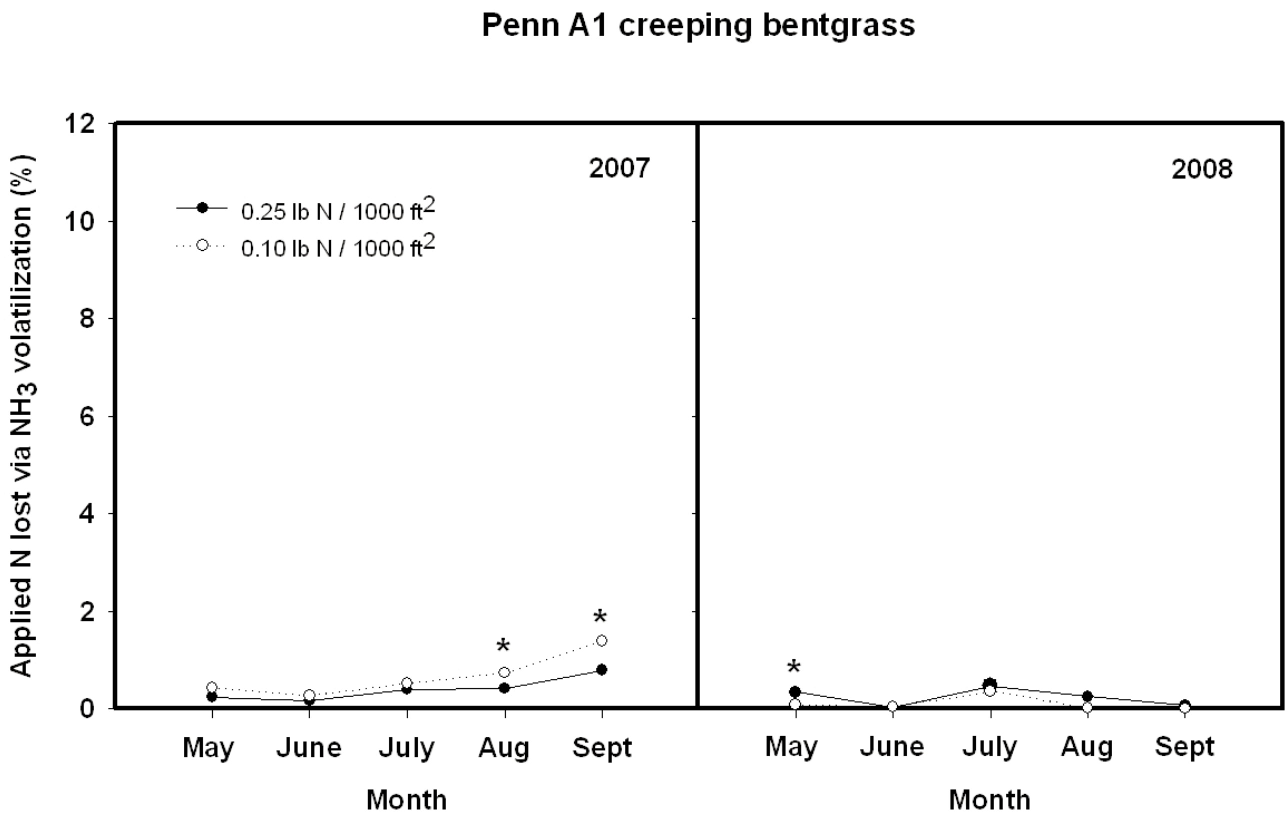

Fig. 3. Ammonia volatilization as affected by foliar urea application rate and sampling month during 2007 and 2008 (* denotes significance at the 0.05 probability level).

Foliar Uptake of Inorganic and Organic Nitrogen Compounds by Creeping Bentgrass Putting Green Turf

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Additional index words: urea, potassium nitrate, ammonium sulfate, amino acids, ^{15}N

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Photo by Mike Richardson

Applying foliar fertilizer to a putting green

Summary. Foliar nitrogen (N) fertilization often comprises a major portion of the total N inputs applied to creeping bentgrass golf greens annually. Many of these applications are made using fertilizers that have been formulated and marketed as specialty foliar fertilizers. Various forms of inorganic and organic N are usually included in these products purchased by golf course superintendents. However, little is currently known about the foliar absorption efficiency among different chemical N forms routinely applied to putting greens. This project was conducted to evaluate foliar uptake of N after application of different ^{15}N-labeled inorganic and organic sources. Three common N fertilizer forms [(urea, ammonium sulfate ($(NH_4)_2SO_4$), and potassium nitrate (KNO_3)] were used in the trial, along with three amino acids (glycine, glutamic acid, and proline). All treatments were applied at a rate of 0.10 lb N/1000 ft^2 on 18 September 2008 to plots within a 'Penn G2' creeping bentgrass research green. Plant tissue samples were taken 1 h and 8 h after application for N analysis. Foliar uptake of the various N compounds ranged from 37-56% of the N applied at the final sampling time of 8 h after application. Nitrogen source had a significant effect on the amount of fertilizer N recovered within plant leaves/shoots. Absorption of KNO_3 into aerial plant parts was significantly lower than all of the chemical forms tested, while the other treatments were taken up similarly.

Abbreviations: KNO_3 (potassium nitrate), $(NH_4)_2SO_4$ (ammonium sulfate), NH_2 $CONH_2$ (urea), NH_4^+ (ammonium), NO_3^- (nitrate), UR (urea), AS [$(NH_4)_2SO_4$], KN (KNO_3), GLY (glycine), GLU (glutamic acid), PRO (proline)

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Foliar fertilization has become an increasingly common practice on golf courses around the world. While typically used as a supplement to traditional root-feeding programs, the importance of foliar fertilization has been magnified by the management practices of today's golf course superintendent. Often, this method of delivering plant nutrients makes up a large percentage of the total annual nitrogen (N) applied to golf course putting greens. Despite its prevalent use in golf course management, there have been relatively few research studies investigating foliar absorption of N by turfgrasses and no studies which document foliar uptake of nutrients in a field setting.

Urea (NH_2CONH_2), ammonium sulfate ($(NH_4)_2SO_4$), and potassium nitrate (KNO_3) are common sources of N that are water-soluble and thus can be used as foliar fertilizers. Both $(NH_4)_2SO_4$ and KNO_3 dissociate when added to water, leaving the N components in an ionic state. As is the case with root absorption, plant leaves can take up these N fertilizers as ions, more specifically ammonium (NH_4^+) and nitrate (NO_3^-). While urea stays in its original, uncharged form during mixing with water, the foliar pathway allows for direct entry of the intact urea molecule (Wittwer et al., 1963), as well as any NH_4^+-N derived from urease action on plant leaf surfaces. The previous descriptions of how these common N fertilizer sources can be utilized by plant leaves/shoots build the foundation for their inclusion within turf industry foliar products. Though these particular N fertilizers have been studied to some degree as foliar products in the turfgrass scientific literature (Bowman and Paul, 1989; Bowman and Paul, 1990), and even evaluated against each other (Bowman and Paul, 1992), no previous research has attempted to determine absorption efficiency under putting green conditions in the field.

Other small-molecular-weight organic N compounds, such as amino acids, are also often included in the various foliar fertilizer formulations currently marketed to golf course superintendents. Plants are autotrophic by nature and thus are fully capable of producing these compounds on their own, but companies claim that these amino acid additives either create a synergistic effect or can be used as chelating agents for enhanced foliar absorption of nutrients. In the assumed absence of mineralization on the turfgrass leaf surface, foliar fertilization with these amino acids would require diffusion through the plant leaf surface in the original chemical state. Therefore, regardless of the reasons behind their addition to commercially-available foliar products, these organic forms of N still need to make it into the plant to be useful. While previous horticultural research has investigated foliar absorption of amino acids using direct measurement with isotopic tracers (Furuya and Umemiya, 2002), there are no similar studies that have been specific to turfgrasses. Given the lack of research in this area, a study was initiated to directly measure foliar uptake of N supplied through different compounds, sources, and available forms of N on creeping bentgrass (*Agrostis stolonifera*) putting green turf.

Materials and Methods

This field research study was conducted at the University of Arkansas Research and Extension Center in Fayetteville, Arkansas. An experimental area of 'Penn G2' creeping bentgrass was established on a sand-based putting green (USGA, 1993) and maintained according to typical putting green management practices for the region. Within the experimental areas, three replicated plots were designated for each of the following six N source treatments: urea, $(NH_4)_2SO_4$, KNO_3, glycine, glutamic acid, and proline. The use of ^{15}N-labeled compounds enabled positive identification of fertilizer N within the plant tissue and also provided the sensitivity necessary to analyze for the small amounts of N applied to the turfgrass canopy during foliar fertilization.

Applications of all treatments were made on 18 September 2008, to 2 by 4 ft plots with 6 inch borders. Foliar N was applied in a spray volume of 58 gallons/A with the aid of a spray shield and a single nozzle CO_2-pressurized sprayer. A

Teejet® (TX-VS2) hollow cone spray nozzle was selected to produce a fine atomized spray pattern for even, thorough plot coverage facilitating foliar uptake. An application rate of 0.10 lb N/1000 ft^2 was selected for all six treatments, as this corresponds with a typical foliar N application rate used by golf course superintendents. For an 8 h period after treatment, plots received no irrigation or rainfall to limit all N absorption to the foliar uptake pathway. Plant leaf tissues were sampled at 1 and 8 h after application to examine foliar N absorption efficiency over time.

Results and Discussion

Foliar uptake was significantly affected by N source due to a reduction in uptake of one treatment. When expressed as a percentage of that which was applied to plots, all of the compounds tested were absorbed similarly, with the exception of KNO_3, which was significantly lower than the other treatments (Fig. 1). At one hour after treatment, foliar absorption efficiency across all of the N compounds ranged from 27 to 43%, while samples taken seven hours later ranged from 37 to 56%. This means that all sources of N continued to diffuse into the plant leaves/shoots over an 8 h period.

Of the commonly used fertilizer N sources, urea and $(NH_4)_2SO_4$ were both superior to KNO_3 in terms of uptake through the putting green turfgrass foliage (Fig. 1). Forty-two percent of the urea-N applied was taken up at 1 h after application and 56 % by the 8 h sampling. Fertilizer N supplied by $(NH_4)_2SO_4$ was also recovered relatively well within creeping bentgrass leaf tissue, with 40% being absorbed within 1 h and 55% at the 8 h sampling. By comparison, KNO_3-treated samples only contained 27% of the total amount of N applied at 1 h and 37% at 8 h post-treatment.

As the only source that requires uptake of N as the anion NO_3^-, the poor absorption of KNO_3 treatments is not unexpected based on previous research. The scientific consensus on how polar solutes diffuse through plant leaves is through tiny (<1 nm), hydrophilic pores that traverse the leaf cuticle (Schonherr, 1976; Marschner, 1995). These transport channels for water and small solute molecules have been reported by Tyree, et al. (1990) to be lined with negative charges. Since the NO_3^- ion also holds a negative charge, and like charges are repelled, this may explain why we observed significantly lower foliar uptake with KNO_3 when compared to NH_4^+-based N sources, like $(NH_4)_2SO_4$ or urea.

There was not a significant difference between urea and $(NH_4)_2SO_4$ in terms of recovery in plant tissue, which suggests that efficient utilization of foliar-applied N can be achieved with either source. While this is true, $(NH_4)_2SO_4$ has a higher salt index and phytotoxicity can be a problem with its use as a foliar spray. Indeed, even at the low application rate used in this study, slight yellowing of creeping bentgrass foliage was observed in plots treated with this form of N. Based on this temporary decline in visual quality when using $(NH_4)_2SO_4$ as a foliar spray, along with the previously discussed deficiencies of KNO_3, urea is a good option for foliar application on putting greens when choosing among these three N sources.

Creeping bentgrass foliage was quite receptive to all three of the amino acids tested. While proline was numerically higher in percentage foliar absorption, it was not significantly different than glutamic acid or glycine. Percentages of the labeled N supplied by proline, glutamic acid, and glycine was recovered in plant tissue 8 h after application at 52, 51, and 48% of the N delivered through spray, respectively (Fig. 1). While these pure compounds of amino acids are not to be considered as stand-alone fertilizer N sources, these data allude to direct uptake of these organic N forms by creeping bentgrass leaves when excluding the possibility of microbial transformation of amino acids on the leaf surface. The finding that amino acids can be efficiently taken up by turfgrasses, serves as a first-step in substantiating their inclusion within commercially-available foliar fertilizers. However, it should be noted that it is still not known what happens to exogenously applied amino acids once inside the plant.

The potential beneficial roles of chelation, N transport, and stress alleviation for glycine, glutamic acid, and proline, respectively, each rely on some degree of chemical stability within plant cells or the vascular system. Further research utilizing double-labeled amino acids with both ^{15}N and either ^{13}C or ^{14}C isotopes as tracers and/or more specific methodology could help answer some of these questions more conclusively.

This study has been repeated and once data are compiled we hope the results from this trial will assist golf course superintendents who wish to maximize foliar fertilization efficiency through proper selection of N form. Additionally, this research may benefit the turfgrass industry in lending scientific knowledge to companies who formulate specialty foliar fertilizers, so that they may create better products for their clientele.

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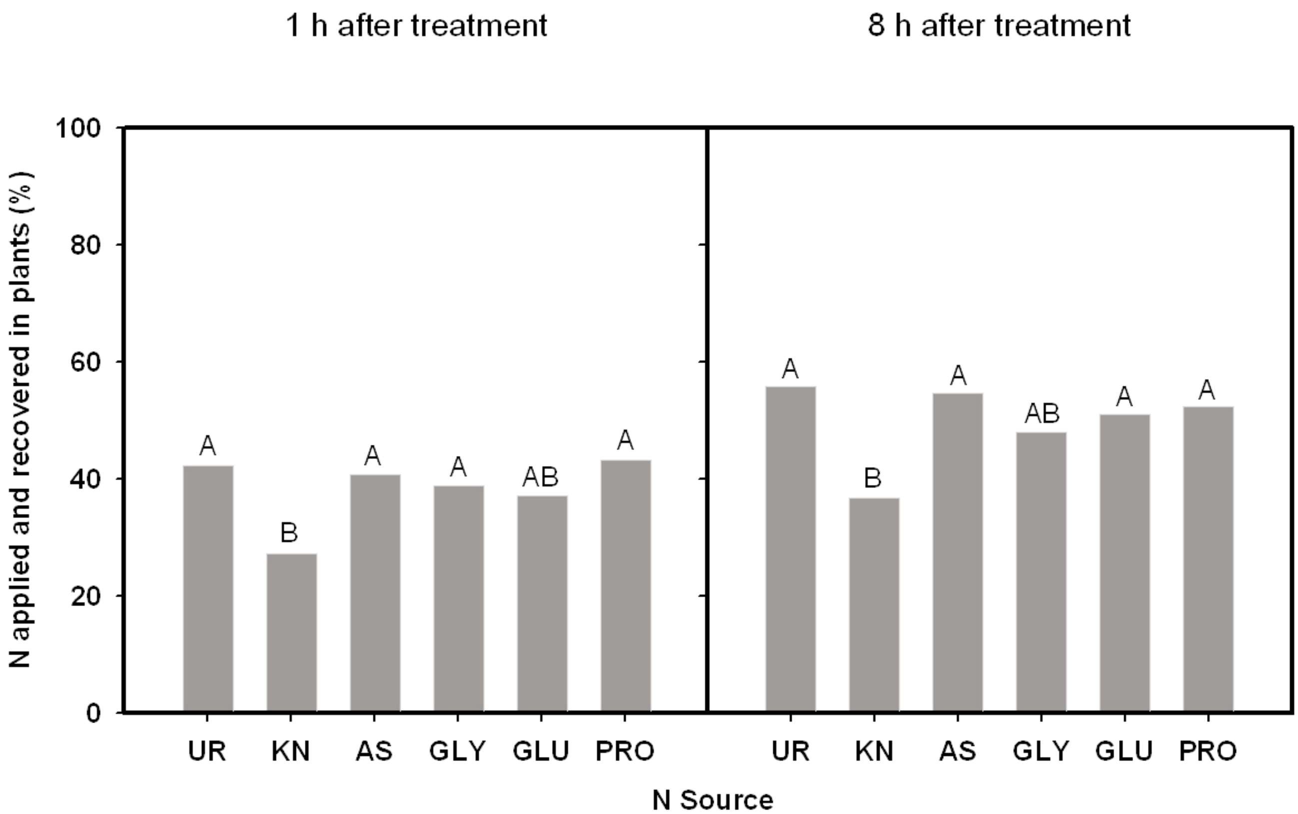

Fig. 1. Foliar uptake of N supplied by six different inorganic or organic N compounds (UR = urea, AS = $(NH_4)_2SO_4$, KN = KNO_3, GLY = glycine, GLU = glutamic acid, PRO = proline) sampled at 1 h (left) and 8 h (right) after treatment (Bars not sharing a letter are significantly different at P < 0.05).

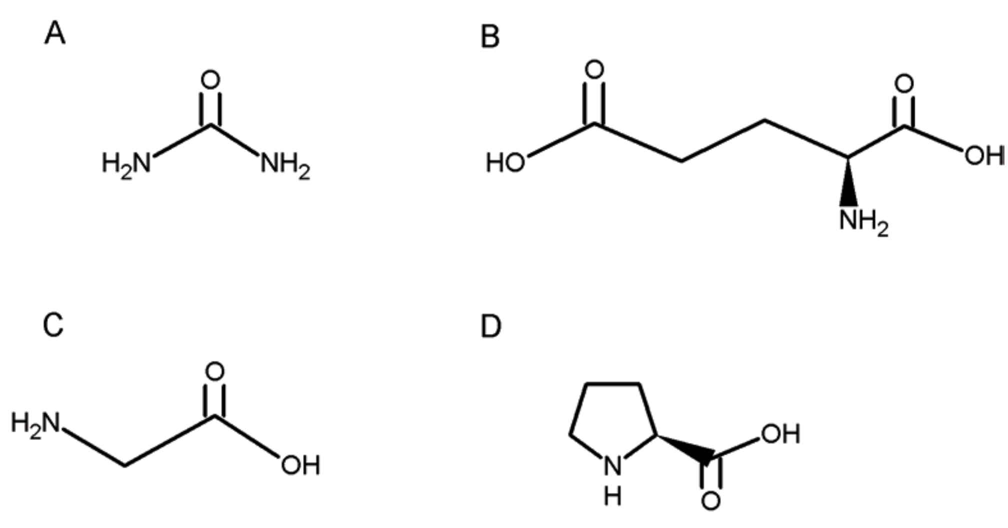

Fig. 2. Chemical structures of the synthetic and natural organic N compounds used in the study: (A) urea, (B) glutamic acid, (C) glycine, and (D) proline.

Direct Measurement of Foliar Absorbed Urea-Nitrogen Following Application to Putting Green Turfgrass Species

Photo by Josh Folkers

Foliar application of nutrients to putting green

Chris Stiegler[1], Mike Richardson[1], John McCalla[1], and Josh Summerford[1]

Stiegler, C., M. Richardson, A. J. McCalla, and J. Summerford. 2009. Direct measurement of foliar absorbed urea-nitrogen following application to putting green turfgrass species. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:121-126.

Additional index words: creeping bentgrass, ultradwarf bermudagrass, ^{15}N, isotopic tracer

Summary. Foliar fertilization often comprises a significant portion of the total annual nitrogen (N) applied to putting greens. Despite the prevalent use of this N fertilization method, turfgrass scientific research efforts devoted to foliar absorption have been limited. Most glaringly, there have been no studies to date that document foliar uptake of N in a real-world, field setting. This study was initiated to evaluate the efficiency of this practice in the field and address the factors that may affect the foliar absorption process. A ^{15}N isotopic tracer field study was conducted to compare seasonal uptake of foliar-applied nitrogen by Penn A-1 creeping bentgrass and Tifeagle ultradwarf bermudagrass when managed for putting green utility. ^{15}N-labeled urea (46-0-0) was applied monthly, May through September, at rates of 0.10 lb N/1000 ft^2 and 0.25 lb N/1000 ft^2. Both species proved receptive to foliar uptake of urea-N, and absorption into plant tissues happened rapidly. A range of 24-57% of the fertilizer N applied was recovered in leaves/shoots at 1 h after treatment, while peak foliar absorption was generally observed at 4 h after treatment. Foliar uptake, when measured as a percentage of N applied, was significantly reduced at higher application rates on both species. Month of year significantly affected foliar absorption by creeping bentgrass. This was seen as a progressive reduction across the season in the percentage of N applied and recovered in creeping bentgrass plant tissue (May = 59%; September = 37%). However, no seasonal effect was observed on ultradwarf bermudagrass as percent foliar absorption remained fairly constant (45-50%) throughout the five months of this study.

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Foliar fertilization refers to the process of nutrient uptake through the foliage or other aerial plant parts. As a supplement to traditional root-feeding programs, foliar fertilization has been observed to be an increasingly common practice in today's golf course management. Lending credence to this perception, recent surveys of Arkansas golf course superintendents indicate that nearly all respondents use foliar fertilization on some area of their golf course and this method of nutrient application often comprises a major portion of annual nitrogen (N) inputs to putting greens (data not shown).

While there continues to be practical turfgrass research devoted to growth and color response from various foliar products, few studies have actually investigated foliar nutrient uptake dynamics or efficiency. The majority of these undertakings have come from a small group of researchers looking at N absorption into cool-season turfgrass leaves grown in controlled, moderate temperature environments (Wesely et al., 1985; Bowman and Paul, 1989; Bowman and Paul, 1990; Bowman and Paul, 1992). While these contributions have been significant, more research is needed to improve foliar nutritional strategies for golf course superintendents who wish to maximize plant uptake and reduce losses to the environment.

The development of a method to evaluate foliar uptake of N in the field would more closely resemble the seasonal environmental conditions that golf course superintendents face when using this practice. The importance of using real-world conditions when studying foliar fertilization is realized when considering previous agricultural research that shows that environmental factors and seasonal dynamics of leaf cuticle characteristics can influence the foliar absorption of N solutions (Oosterhuis et al., 1991; Bondada et al., 1997). Therefore, the aim of this project is to assess foliar uptake of N in the field, over successive months, during a two-year putting green research trial.

Materials and Methods

This field research study was conducted at the University of Arkansas Research and Extension Center in Fayetteville, Ark. Experimental areas of 'Penn A1' creeping bentgrass (*Agrostis stolonifera*) and 'Tifeagle' ultradwarf bermudagrass (*Cynodon dactylon* x *C. transvaalensis*) were established on a sand-based putting green (USGA, 1993) and maintained according to typical putting green management practices for the region. Within the experimental areas, four replicated plots were designated for each sampling date and each turfgrass species.

An isotopic tracer technique that allows for positive identification and direct measurement of fertilizer N in the plant tissue was used in this study. Applications of foliar urea-N were made once-monthly using urea (46-0-0 & 2.577 atom % ^{15}N), May through September 2007, to 2 by 4 ft plots with 6 inch borders. Treatments were repeated in the same months during 2008. Foliar N was applied in a spray volume of 58 gallons/A with the aid of a spray shield and a single nozzle CO_2-pressurized sprayer. A Teejet® (TX-VS2) hollow cone spray nozzle was selected to produce a fine atomized spray pattern for even, thorough plot coverage facilitating foliar uptake. Application rates of 0.10 and 0.25 lb N/1000ft^2 were used and designated as a low and high rate, respectively. These correspond with foliar N application rates commonly used by golf course superintendents. For a 24 h period after treatment, plots received no irrigation or rainfall to limit all N absorption to the foliar uptake pathway. Plant leaf tissues were sampled at 1, 4, 8, and 24 h after application to develop a time-course analysis of foliar N uptake.

Results and Discussion

Percentages of urea-N applied and recovered within plant tissue samples were affected by N rate and time allowed for spray droplets to remain on the surface of leaves prior to rinsing (i.e., sampling time). These significant ($P \leq 0.05$) main effects (N rate and time) were observed on both species, while the main effect of application month only affected foliar absorption of urea-N on creeping bentgrass. Statistical analysis revealed no higher-order interactions for either species. Therefore, further discussion will only focus on the main effects of N rate, month of year, and sampling time. Figures 1, 2, and 3 graphically represent these main effects and will be referred to throughout the discussion.

The use of the 0.25 lb N/1000 ft^2 (high) application rate compared to the 0.10 lb N/1000 ft^2 (low) rate resulted in significant reductions in foliar absorption. This trend was seen on both creeping bentgrass and ultradwarf bermudagrass putting green turf (Fig. 1). Averaged across all sampling times and application months on creeping bentgrass, the low N rate treatments measured 46% N uptake, while the high N rate was 40%. On ultradwarf bermudagrass, the percentage absorption differences were similarly affected by N rate (Fig. 1). We speculate that the nanometer-small hydrophilic pores within the leaf cuticle (Schonherr, 1976), where foliar absorption of sprayed solutions is deemed to take place, must have a limited capacity for entry of urea-N and/or the NH_4^+ ion. Based on this, turfgrass leaves may be more receptive to spray droplets of lower N concentration, which could explain our results. However, it should be noted that greater amounts of N were recovered within plant tissue when using the higher N rate; it was just a significantly smaller percentage of that which was applied.

As expected, the amount of time allowed between foliar urea-N application and subsequent plant sampling significantly affected foliar uptake (Fig. 2). Absorption of foliar urea-N through leaves on the putting green is a diffusion process that is governed by time and various other factors. General principles of diffusion dictate that the longer the solution is allowed to remain on leaf surfaces, the more possibility there is for increased foliar uptake. As such, the highest maximum mean percentage absorption of N (n = 4) achieved in our study was in the month of May on creeping bentgrass at 24 h after application (76%). However, looking at the curvilinear uptake graphs (Fig. 2), it should be noted that the greatest increase in percentage foliar absorption of N occurred between the sampling intervals of 0 and 1 h after application. This was consistent for both putting green turfgrass species and demonstrates the effectiveness of foliar urea-N applications in quickly supplying turf plants with this critical macronutrient.

From a statistical perspective, the effects of time on foliar absorption were somewhat different between the two species studied. Ultradwarf bermudagrass foliar uptake of N peaked at 4 h after application, while statistically significant portions of urea-N continued to diffuse into turfgrass leaves of creeping bentgrass up until the last sampling period of 24 h after treatment (Fig. 2). As a cool-season turfgrass species, creeping bentgrass undergoes heat- and water- deficit stress during the summer months in the transition zone. It has been well-documented in other crop species that as a means of coping with these stresses, plants respond by producing increased amounts and types of leaf surface waxes. Ultradwarf bermudagrass, being a warm-season turfgrass, would be expected to incur much less summer stress than creeping bentgrass. This could mean more plant acclimating leaf cuticle wax development on creeping bentgrass than on ultradwarf bermudagrass, leading to a more tortuous path for foliar N absorption and a slower time to peak absorption as seen here. From an agronomic perspective, though maximizing foliar uptake of urea-N on creeping bentgrass putting greens is a worthwhile goal of golf course superintendents, delaying necessary management practices (e.g., syringing greens, etc.) in an effort to obtain an extra 10% of N from a light rate foliar application is not likely to be practical or highly beneficial.

Seasonal effects (month of year for treatment event) on foliar absorption of urea-N applications were only seen on creeping bentgrass putting green turf and not on the ultradwarf bermudagrass. When expressed as a percentage of applied N recovered in plant tissue samples, there was a significant decrease as the season progressed. The May applications to creeping bentgrass putting greens (averaged across all sampling times and N rates) resulted in 59% absorption, while in July, August, and September these numbers lowered to 37-38% of that which was applied (Fig. 3). Foliar uptake of urea-N treatments on ultradwarf bermudagrass was not significantly affected from month to month and the average of percentage N absorbed across all sampling times and N rates was between 45-50%. The previously described theory of more leaf cuticle wax additions in response to magnified heat stress on creeping bentgrass vs. ultradwarf bermudagrass might also play a part in explaining the differences in seasonal uptake dynamics seen between the two species. It is currently believed that these alterations in leaf cuticle waxes also make the creeping bentgrass leaf surfaces more hydrophobic and, therefore, possibly less receptive to nutrient absorption. Continued laboratory investigations are underway to better understand this observed trend.

This study has been repeated and once data are compiled and analyzed, research-based recommendations to golf course superintendents for enhanced utilization of foliar nutrition on putting greens should be more concrete. However, based solely on first-year results there are a few take home points to convey. First, both creeping bentgrass and ultradwarf bermudagrass golf course greens are receptive to rapid foliar uptake of urea-N, and the efficiency of this practice is high when compared to the 33% global estimate of N-use efficiency for some agricultural crops (Raun and Johnson, 1999). However, foliar N fertilization of putting greens should generally be used as a supplement, and not a replacement, for traditional root-feeding methods. Secondly, in a practical sense, most of the urea-N applied to putting green turfgrass foliage is absorbed in the first 4 h after application. Lastly, foliar uptake efficiency by creeping bentgrass foliage was reduced during warmer months, suggesting a change in the composition of the leaf cuticle.

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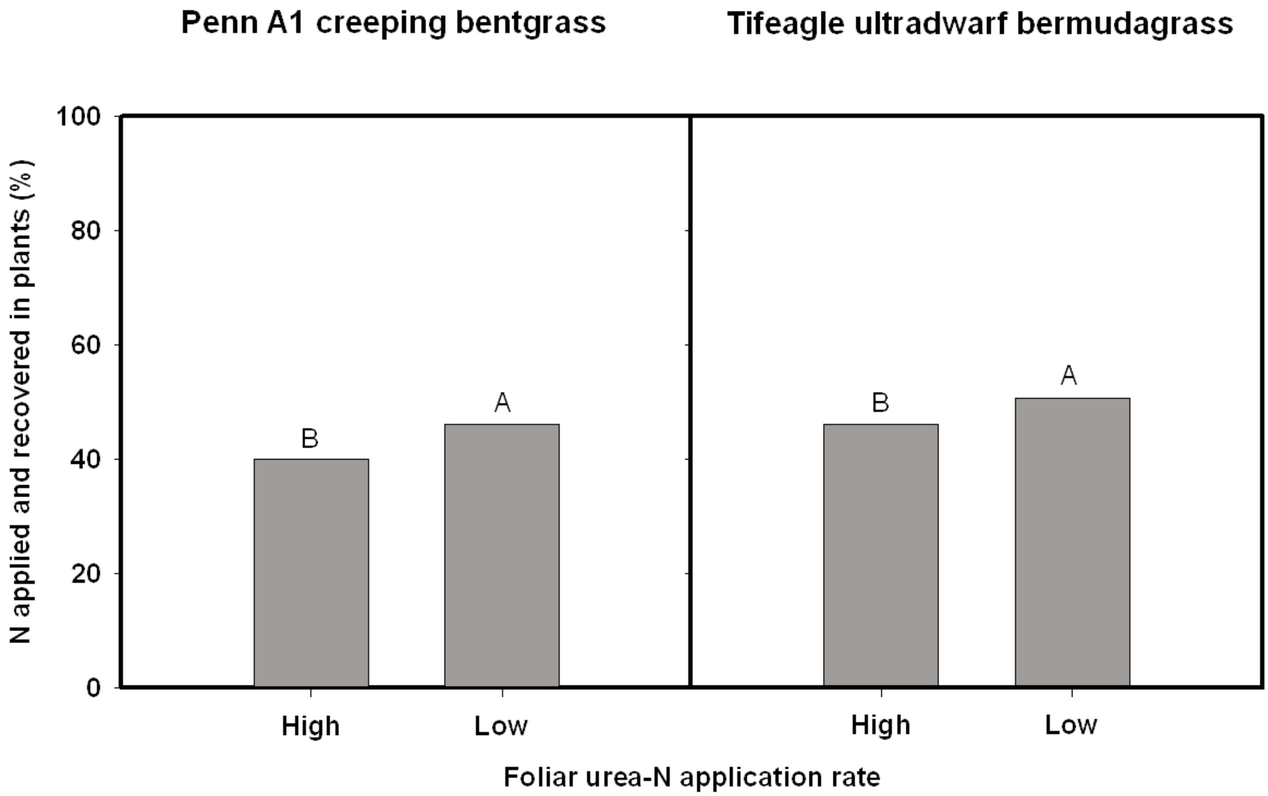

Fig. 1. Percentage of foliar urea-N absorption by Penn A1 creeping bentgrass (n = 159) and Tifeagle ultradwarf bermudagrass (n = 160) as affected by N rate. Bars with different letters indicate significant difference at $P \leq 0.05$.

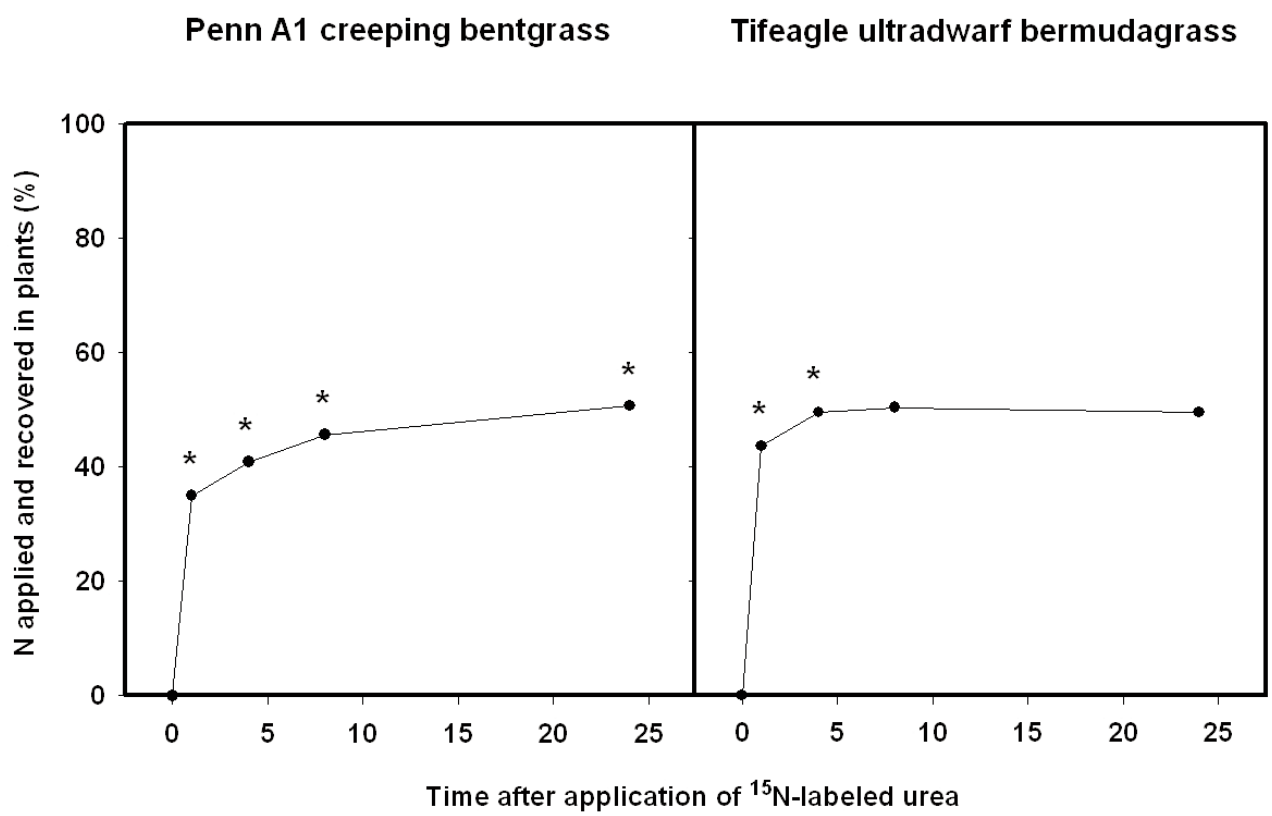

Fig. 2. Percentage of foliar urea-N absorption as affected by sequential sampling time intervals over a 24 h period after application (* denotes significant difference from previous sampling time at $P \leq 0.05$).

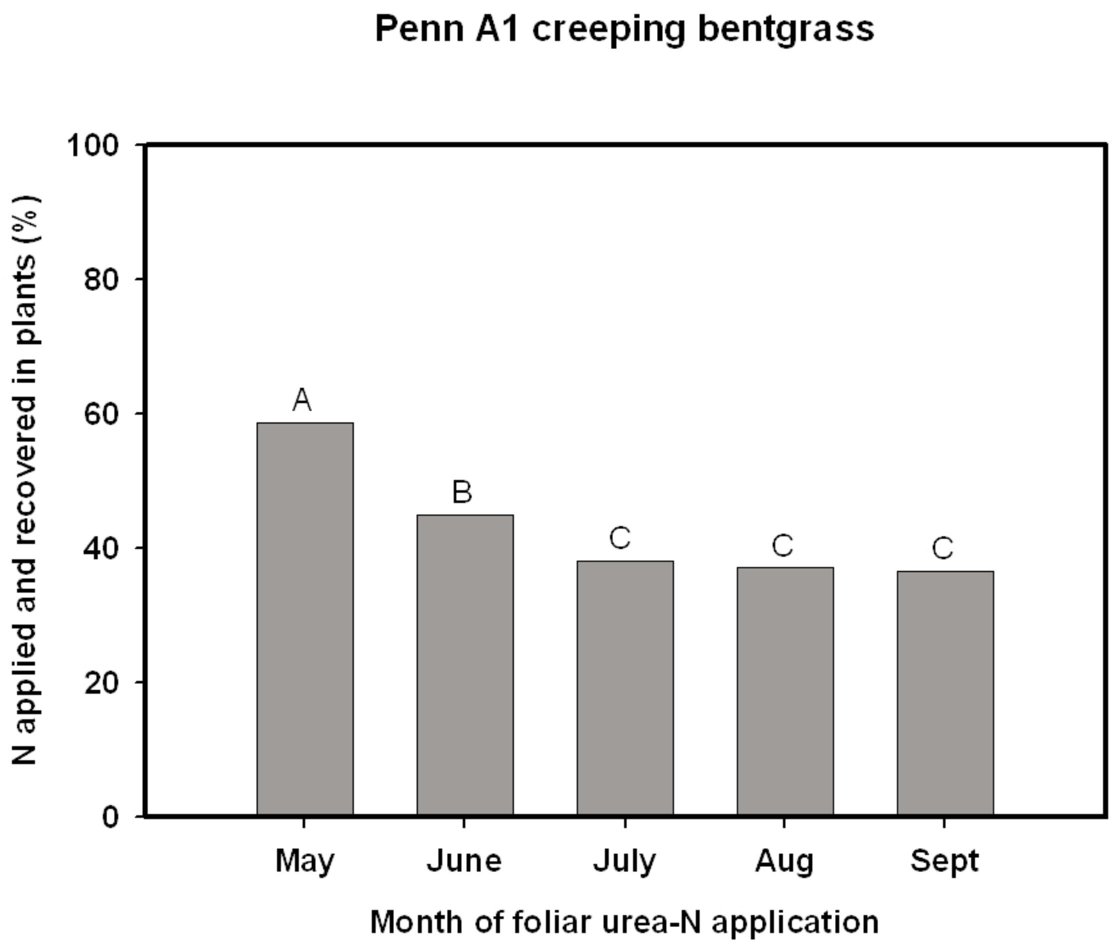

Fig. 3. Percentage of foliar urea-N absorption as affected by month of year in which application event took place. Bars with different letters indicate significant difference at $P \leq 0.05$ (n = 159).

Summary of the 2008 NTEP Bentgrass Fairway/Tee Trial-Establishment

Establishment of the 2008 NTEP tee and fairway trial

Josh Summerford[1], Doug Karcher[1], Mike Richardson[1], and Aaron Patton[2]

Additional index words: *Agrostis stolonifera, Agrostis capillaris*, colonial bentgrass, creeping bentgrass, turfgrass, cultivars, fairway, digital image analysis.

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Summary. Creeping bentgrass is a commonly used turfgrass species for golf course fairways throughout the northern and central United States. Improvements in heat tolerance and disease resistance have resulted in attempts to use this species as a fairway or tee grass in more southern environments. Identifying cultivars that are well-adapted to the region is a focus of the University of Arkansas turfgrass research program. The National Turfgrass Evaluation Program is the predominant means by which cultivars are tested throughout North America. A bentgrass cultivar trial, including selections of creeping and colonial bentgrass was planted in the fall of 2008 at the Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. The trial was maintained at a 1.0 inch mowing height during establishment, and data on turfgrass establishment were collected. Overall the creeping bentgrass cultivars generally had higher establishment vigor than colonial bentgrass. There were significant differences among cultivars with regard to green turfgrass coverage during establishment.

Abbreviations: NTEP, National Turfgrass Evaluation Program

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Creeping bentgrass (*Agrostis stolonifera*) is the predominate turfgrass species used for golf course putting greens in northern and central Arkansas; however, its use on other golf course areas, such as fairways or tees, has not been evaluated. Over the past several decades, improvements in heat tolerance and disease resistance have warranted the evaluation of this species for golf course fairways in the transition zone.

The National Turfgrass Evaluation Program (NTEP) is an organization within the U.S. Department of Agriculture that annually oversees turfgrass cultivar evaluation experiments at various sites throughout the U.S. and Canada. Each turfgrass species is tested on a four to five year cycle at sites throughout the growing region for that particular species. The University of Arkansas has been an active participant in the NTEP and was awarded a site for the 2008 NTEP Bentgrass Fairway/Tee Trial which included both creeping bentgrass and colonial bentgrass (*Agrostis capillaris*) cultivars. This is the first time that this particular study has been conducted at the University of Arkansas. When seeding a new fairway, rapid establishment is important to make the area playable as quickly as possible. Rapid establishment can also reduce weed pressure, which enhances turf quality and reduces costs associated with weed control. The objective of this study was to evaluate the establishment rate of 27 creeping and colonial bentgrasses included in the 2008 NTEP Bentgrass Trial at Fayetteville, Ark.

Materials and Methods

This cultivar trial was planted on 1 October 2008 at the Arkansas Agricultural Research and Extension Center in Fayetteville on a silt loam, native soil rootzone with an average pH of 6.2. Twenty-three cultivars (Table 1) were officially included in the 2008 NTEP Bentgrass Fairway/Tee Trial, and an additional four cultivars were included at the Arkansas site (Alister, Tyee, SR-1020, and Pennlinks II/Penneagle II blend) due to their common use in this region as putting green turf or superior performance in past putting green trials. Each entry was broadcast seeded into four replicate 6 by 6 ft plots at a seeding rate of 1.1 lb/1000 ft^2. Milorganite fertilizer (6-2-0) was applied with the seed at a rate of 1 lb N/1000 ft^2 to provide adequate nutrition for germination. Following seeding, each plot was individually raked to ensure even distribution of the seed as well as to increase seed-to-soil contact. The trial area was covered with a germination blanket to help maintain soil moisture and buffer surface temperatures. Following germination, the cover was removed and data collection initiated. Plots were maintained at a mowing height of 1" using a walk mower, beginning at six weeks after planting, and plots were fertilized at 0.5 lb N/1000 ft^2 per month of active growth. Irrigation was applied once daily during establishment to promote germination and as needed thereafter to avoid drought stress.

Plots were visually rated for seedling vigor on a 1 to 9 scale (1 = no germination, 9 = excellent germination) on 21 October 2008 (3 wks after seeding). Cultivars were evaluated weekly using digital image analysis to determine percent turfgrass cover. Two digital images were taken per plot using a light box to ensure uniform lighting conditions throughout all evaluations.

Results and Discussion

Establishment vigor. There were significant differences in establishment vigor among bentgrass cultivars at three weeks after seeding (Table 1). Eleven bentgrass cultivars ranked the highest in establishment vigor for this trial, including ten creeping bentgrass cultivars and one colonial bentgrass cultivar. The ten creeping bentgrass cultivars were Penncross, 007, CY-2, LTP-FEC, Pennlinks II/Penneagle II, Princeville, A08-TDN2, Authority, L-93, and Memorial. The colonial bentgrass cultivar that ranked in the top group was A08-EBM. Two colonial bentgrass cultivars, Alister and Greentime, ranked significantly lower than the highest group.

Green turfgrass coverage. There were significant differences in green turfgrass coverage among bentgrass cultivars in the trial only on the first two evaluations dates (Table 2). Overall, twenty-three cultivars ranked in the top statistical group; however, only four were significantly different from the bottom three performing cultivars. The highest four ranking cultivars on 27 October 2008, were all creeping bentgrass cultivars and included Penncross, Crystal Bluelinks, Princeville, and Declaration. Of the lowest three ranking entries, there was one creeping bentgrass, PST-OJD, and two colonial bentgrasses, Greentime and Alister. The bottom two ranking entries, both colonial bentgrasses, were also the two lowest ranking entries in establishment vigor (Table 1). Establishment will continue to be monitored throughout the winter and spring until complete turfgrass coverage is obtained.

Overall, the creeping bentgrass species was the better performing species of the two in this study, indicating that creeping bentgrass would be a better choice when speed of establishment is an important factor in cultivar selection. Data on turf quality, cover, color, abiotic stress tolerance, and biotic pest resistance will be collected from 2009 – 2012 for this study and reported in future issues of the Arkansas Turfgrass Report.

Table 1. Turf establishment vigor ratings for creeping and colonial bentgrass cultivars in the 2008 NTEP Bentgrass fairway/tee trial. Cultivars are listed by rank, from best to worst establishment vigor, for the 21 October 2008 evaluation date (3 weeks after seeding).

Entry	Species	Establishment vigor 21 Oct.
		---------------- 1-9 -----------------
Penncross	Creeping	8.0
007	Creeping	7.3
CY-2	Creeping	7.3
LTP-FEC	Creeping	7.3
PennlinksII/Penneagle II[y]	Creeping	7.3
Princeville	Creeping	7.3
A08-EBM[z]	Colonial	7.0
A08-TDN2[z]	Creeping	7.0
Authority	Creeping	7.0
L-93	Creeping	7.0
Memorial	Creeping	7.0
Crystal Bluelinks	Creeping	6.7
PST-OJD[z]	Creeping	6.7
SR-1020[y]	Creeping	6.7
SRP-1WM[z]	Creeping	6.7
T-1	Creeping	6.7
BCD	Colonial	6.3
Benchmark DSR	Creeping	6.3
Declaration	Creeping	6.3
MVS-Ap-101[z]	Creeping	6.3
Tyee[y]	Creeping	6.3
A08-FT12[z]	Colonial	6.0
HTM	Creeping	6.0
PST-R9D7[z]	Colonial	6.0
Tiger II	Colonial	6.0
Alister[y]	Colonial	5.7
Greentime	Colonial	5.3
$LSD_{(0.05)}$		1.3

[y] Not an official entry of the 2008 NTEP bentgrass trial and was included as an Arkansas standard.

[z] Entry is experimental and at this time not commercially available.

Table 2. Green turfgrass coverage ratings for creeping and colonial bentgrass cultivars in the 2008 NTEP Bentgrass fairway/tee trial. Cultivars are listed by rank, from highest to lowest average percent coverage.

		Green turfgrass coverage						
Entry	Species	17-Oct	27-Oct	3-Nov	17-Nov	24-Nov	2-Dec	Average
		(%)						
Penncross	Creeping	98.0	97.4	99.1	98.8	98.4	97.6	98.2
Crystal Bluelinks	Creeping	98.0	96.2	97.6	99.2	99.2	97.9	98.0
Princeville	Creeping	97.6	96.2	97.7	98.8	98.1	97.5	97.6
Declaration	Creeping	96.5	95.0	97.7	98.9	98.9	97.8	97.5
PennlinksII/Penneagle II[y]	Creeping	96.6	92.6	98.0	99.1	98.9	98.0	97.2
007	Creeping	96.9	91.1	98.2	99.2	99.0	97.8	97.1
A08-EBM[z]	Colonial	95.3	92.6	97.6	99.3	99.1	98.3	97.0
A08-TDN2[z]	Creeping	94.2	93.5	98.4	98.9	98.8	97.7	96.9
SR-1020[y]	Creeping	95.7	92.0	96.9	98.8	98.7	97.9	96.7
MVS-Ap-101[z]	Creeping	95.2	90.9	95.8	98.6	98.8	97.2	96.1
Memorial	Creeping	92.9	89.7	96.4	98.8	98.6	97.7	95.7
L-93	Creeping	94.3	89.6	92.8	99.2	99.1	98.0	95.5
PST-R9D7[z]	Colonial	94.0	87.5	96.8	98.4	97.8	96.9	95.2
SRP-1WM[z]	Creeping	94.7	87.9	96.0	98.8	97.3	96.6	95.2
LTP-FEC[z]	Creeping	95.8	90.4	94.6	97.5	97.0	95.1	95.1
Tiger II	Colonial	91.2	86.2	94.8	99.1	98.6	97.9	94.7
Authority	Creeping	92.4	85.8	94.3	99.0	98.6	97.8	94.6
HTM	Creeping	91.4	86.1	95.3	98.6	98.6	97.5	94.6
BCD	Colonial	90.9	84.8	95.5	99.0	98.9	98.1	94.5
CY-2	Creeping	92.3	86.3	95.5	98.1	98.6	96.5	94.5
A08-FT12[z]	Colonial	91.5	86.2	94.8	98.7	98.1	97.2	94.4
Tyee[y]	Creeping	89.3	80.3	93.1	97.9	96.3	95.7	92.1
Benchmark DSR	Creeping	93.2	79.9	88.4	96.2	96.3	95.5	91.6
T-1	Creeping	90.4	74.7	91.4	97.2	96.9	94.4	90.8
PST-OJD[z]	Creeping	84.1	78.4	90.8	96.7	97.9	94.6	90.4
Greentime	Colonial	85.1	75.0	91.3	97.9	96.9	94.7	90.2
Alister[y]	Colonial	81.9	67.6	86.5	96.1	94.1	89.8	86.0
$LSD_{(0.05)}$		9.0	9.0	NS	NS	NS	NS	NS

[y] Not an official entry of the 2008 NTEP bentgrass trial and was included as an Arkansas standard.

[z] Entry is experimental and at this time not commercially available.

Summary of the 2008 NTEP Bentgrass Putting Green Trial-Establishment

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Additional index words: *Agrostis stolonifera*, *Agrostis canina*, creeping bentgrass, velvet bentgrass, turfgrass, cultivars, putting green, digital image analysis.

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Establishment of the 2008 NTEP bentgrass putting green trial

Summary. Creeping bentgrass continues to be the prevailing turfgrass species used for golf course putting greens throughout northern and central Arkansas. Identifying cultivars that are well-adapted to the region remains a central focus of the University of Arkansas turfgrass research program. The National Turfgrass Evaluation Program is the predominant means by which cultivars are tested throughout North America. A bentgrass cultivar trial, including selections of creeping and velvet bentgrass, was planted in the fall of 2008 at the Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. The trial was maintained at a mowing height of 0.200" and an application rate of 0.5 lb N/1000 ft^2 per growing month during establishment. Data on turfgrass establishment, including visual estimates of germination vigor and digital image analysis measurements of green coverage, were collected. On average, the creeping bentgrass cultivars had higher green turf coverage compared to the velvet bentgrass cultivars. There were significant differences among cultivars with regard to establishment vigor.

Abbreviations: NTEP, National Turfgrass Evaluation Program

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Creeping bentgrass (*Agrostis stolonifera*) provides the most uniform and fastest surface for golf course putting greens in northern and central Arkansas and in environments throughout the transition zone and Northern United States. Over the past several decades, improvements in density, heat tolerance and disease resistance have made this species ideal for putting greens.

The National Turfgrass Evaluation Program (NTEP) is an organization within the U.S. Department of Agriculture that annually oversees turfgrass cultivar evaluation experiments at various sites throughout the U.S. and Canada. Each turfgrass species is tested on a four- to five-year cycle at sites throughout the growing region for that particular species. The University of Arkansas has been an active participant in the NTEP and was awarded a site for the 2008 NTEP Bentgrass Putting Green Trial, which included both creeping bentgrass and velvet bentgrass (*Agrostis canina*) cultivars. When seeding a new putting green, rapid establishment is important because golf facility revenue is dependent on the playability of the putting greens. Rapid establishment also reduces weed pressure over time resulting in a more uniform surface. The objective of this study is to evaluate the establishment rate of all species and cultivars included in the 2008 NTEP Bentgrass Trial at Fayetteville, Ark.

Materials and Methods

This cultivar trial was planted on 30 September 2008 at the Arkansas Agricultural Research and Extension Center in Fayetteville on a sand-based rootzone that was constructed according to USGA recommendations. Nineteen cultivars were officially included in the 2008 NTEP Bentgrass Putting Green Trial (Table 1) and an additional eleven cultivars were included at the Arkansas site (Crystal Bluelinks, CY-2, MacKenzie, Crenshaw, Penn A-4, Penn G-1, Penn G-2, Penn G-6, Shark, SR 1020, and Tyee) due to either their common use in this region or superior performance in a previous cultivar trial. Each entry was broadcast seeded into four replicate 6 by 6 ft plots at a seeding rate of 1.1 lb/1000 ft^2. Milorganite fertilizer (6-2-0) was applied with the seed at a rate of 1 lb N/1000 ft^2 to provide adequate nutrition for germination. Following seeding, each plot was individually raked to ensure even distribution of the seed as well as to increase seed-to-sand contact. Irrigation was applied five times daily, in the absence of rainfall, to ensure adequate moisture for germination, and as needed to avoid drought stress following germination. Plots were maintained at a mowing height of 0.200 inch, beginning at eight weeks after planting, and nitrogen was applied at 0.5 lb N/1000 ft^2 per month of active growth.

Plots were visually rated for seedling vigor on a 1 to 9 scale (1 = no germination, 9 = excellent germination) on 17 October 2008 (approximately 3 wks after seeding). Cultivars were evaluated weekly using digital image analysis to determine percent turfgrass coverage. Two digital images were taken per plot using a light box to ensure uniform lighting conditions throughout all evaluations.

Results and Discussion

Establishment vigor. There were significant differences in establishment vigor among bentgrass cultivars on the 17 October 2008 evaluation date (Table 1). Thirteen bentgrass cultivars ranked in the top statistical group for establishment vigor, including twelve creeping bentgrass cultivars and one velvet bentgrass cultivar. The twelve creeping bentgrass cultivars were LTP-FEC, CY-2, Crystal Bluelinks, Shark, Alpha, Declaration, Penn A-4, Penn G-1, Penncross, T-1, MacKenzie, and Penn A-1. The velvet bentgrass cultivar that also ranked in the top group was Villa; however Villa did not have significantly higher establishment vigor than the other velvet bentgrass, SR7200, in this trial. Four creeping bentgrass cultivars were in the lowest ranking group for establishment vigor, including HTM, L-93, V8, and Penn A-2.

Green turfgrass coverage. There were significant differences in green turfgrass coverage among bentgrass cultivars for the 10 November 2008 evaluation date (Table 2). This evaluation date was 6 weeks after planting, and up to this point there was little variation in green turfgrass coverage among cultivars in the trial. On the 10 November evaluation date, only the top four cultivars (Penn G-2, MVS-AP-101, Penn G-1, and Penn G-6) were significantly different from the bottom four (T-1, Tyee, Villa, and SR7200). As a species, the creeping bentgrass cultivars had a higher average, 71.7% coverage, compared to the velvet cultivars, 59.0% coverage, which ranked as the bottom two cultivars for percent coverage on this date. Establishment will continue to be monitored throughout the winter and spring until complete turfgrass coverage is obtained.

Overall, establishment vigor had little bearing on the green turfgrass coverage as the study progressed. There was also little difference among creeping bentgrass cultivars with regard to establishment, indicating that most cultivars in this trial establish at similar rates and therefore other characteristics are more important to cultivar selection than establishment rate. Turfgrass coverage was affected by unseasonably cold temperatures in November and December (Richardson and Stiegler, 2009), resulting in delayed establishment rates toward the end of this evaluation period. Data on turf quality, cover, color, abiotic stress tolerance, and biotic pest resistance will be collected from 2009–2012 for this study and reported in future issues of the Arkansas Turfgrass Report.

Table 1. Turf establishment vigor ratings for creeping and velvet bentgrass cultivars in the 2008 NTEP Bentgrass putting green trial. Cultivars are listed by rank, from best to worst establishment vigor, for the 17 October 2008 evaluation date.

		Establishment vigor
Entry	Species	17 Oct.
		----------- 1-9 --------------
LTP-FEC[z]	Creeping	7.7
CY-2[y]	Creeping	7.0
Crystal Bluelinks[y]	Creeping	7.0
Shark[y]	Creeping	7.0
Alpha	Creeping	6.7
Declaration	Creeping	6.7
Penn A-4[y]	Creeping	6.7
Penn G-1[y]	Creeping	6.7
Penncross	Creeping	6.7
T-1	Creeping	6.7
MacKenzie[y]	Creeping	6.3
Penn A-1	Creeping	6.3
Villa	Velvet	6.3
MVS-AP-101[z]	Creeping	6.0
Penn G-2[y]	Creeping	6.0
Penn G-6[y]	Creeping	6.0
SRP-1BLTR3[z]	Creeping	6.0
SRP-1GMC[z]	Creeping	6.0
Tyee[y]	Creeping	6.0
A08-TDN2[z]	Creeping	5.7
Authority	Creeping	5.3
SR 1020[y]	Creeping	5.3
SR 7200	Velvet	5.3
AFM	Creeping	5.0
PST-OJO[z]	Creeping	5.0
HTM	Creeping	4.7
L-93	Creeping	4.7
V8	Creeping	4.7
Penn A-2	Creeping	3.3
$LSD_{(0.05)}$		1.5

[y] Not an official entry of the 2008 NTEP bentgrass trial and was included as an Arkansas standard.

[z] Entry is experimental and at this time not commercially available.

Table 2. Green turfgrass coverage ratings for creeping and velvet bentgrass cultivars in the 2008 NTEP Bentgrass putting green trial. Cultivars are listed by rank, from highest to lowest percent coverage, for the average green turfgrass coverage.

		Green turfgrass coverage						
Entry	Species	27-Oct	3-Nov	10-Nov	17-Nov	24-Nov	2-Dec	Average
		(%)						
Penn G-2[y]	Creeping	25.7	67.5	83.4	88.4	90.5	87.9	73.9
MVS-AP-101[z]	Creeping	25.4	68.9	82.9	86.5	80.3	82.9	71.2
CY-2[y]	Creeping	20.8	68.2	77.7	86.1	83.2	85.2	70.2
Penn G-1[y]	Creeping	26.9	64.7	81.8	86.3	76.9	82.9	69.9
Penn G-6[y]	Creeping	23.4	59.7	81.0	80.5	85.9	84.9	69.2
Penn A-4[y]	Creeping	32.0	58.4	76.4	82.1	85.7	77.9	68.8
Crystal Bluelinks[y]	Creeping	20.4	59.4	74.5	81.8	84.7	79.3	66.7
Authority	Creeping	15.2	63.2	75.6	80.7	83.0	80.6	66.4
A08-TDN2[z]	Creeping	22.8	58.1	74.1	79.4	80.9	79.0	65.7
LTP-FEC[z]	Creeping	28.9	57.2	73.6	76.7	81.1	76.6	65.7
Penncross	Creeping	17.7	63.0	74.4	77.2	76.8	78.3	64.6
Alpha	Creeping	27.4	57.1	74.6	76.6	76.4	75.3	64.6
Penn A-2	Creeping	19.9	57.6	72.3	77.3	82.7	76.9	64.4
SRP-1BLTR3[z]	Creeping	25.7	58.2	71.8	80.3	76.2	73.8	64.3
Declaration	Creeping	21.2	58.5	72.5	76.9	80.4	76.5	64.3
SR 1020[y]	Creeping	25.1	55.9	67.8	77.3	72.8	71.5	61.7
V8	Creeping	33.9	53.6	66.0	76.4	69.7	70.7	61.7
AFM	Creeping	38.1	50.3	65.0	70.9	73.5	70.2	61.3
T-1	Creeping	37.1	52.0	64.4	73.0	70.3	70.7	61.2
HTM	Creeping	30.5	53.5	64.7	73.9	73.7	70.3	61.1
MacKenzie[y]	Creeping	27.1	51.8	65.5	74.3	75.9	71.6	61.0
L-93	Creeping	26.8	51.9	64.9	73.3	75.9	73.1	61.0
PST-OJO[z]	Creeping	24.6	52.7	68.6	75.0	73.4	71.6	61.0
Penn A-1	Creeping	18.1	57.1	68.2	76.3	73.6	71.7	60.8
Tyee[y]	Creeping	35.2	47.4	63.3	75.1	70.3	68.4	60.0
SRP-1GMC[z]	Creeping	22.5	49.8	65.6	72.4	77.1	71.8	59.9
Shark[y]	Creeping	32.1	48.0	65.9	71.4	64.2	69.4	58.5
Villa	Velvet	19.4	51.9	61.4	69.3	68.6	67.3	56.3
SR 7200	Velvet	33.0	47.3	56.5	62.6	62.1	63.0	54.1
$LSD_{(0.05)}$		NS	NS	16.5	NS	NS	NS	NS

[y] Not an official entry of the 2008 NTEP bentgrass trial and was included as an Arkansas standard.

[z] Entry is experimental and at this time not commercially available.

Bermudagrass Cultivars Differ in Their Traffic Tolerance

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Additional index words: Cady traffic simulator, turfgrass coverage, wear

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Photo by Mike Richardson

Close-up view of the Cady traffic simulator

Summary. Bermudagrass is the most widely used turfgrass species for golf courses and sports fields in the southern U.S. and transition zone. Continuous trafficking from play or equipment can reduce bermudagrass coverage and turf quality. This study evaluated 42 bermudagrass cultivars for their traffic tolerance. Traffic was applied in fall 2007 and summer 2008 with a Cady traffic simulator to evaluate traffic tolerance. Twelve cultivars were rated highest in traffic tolerance in at least nine of 10 dates including Barbados, Celebration, OKC 70-18, Premier, Riviera, Sovereign, Southern Star, SWI-1003, SWI-1046, Tifton No. 1, Tifton No. 4, and Tifway. The cultivars Arizona Common, Ashmore, and B-14 had relatively poor traffic tolerance as they ranked in the top statistical category a maximum of only two out of 10 rating dates. These results demonstrate that several bermudagrass cultivars possess superior traffic tolerance, and some have poor traffic tolerance. Selecting improved, traffic tolerant bermudagrasses will help reduce maintenance inputs and increase sustainability of golf courses and athletic fields.

Abbreviations: TPI, turf performance index

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Bermudagrass (*Cynodon* spp.) is the most widely used turfgrass species within the state of Arkansas and throughout the southern U.S. and transition zone, due to its low establishment costs, aggressive growth rate, adaptation to a wide range of mowing heights, and its drought and traffic tolerance. Regular traffic that occurs on sports fields, golf courses, and residential areas can be detrimental to bermudagrass growth. Previous research has identified traffic tolerant cultivars (Youngner, 1961; Shearman and Beard, 1975), but more research is needed to examine the traffic tolerance of new bermudagrass cultivars. The objective of this study was to quantify differences in bermudagrass cultivars' traffic tolerance.

Materials and Methods

This study was conducted in the fall of 2007 and summer of 2008 to evaluate seasonal differences in traffic tolerance within bermudagrass cultivars. The study was located at the University of Arkansas Research and Extension Center in Fayetteville, Ark. and utilized the National Turfgrass Evaluation Program 2002 National Bermudagrass Test (Morris, 2007). There were a total of 42 cultivars in the study including 30 cultivars that are currently commercially available. Plot size was 6 by 6 ft, and there were three replications of each cultivar. Plots were maintained under golf course fairway or sports field conditions, with a mowing height of 0.5 inch and monthly applications of 1.0 lb N/1000ft^2 during the growing season. Traffic was applied weekly using a Cady traffic simulator (Henderson et al., 2005). Once each week for four consecutive weeks, four passes in the forward direction were made to each plot. Traffic was applied to half of each plot for fall traffic evaluations and the other half of each plot was used for summer traffic evaluations.

Digital images were taken prior to each traffic application and after the final traffic application to evaluate damage. Digital image analysis was used to evaluate the amount of green turfgrass cover as affected by the traffic simulator (Richardson et al, 2001). Turf Performance Index (TPI) was used to compare differences among the cultivars. Turf Performance Index was determined as the number of times each cultivar was ranked in the highest statistical category.

Results and Discussion

Coverage data from fall 2007 was difficult to determine because the plants entered into dormancy prior to the last traffic date. This made it difficult to determine if green turf coverage was affected by traffic or by the plants losing their green pigment as they entered winter dormancy. There were five collection dates used to calculate a TPI rating for both fall 2007 and summer 2008. The fifth and final collection date used to calculate the TPI for fall 2007 was in the spring 2008 after complete green-up had occurred (Table 1).

In the fall 2007, Premier and Tifway were the only two cultivars that were in the top statistical group on all five rating dates. In the summer 2008, there were 27 cultivars that ranked in the top statistical category for all five rating dates and these would include Aussie Green, Barbados, Celebration, CIS-CD7, GN-1, Midlawn, Mohawk, NuMex Sahara, OKC 70-18, Premier, Patriot, Riviera, Southern Star, Sovereign, Sundevil II, Sunstar, SWI-1003, SWI-1014, SWI-1046, Tifsport, Tift No. 1, Tift No. 2, Tift No. 3, Tift No. 4, Tifway, Transcontinental, and Yukon.

Notable differences in cultivar traffic tolerance existed across the two seasons. Aussie Green, GN-1, SWI-1014, and Tift No. 3 performed relatively poorly in fall 2007, receiving TPIs of 2, 0, 0, and 0, respectively. However, in summer 2008, each cultivar had much better traffic tolerance, each receiving a TPI of 5. This may indicate that these cultivars perform better in summer months and should not be used in situations where fall traffic will be intensive.

Looking at the results across both seasons, there were 12 cultivars that received a TPI of at least nine out of the ten rating dates including: Barbados, Celebration, OKC 70-18, Premier, Riviera, Southern Star, Sovereign, SWI-1003, SWI-1046, Tift No. 1, Tift No. 4, and Tifway. Arizona Common and Ashmore were two cultivars that only ranked in the highest statistical category one time. Statistical analysis was performed to evaluate differences between seeded and vegetative cultivars and no clear differences existed (data not shown).

The ultimate goal of this study is to help golf course and sports field managers select cultivars that have good traffic tolerance and avoid those cultivars with poor traffic tolerance. Although traffic compacts soil and decreases rooting, this study only measured the immediate response of the turf to the simulated wear that it received. These results demonstrate that several bermudagrass cultivars possess superior traffic tolerance, while some have poor traffic tolerance. Selecting improved, traffic tolerant bermudagrasses will help reduce maintenance inputs and increase sustainability of golf courses and athletic fields. Additional data will be collected during bermudagrass spring green-up of plots trafficked in fall 2008.

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Table 1. Turf performance index (TPI) of 42 bermudagrass cultivars for traffic tolerance over five sampling dates in the fall of 2007 and summer 2008.

Cultivar	TPI fall 07[z]	TPI summer 08	TPI Total
Premier[y] (OR 2002)	5	5	10
Tifway[y]	5	5	10
Barbados[y x] (SWI-1044)	4	5	9
Celebration[y x]	4	5	9
OKC 70-18	4	5	9
Riviera[y x]	4	5	9
Southern Star[y x]	4	5	9
Sovereign[y x] (SWI-1012)	4	5	9
SWI-1003[x]	4	5	9
SWI-1046[x]	4	5	9
Tift No. 1	4	5	9
Tift No. 4	4	5	9
CIS-CD5[x]	4	4	8
CIS-CD7[x]	3	5	8
Contessa[y x] (SWI-1045)	4	4	8
Patriot[y]	3	5	8
Princess 77[yx]	4	4	8
Sundevil II[y x]	3	5	8
Sunsport[y x] (SWI-1001)	4	4	8
Sunstar[y x]	3	5	8
Tifsport[y]	3	5	8
Tift No. 2	3	5	8
Veracruz[y x] (SWI-1041)	4	4	8
Yukon[y x]	3	5	8
Aussie Green[y]	2	5	7
Midlawn[y]	2	5	7
Mohawk[y x]	2	5	7
Sunbird[y x] (PST-R68A)	3	4	7
Transcontinental[y x]	2	5	7
NuMex Sahara[y x]	1	5	6
GN-1[y]	0	5	5
LaPaloma[y x] (SRX 9500)	2	3	5
MS-Choice[y]	2	3	5
Panama[y x]	1	4	5
SR 9554[yx]	2	3	5
SWI-1014[x]	0	5	5
Tift No. 3	0	5	5
Sultan[yx] (FMC-6)	2	2	4
CIS-CD6[x]	1	2	3
B-14[x]	1	1	2
Arizona Common[yx]	0	1	1
Ashmore[y]	1	0	1

[z] Turf Performance Index (TPI) indicates the number of times that particular cultivar was in the highest statistical group.
[y] Indicates commercially available cultivar in 2007(www.ntep.org).
[x] Indicates seeded bermudagrass cultivar.

Differences Exist in the Divot Recovery Among Bermudagrass and Zoysiagrass Cultivars


Photo by Antonio Pompeiano

University of Arkansas divoting tool

Jon Trappe[1], Aaron Patton[1], Doug Karcher[2], and Mike Richardson[2]

Additional index words: fairway, tee, golf course, digital image analysis

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Summary. Bermudagrass and zoysiagrass are the most popular species for golf course tees and fairways in Arkansas. Utilizing species and cultivars that have faster divot recovery will improve playing conditions on golf courses. Five of the most common cultivars of bermudagrass and seven of the most common cultivars of zoysiagrass grown in Arkansas were divoted to evaluate the time necessary for 50% recovery. Riviera, Princess-77, Palisades, El Toro and Diamond had the fastest divot recoveries while Zorro, Tifway, Patriot, Meyer, Tifsport, Cavalier, and Zenith had the slowest recoveries. These results, which are that some zoysiagrass cultivars have divot recovery similar to bermudagrass, are consistent with the findings of previous research of divot recoveries of bermudagrass or zoysiagrass in separate field studies. The findings of this research will ultimately help golf course superintendents reduce the costs associated with maintaining golf course fairways or tees as well as improve the playability of the golf course.

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Bermudagrass (*Cynodon* spp.) growth is typically considered more aggressive than zoysiagrass (*Zoysia* spp.) during establishment; however, newer cultivars of zoysiagrass have improved establishment rates and divot recovery (Karcher et al., 2005b; Patton et al., 2007). Karcher et al. (2005a, 2005b) recently examined the divot recovery of numerous bermudagrass and zoysiagrass cultivars in separate field studies. Although these species were in separate studies, data suggests that the recuperative capacity of these two species may not be as different as previously thought. The objective of this study is to quantify the divot recovery of bermudagrass and zoysiagrass cultivars when planted and managed in the same study.

Materials and Methods

Five cultivars of bermudagrass and seven cultivars of zoysiagrass were established in the summer of 2007 (Fig. 1). Plots were maintained under golf course fairway or sports field conditions, with a mowing height of 0.5 inch and monthly applications of 1.0 lb N/1000ft^2 for bermudagrass and 0.5 lb N/1000ft^2 for zoysiagrass during the growing season. Plots were divoted on 25 August 2008. Standardized divots (2.0 by 4.0 inch) were cut from each plot using a modified edger (Fry et al., 2008) and then backfilled with topdressing sand. Recovery was monitored for each divot by collecting digital images semiweekly, beginning on the day of injury and continuing until full recovery was reached. Each image was analyzed for percent green turf cover using SigmaScan Pro software (Richardson et al., 2001. Three images (subsamples) were collected and averaged for each plot. A full description of this technique and data analysis is presented elsewhere (Karcher et al., 2005a).

Results and Discussion

Diamond, El Toro, and Palisades zoysiagrass in addition to Princess-77 and Riviera bermudagrass had the fastest times to reach 50% divot recovery (Fig. 1). Those cultivars with relatively slower recoveries included Zorro, Tifway, Patriot, Meyer, Tifsport, Cavalier, and Zenith.

Previous divot studies with bermudagrass and zoysiagrass divot recovery were performed by Karcher et al. (2005a, 2005b) and were conducted simultaneously at the same location; however, cultivars between species were not evaluated within the same trial. As a result, comparisons across the two species of the trials could not be performed. These results, which are that some zoysiagrass cultivars have divot recovery similar to bermudagrass, are consistent with the findings of previous research of divot recoveries of bermudagrass or zoysiagrass in separate field studies.

There were some similarities in trends that existed between this research and that of Karcher et al. (2005a, 2005b). Riviera and Princess-77 were among those cultivars with the fastest time to reach 50% recovery in our trial and that of Karcher et al. (2005a). Tifsport also had a similar performance in both studies, as it had a relatively longer time to reach 50% recovery. One additional similarity is the superior performance of Palisades in both this research and that of Karcher et al. (2005b).

One difference that existed between this work and that of Karcher et al. (2005a, 2005b) is the overall length of time for divots to reach 50% recovery. In Karcher et al (2005a, 2005b), plots were divoted on 1 August, and in this current study, plots were divoted on 25 August. This delay in the growing season may have been one reason for the difference in days to reach 50% recovery for these studies. Another potential explanation for this difference in recovery time is the summer of 2008 was unseasonably cool and wet, which would have reduced growth rates of bermudagrass and zoysiagrass (Richardson and Stiegler, 2009). Additionally, Cavalier and Zenith had relatively longer recovery times than what was found in previous research. To better understand these differences, this study will be repeated using these same species and cultivars in 2009.

This research will better equip golf course superintendents with the knowledge of which cultivars of bermudagrass and zoysiagrass have the fastest recovery time from divoting by providing them with more information on species and cultivar selection. Through better cultivar/species selection, costs associated with maintaining golf course fairways and tees could be reduced while improving the playability of the golf course. This study will be conducted again in 2009 to enhance our understanding of the divot recovery of these species and cultivars.

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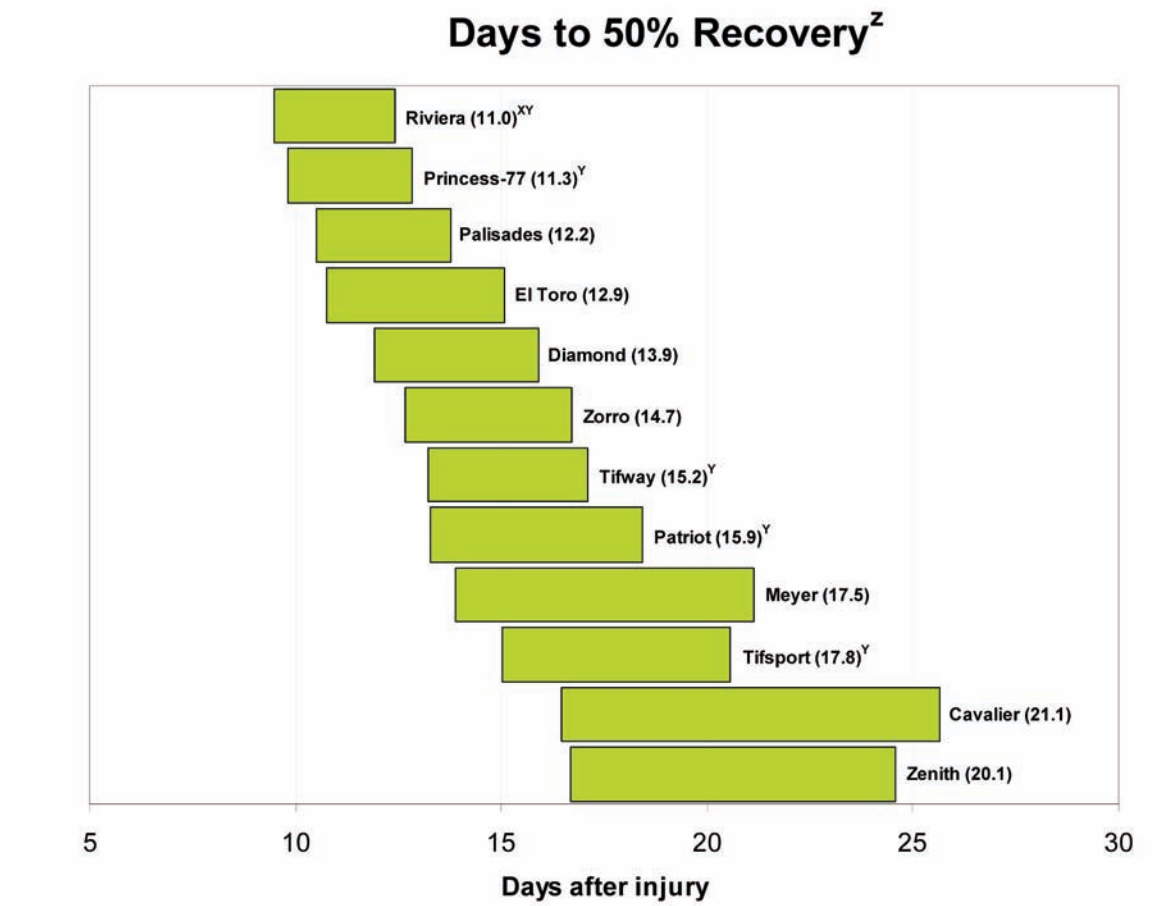

[z] Recovery was calculated as described by Karcher et al. 2005a.
[X] Confidence interval (95%) box displaying number of days to reach 50% recovery; the estimated number of days for each cultivar is in parentheses. Pairs of means are significantly different (P=0.05) if their confidence interval bars do not overlap.
[y] Indicates a bermudagrass cultivar.

Fig. 1. Estimated number of days for divots to reach 50% recovery for various bermudagrass and zoysiagrass cultivars.

Golf Ball Lie Differs Among Bermudagrass, Zoysiagrass, and Their Cultivars

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Additional index words: fairway, golf, *Cynodon dactylon, Cynodon dactylon x C. traansvalensis, Zoysia japonica, Zoysia matrella*

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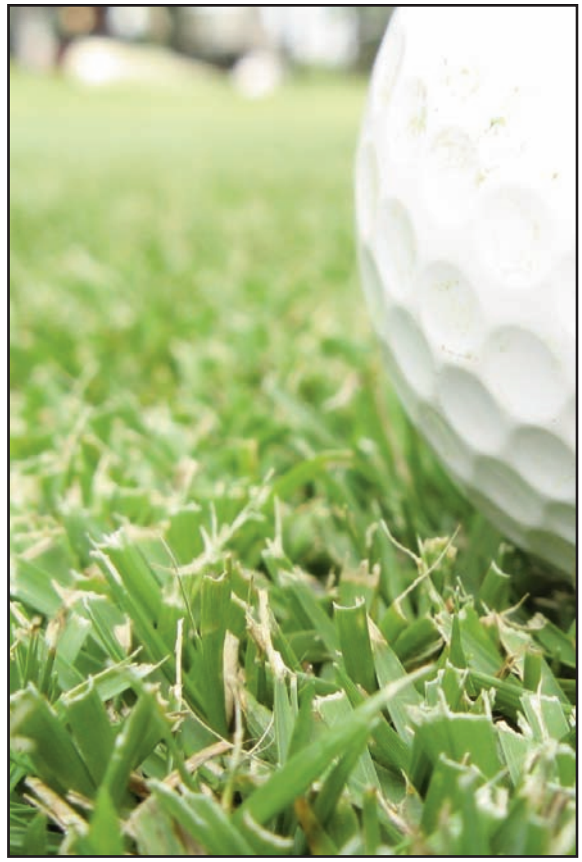

Photo by Aaron Patton

Golf ball lie in Meyer zoysiagrass

Summary. The place at which a golf ball comes to rest in the canopy can have a dramatic effect on how a player will attempt the next shot. Although turfgrass species and cultivars are continuously being evaluated to improve playing conditions on golf courses, very little research has evaluated golf ball lie in fairways, especially with respect to bermudagrass and zoysiagrass. A recently developed technique for quantifying golf ball lie using digital image analysis effectively distinguishes differences in ball lie of varying turf canopies. The objective of this study is to quantify differences in the percent of ball exposed under fairway conditions using digital image analysis for two bermudagrass and zoysiagrass species and their cultivars. Across a total of five collection dates in this study, bermudagrass cultivars had a greater percent of the ball exposed, or improved ball lie, than zoysiagrass cultivars. Those cultivars with the best ball lie include Cavalier zoysiagrass, Patriot, Princess-77, Tifsport, and Tifway bermudagrass. The cultivars Palisades zoysiagrass and Riviera bermudagrass both had poor ball lie on several different dates in the study. This research will allow superintendents to select cultivars or species to meet the needs of their players and the difficulty of the playing conditions on the course.

Abbreviations: ZJ, *Zoysia japonica*; ZM, *Zoysia matrella*; CD, *Cynodon dactylon*; CDT, *Cynodon dactylon* × C. *transvaalensis*; C, *Cynodon* spp.; Z, *Zoysia* spp

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The position at which a golf ball comes to rest in a turf canopy greatly influences how a player will attempt their next shot. Bermudagrass (*Cynodon* spp.) and zoysiagrass (*Zoysia* spp.) are the two most commonly used turfgrasses for golf course fairways in Arkansas. Determining which cultivars of these species have the best ball lie will ultimately allow superintendents to improve playing conditions on golf courses. Researchers at the University of Arkansas recently developed a method to measure golf ball lie (Richardson et al., 2008). Zoysiagrass has been attributed to providing a good golf ball lie for players to make their shot (Bevard, 2005; Hurley, 1976). The more rigid leaves and dense canopy of zoysiagrass provides a favorable surface to support a golf ball higher from the ground (Erusha et al, 1997). Cella et al. (2005) investigated the effect of leaf angle, thatch depth, and tiller density on ball lie in Kentucky Bluegrass and found that better ball lie was more correlated with tiller density.

Although zoysiagrass has been attributed with having a good ball lie, there have been no studies that directly compare bermudagrass and zoysiagrass for ball lie under fairway conditions. Also, knowing how ball lie characteristics for various cultivars and species is affected by differing mowing frequencies may provide better information for golf courses with differing budgets and maintenance capabilities. The objective of this research is to quantify differences in the percent of ball exposed for two bermudagrass and zoysiagrass species and their cultivars.

Materials and Methods

Five cultivars of bermudagrass and seven cultivars of zoysiagrass were established in the summer of 2007 (Table 1). Plots were maintained under golf course fairway conditions, with a mowing height of 0.5 inches and monthly applications of 1.0 lb N/1000 ft^2 for bermudagrass and 0.5 lb N/1000 ft^2 for zoysiagrass during the growing season. Golf ball lie on each cultivar was measured on two dates immediately after mowing, and on three dates on plots that were not mown for four days. Three golf balls were randomly rolled onto each plot and the depth that the ball came to rest in the canopy was measured using a device developed at the University of Arkansas (Richardson et al., 2008). Each golf ball was considered a subsample and the three subsamples were averaged for each plot on each sampling date.

Results and Discussion

Differences in ball lie existed between species and among cultivars. In three of the five sampling dates, bermudagrass cultivars had a better ball lie than zoysiagrass cultivars (Table 1). This is significant when correlated with anecdotal observations of both professional and amateur players and reports in professional publications, in which zoysiagrass is attributed with having a good ball lie. These anecdotal obeservations may be due in part to *Zoysia* spp. having more rigid leaves that originate from lower on the stem of the plant when compared to bermudagrass. This particular growth habit of zoysiagrass may cause the ball to sit lower with respect to the turfgrass plants, and thus have less percent of ball exposed. This growth habit may result in zoysiagrass having less percent ball exposed, even though the ball may be elevated above the soil surface and still providing an adequate ball lie. Other factors such as tiller density (Cella, 2005) may affect ball lie within or across species and thus need to be evaluated.

Of those bermudagrass cultivars, Patriot, Princess-77, Tifsport, and Tifway all had superior ball lie in the four sampling dates where differences occurred. Cavalier was the only zoysiagrass cultivar that was in the highest statistical category for the four dates in which significant differences occurred. Palisades had the lowest ball lie measurements for three of the four dates in which significant differences occurred. Riviera, the only common bermudagrass (*Cynodon dactylon*) cultivar in the study, was in the lowest statistical category for ball lie in two sampling dates, possibly indicating that common bermudagrass cultivars may produce inferior ball lies compared to hybrid bermudagrass (*C. dactylon* × *C. transvaalensis*).

Of those significant differences that existed between species and among cultivars, most were between a 1 and 6% difference in percent of ball exposed; however, the unmown plots for August 28 had much larger differences. Although no direct comparison was made, ball lie was poorer in unmown turf and the range in ball exposed across cultivars was larger in unmown vs. mown turf. Even though differences existed for percent ball exposed, the impact of these differences on a players shot is unclear. More research is needed to correlate the percent of ball exposed to the difficulty of a golf shot. This research will allow superintendents to select cultivars or species to meet the needs of their players and the difficulty of the playing conditions on the course.

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Table 1. Ball lie, expressed as percent of ball exposed for various cultivars of bermudagrass and zoysiagrass across five dates.

		Ball Lie[z]				
		Mown		Unmown		
Cultivar	Species	28 Aug.	24 Sep.	7 Jul.	28 Aug.	24 Sep.
		%				
Cavalier	ZM[y]	95.4	95.5 abc[x]	88.5 ab	85.5 abc	88.5 a
Diamond	ZM	96.5	94.5 bc	91.3 a	88.1 ab	89.9 a
El Toro	ZJ	96.6	95.6 abc	89.3 ab	88.1 bcd	85.1 a
Meyer	ZJ	96.7	94.7 abc	86.7 b	86.8 abc	84.5 a
Palisades	ZJ	95.3	93.3 c	88.7 ab	75.7 d	73.1 b
Patriot	CDT	95.7	97.0 a	89.3 ab	91.1 a	90.8 a
Princess-77	CDT	95.9	95.7 abc	90.2 ab	84.8 abc	90.1 a
Riviera	CD	96.2	94.4 bc	87.5 b	88.6 ab	90.3 a
Tifsport	CDT	96.6	96.2 ab	90.2 ab	88.2 ab	91.0 a
Tifway	CDT	97.7	96.2 ab	90.4 ab	91.9 a	88.4 a
Zenith	ZJ	95.8	94.8 abc	88.7 ab	80.3 cd	83.9 a
Zorro	ZM	96.7	95.7 abc	87.8 ab	82.0 bcd	84.5 a
mean		96.3	95.3	89.1	85.4	86.7
Species						
Bermuda	C	96.4	95.9 a	89.5	88.9 a	90.1 a
Zoysia	Z	96.1	94.9 b	88.7	82.9 b	84.2 b

[z] Ball lie expressed as percent ball exposed.
[y] ZJ = *Zoysia japonica*; ZM = *Zoysia matrella*; CD = *Cynodon dactylon*; CDT = *Cynodon dactylon* × *C. transvaalensis*; C = *Cynodon* spp.; Z = *Zoysia* spp.
[X] Cultivars within the same column are not significantly different.

Successful Bermudagrass Overseeding is Dependent on Species Selection and Pre-plant Cultivation, and Traffic Timing

Differences in overseeding treatments

Jon Trappe[1], Aaron Patton[1], Doug Karcher[2], and Mike Richardson[2]

Additional index words: annual ryegrass, perennial ryegrass, intermediate ryegrass, tetraploid, meadow fescue, seeding, core aerification, vertical mowing

Trappe, J., A. Patton, Doug Karcher, and M. Richardson 2009. Successful bermudagrass overseeding is dependent on species selection and pre-plant cultivation, and traffic timing. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:148-152.

Summary. Overseeding cool-season turfgrass into dormant or semidormant warm-season turf is a practice implemented by turfgrass managers to improve aesthetics and provide an actively growing playing surface. This study was conducted to determine the effects of three pre-plant cultivation techniques and post-seeding traffic on the establishment of five overseeding turfgrass species. In September 2007, five overseeding species, including annual ryegrass, intermediate ryegrass, meadow fescue, perennial ryegrass, and tetraploid perennial ryegrass, were established into Riviera bermudagrass. Pre-plant cultivation techniques included core-aerification, vertical mowing, and an untreated control. Traffic was applied at either 1, 2, or 4 weeks after seeding to determine their effect on overseeding establishment. Plots aerified before seeding resulted in the greatest overseeding turf coverage in November 2007 and March 2008. Perennial and annual ryegrass overseeded plots had the highest turf coverage among overseeding species in November 2007; however, annual ryegrass had less coverage than perennial ryegrass in March 2008. Traffic was more damaging when applied 4 WAP (weeks after planting) than 1 or 2 WAP.

Abbreviations: WAP, weeks after planting; AR, annual ryegrass; IR, intermediate ryegrass; MF, meadow fescue; PR, perennial ryegrass; TR, tetraploid perennial ryegrass; pure live seed (PLS)

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Although some form of pre-plant cultivation technique such as scalping, verticutting, or aerifying is commonly used by turf managers, knowledge of their effectiveness is based largely on anecdotal observations; and thus a need exists to evaluate these methods. Research that has investigated verticutting alone as a pre-plant cultivation technique found that it is more effective for overseeding grass establishment than a nontreated control (Schmidt, 1970). Schmidt and Blaser (1962) concluded that verticutting was a more effective establishment technique for turfgrass coverage than aerification. Recently, researchers have investigated other cool-season turfgrass species for winter overseeding. Richardson et al. (2007) found that meadow fescue (*Festuca pratensis*) and tetraploid perennial ryegrass (*Lolium perenne*) provided acceptable turfgrass quality when overseeded into a bermudagrass stand.

Overseeding turf stands are often subjected to traffic. However, little is known about the effects of traffic as well as timing after seeding and their affect on establishment. It is important to know when play can resume on an overseeded field so that turf managers can more effectively establish an overseeded stand of turf. The objective of this study is to determine the effects of three pre-plant cultivation techniques and traffic on the establishment of five overseeding turfgrass species.

Materials and Methods

On 24 September 2007, five cool-season turfgrasses, including annual ryegrass (*Lolium multiflorum*), intermediate ryegrass (*L. multiflorum* x *L. perenne*), meadow fescue, perennial ryegrass (*L. perenne*), and tetraploid perennial ryegrass were overseeded into a mature (>4 yr) stand of Riviera bermudagrass (*Cynodon dactylon*) turf at the University of Arkansas Agricultural Research and Extension Center at Fayetteville. Species were seeded based on recommended seeding rates (Table 1). Plots were assigned one of three pre-plant cultivation treatments of aerification, verticutting, or an untreated control. Traffic was applied using a Cady traffic simulator (Henderson et al., 2005) making four passes at 1, 2 or 4 weeks after planting (WAP) or an untreated control. Digital image analysis was used to determine turfgrass coverage of the overseeded species when the bermudagrass turf was dormant (Richardson et al., 2001).

Results and Discussion

Perennial and annual ryegrass had the greatest overall turfgrass coverage among the species evaluated in November 2007; however, in March 2008, annual ryegrass had less coverage than perennial ryegrass (data not shown). This may be attributed to the annual life cycle of annual ryegrass. Meadow fescue consistently had the lowest overall turfgrass coverage across all treatments. This may be expected due to its poor traffic and cold tolerance when used as a sports turf (Summerford et al., 2008).

Aerification proved to be a better pre-plant cultivation method for overseeding grass germination and survival than verticutting (Fig. 1). Traffic applied 4 WAP was more detrimental than at 1 and 2 WAP in all overseeding species except perennial ryegrass (Fig. 1). Although previous research has shown tetraploid ryegrass to be similar in traffic tolerance to perennial ryegrass in an established stand of turf (Summerford et al., 2008), perennial ryegrass had greater traffic tolerance during establishment. Aerification was the only pre-plant cultivation technique that helped reduce damage from traffic on seedlings. This may be the result of reduced compaction from the aerification.

These findings will help turfgrass managers to more effectively establish overseeding grasses and ultimately improve the playing conditions of sports fields and golf courses. These results demonstrate that differences exist between overseeding species, pre-plant cultivation technique, and traffic timing and tolerance. Based on these first year results, turfgrass managers would have best overseeding establishment by using aerification as a pre-plant cultivation technique and perennial ryegrass as a species. This study was repeated in the fall of 2008 and those data will be presented in the 2010 Arkansas Turfgrass Report.

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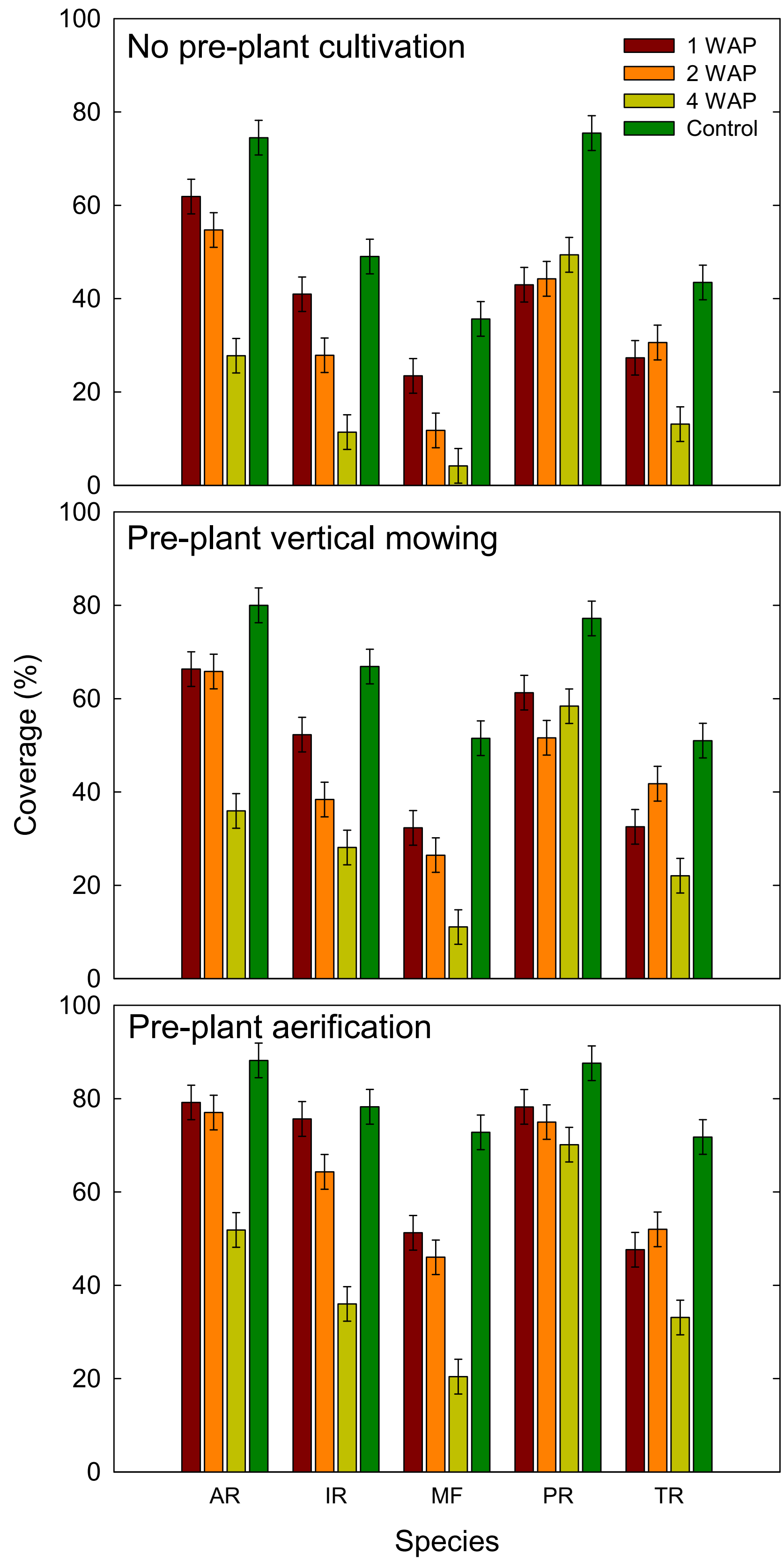

Fig. 1. The effect of three pre-plant cultivation techniques and four traffic timings on November coverage of five overseeding grasses. WAP, weeks after planting; AR, annual ryegrass; IR, intermediate ryegrass; MF, meadow fescue; PR, perennial ryegrass; TR, tetraploid perennial ryegrass.

Table 1. Overseeding species and their corresponding seeding rates.

Species	Seeding rate (lb./1000 ft^2)[z]	Seeds / ft^2[y]
annual ryegrass	14	3150
intermediate ryegrass	13	3150
meadow fescue	13	3150
perennial ryegrass	12	3150
tetraploid perennial ryegrass	19	3150

[z] Seeding rate represents pounds of pure live seed (PLS) per unit area.
[y] Amount of seeds per unit area, displays relative seeding rate for differing species.

Clipping Yield and Scalping Tendency Differ for Bermudagrass and Zoysiagrass Cultivars


Photo by Aaron Patton

Scalping of bermudagrass research plot

Jon Trappe[1], Aaron Patton[1], and Mike Richardson[2]

Additional index words: mowing, PGR, Cavalier, Diamond, El Toro, Meyer, Palisades, Patriot, Princess-77, Riviera, Tifsport, Tifway, Zenith, and Zorro

Trappe, J., A. Patton, and M. Richardson 2009. Clipping yield and scalping tendency differ for bermudagrass and zoysiagrass cultivars. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:153-157.

Summary. Decreased budgets as well as greater attention towards sustainability have increased interest towards reduced mowing requirements. Two growth parameters that impact mowing requirements are clipping yield and scalping tendency. The objectives of this study are to quantify the scalping tendency and clipping yield of various bermudagrass and zoysiagrass cultivars. Five bermudagrass cultivars and seven zoysiagrass cultivars were maintained under typical golf course fairway or sports field conditions to evaluate scalping tendencies and clipping yield. Patriot bermudagrass was the cultivar most prone to scalp, and in general, bermudagrass was more susceptible to scalping than zoysiagrass. Princess-77 bermudagrass produced the highest clipping yields while Cavalier, Meyer, Zorro, and Zenith zoysiagrass consistently yielded the least clippings. These results will assist turfgrass managers to select cultivars or species that potentially require less mowing and are less likely to scalp.

Abbreviations: PGR, Plant growth regulator; ZJ, *Zoysia japonica*; ZM, *Zoysia matrella*; CD, *Cynodon dactylon*; CDT, *Cynodon dactylon* × C. *transvaalensis*; C, *Cynodon* spp.; Z, *Zoysia* spp

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Advancements in turfgrass breeding have resulted in turfgrasses that recover more quickly from stresses such as divoting, wear, disease and environmental stresses such as drought or winterkill. However, species or cultivars that require less maintenance are becoming more desirable to turfgrass managers. Research providing differences in clipping yield among cultivars and species would give superintendents the ability to choose a cultivar or species that would provide a reduced need for amendments such as plant growth regulators (PGRs) and a better way to reduce clipping yield. Additionally, faster growth rates have also led to increased thatch production, which in turn has made some cultivars more prone to scalping. A particular cultivar or species that is more prone to scalping will reduce the playability, aesthetics, and overall health of a turf sward. The objectives of this study were to determine differences in scalping tendencies and clipping yields in bermudagrass (*Cynodon* spp.) and zoysiagrass (*Zoysia* spp.) cultivars.

Materials and Methods

Five cultivars of bermudagrass and seven cultivars of zoysiagrass (Table 1) were established in the summer of 2007 at the University of Arkansas Agricultural Research and Extension Center, Fayetteville, Ark. Plots were maintained under golf course fairway or sports field conditions, with a mowing height of 0.5 inches and monthly applications of 1.0 lb N/1000ft^2 for bermudagrass and 0.5 lb N/1000ft^2 for zoysiagrass during the growing season. Clipping yield was determined by collecting clippings five days after an initial mowing at 0.5 inches. Clippings were collected using a reel-type mower and bucket. Samples were weighed after four days in a dryer at 60 °C for dry weights. Diamond zoysiagrass was not fully established at the time of clipping yield collections, thus results for this cultivar will not be presented for clipping yield.

Scalping was performed during the time of clipping collection and on the same experimental plots. Scalping, removal of more than 1/3 of the turfgrass leaf, was simulated by mowing each plot after a period of 5 days without mowing. Digital images were taken immediately prior to and immediately following mowing and analyzed for percent green cover (Richardson, et al, 2001). An equation of [100*((initial green cover – post green cover)/(initial green cover))] was used to quantify the tendency of a particular plot to scalp by measuring the reduction in green coverage caused by mowing.

Results and Discussion

There were clear trends in the scalping tendencies for the cultivars evaluated. Patriot bermudagrass had significantly more scalping occur than the other 11 cultivars across the three sampling dates (Table 1). Consequently, bermudagrass consistently had significantly more scalping than zoysiagrass when analyzed across species. This may be because of Patriot's aggressive growth rate and high shoot density (Karcher et al. 2005a; Morris, 2007).

There were also clear trends in clipping yield. The cultivar that had the highest clipping yield on each sampling date was Princess-77 (Table 2). Among the zoysiagrass cultivars, Palisades and El Toro had the highest clipping yields. There were also several cultivars that had considerably lower clipping yields, including Cavalier, Meyer, Zorro, and Zenith. The clipping yield rankings of zoysiagrass cultivars were similar to previous rankings on the establishment rate, stolon growth rate, and divot recovery of zoysiagrasses (Karcher et al. 2005b; Patton et al., 2007). Species differences also existed, with bermudagrass consistently having higher clipping yields than zoysiagrass. This difference in species agrees with other work that found bermudagrass to have a faster growth rate than zoysiagrass (Beard, 1973).

Based on these findings, bermudagrass cultivars had higher clipping yields in addition to higher scalping tendencies than zoysiagrass. Some particular cultivars, such as Patriot bermudagrass, had higher clipping yields and also had a higher scalping tendency, while other cultivars that also had high clipping yields did not have a high scalping tendency. There is more work needed to investigate the mechanisms behind scalping and its potential relationship with high clipping yield. These results will assist turfgrass managers to select cultivars or species that potentially require less mowing and are less likely to scalp. They will not only help to improve playing conditions, but will also help to reduce PGR use, equipment wear, labor and fuel costs associated with maintaining a golf course fairway or sports field. These studies will be repeated again in 2009.

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Table 1. Percent scalping tendency across three dates for various bermudagrass and zoysiagrass cultivars.

Cultivar	Species	Scalping[z]		
		4 Aug.	28 Aug.	23 Sept.
		----------------------------%----------------------------		
Cavalier	ZM [y]	0.0 b[x]	0.3 b	0.1 b
Diamond	ZM	0.2 b	0.1 b	0.0 b
El Toro	ZJ	0.1 b	0.5 b	0.7 b
Meyer	ZJ	0.3 b	0.0 b	0.3 b
Palisades	ZJ	0.0 b	0.1 b	0.4 b
Patriot	CDT	0.8 a	2.4 a	15.6 a
Princess-77	CDT	0.1 b	0.4 b	0.3 b
Riviera	CD	0.1 b	0.5 b	0.4 b
Tifsport	CDT	0.2 b	0.4 b	1.4 b
Tifway	CDT	0.3 b	0.2 b	7.2 b
Zenith	ZM	0.1 b	0.0 b	0.3 b
Zorro	ZM	0.0 b	0.0 b	0.1 b
Species				
Bermuda	C	0.3	0.8 a	5.0 a
Zoysia	Z	0.1	0.1 b	0.2 b

[z] Scalping tendency expressed as a percent using the equation [100*(initial green cover – post green cover)/(initial green cover)].

[y] ZJ = *Zoysia japonica*; ZM = *Zoysia matrella*; CD = *Cynodon dactylon*; CDT = *Cynodon dactylon* × *C. transvaalensis*; C = *Cynodon* spp.; Z = *Zoysia* spp.

[x] Values in a column followed by the same letter are not significantly different from another (LSD, α = 0.05).

Table 2. Fresh and dry weight clipping yield of various bermudagrass and zoysiagrass cultivars.

Cultivar	Species	Clipping yield[z] 4 Aug.	28 Aug.	23 Sept.
		---g/m^2---		
Cavalier	ZM[y]	1.8 ef[x]	2.3 cd	3.3 abc
El Toro	ZJ	3.5 d	3.4 b	3.8 ab
Meyer	ZJ	0.8 f	2.0 d	3.0 bc
Palisades	ZJ	6.0 c	3.5 b	4.0 ab
Patriot	CDT	7.6 ab	3.5 b	3.2 abc
Princess-77	CDT	8.6 a	4.6 a	4.3 a
Riviera	CD	6.6 bc	3.8 ab	3.3 abc
Tifsport	CDT	5.8 c	3.6 b	3.4 abc
Tifway	CDT	6.9 bc	3.7 ab	2.8 c
Zenith	ZM	2.7 de	3.0 bc	3.4 abc
Zorro	ZM	1.4 ef	2.5 cd	3.7 abc
Species				
Bermuda	C	7.1 a	3.8 a	3.4
Zoysia	Z	2.7 b	2.8 b	3.6

[z] Clipping yield of cultivars expressed as weight per unit area.
[y] ZJ = *Zoysia japonica*; ZM = *Zoysia matrella*; CD = *Cynodon dactylon*; CDT = *Cynodon dactylon* × *C. transvaalensis*; C = *Cynodon* spp.; Z = *Zoysia* spp.
[x] Values in a column followed by the same letter are not significantly different from another (LSD, α = 0.05).

Shade and Traffic Tolerance of Bermudagrass and Zoysiagrass

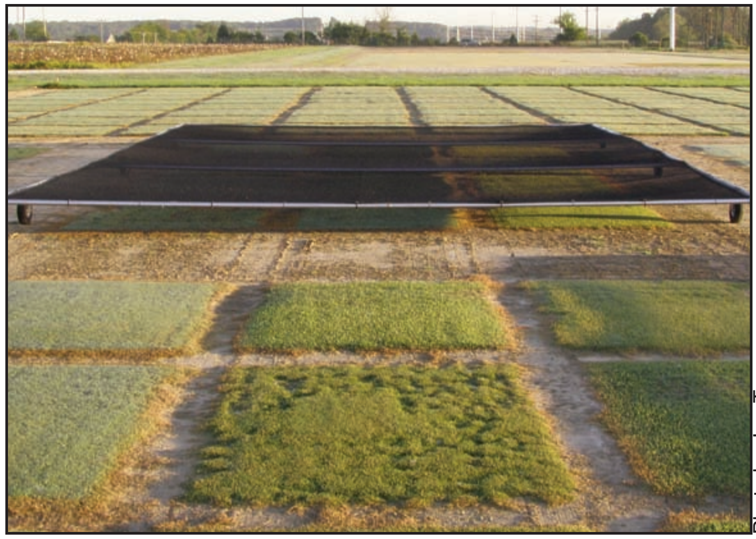
Moveable shade structure

Photo by Jon Trappe

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and Mike Richardson[2]

Additional index words: Cady traffic simulator, *Zoysia japonica*, *Zoysia matrella*, *Cynodon dactylon*, *C. dactylon x C. transvaalensis*.

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Summary. Shade and traffic can reduce turfgrass coverage and playability on both golf courses and sports fields. Five cultivars of bermudagrass and seven cultivars of zoysiagrass were planted in the summer of 2007 and maintained under typical golf course fairway and sports field conditions. Plots were shaded continuously beginning spring 2008 with a 50% light reducing fabric. A second study was implemented using the same plot space to determine traffic tolerance. Digital image analysis was used to measure turfgrass coverage for evaluating shade and traffic tolerance of cultivars. The objective of this study is to evaluate cultivars and species for differences in turf coverage in response to continuous shade as well as simulated traffic. Patriot, Tifsport, and Zenith had poor shade tolerance compared to other cultivars tested in the trial. Meyer, Palisades, Patriot, and Zenith had poor traffic tolerance regardless of the shading treatment. These findings will help turfgrass managers select cultivars and improve playing conditions under conditions of high traffic and/or reduced light.

Abbreviations: PGR, Plant growth regulator; Avg, Average; ZJ, *Zoysia japonica*; ZM, *Zoysia matrella*; CD, *Cynodon dactylon*; CDT, *Cynodon dactylon* × C. *transvaalensis*; C, *Cynodon* spp.; Z, *Zoysia* spp

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Shade is an important factor influencing the maintenance of golf courses and sports fields. The use of shade-tolerant cultivars or species can greatly improve turf quality in shaded areas. Previous work (Baldwin, 2008; McBee and Holt, 1966; Qian and Engelke, 1997) has investigated which cultivars and species perform well under shaded conditions, but very little research has compared the most commonly used cultivars of bermudagrass and zoysiagrass in a combined trial. Bunnell et al. (2005) found that 'Meyer' zoysiagrass had better shade tolerance than 'Tifsport' and 'Tifway' bermudagrass, but comparisons of other commonly used zoysiagrass cultivars to commonly used bermudagrass cultivars are unavailable.

Regular traffic that occurs on sports fields, golf courses, and residential areas can be detrimental to bermudagrass and zoysiagrass growth. Previous research has investigated which species have superior traffic tolerance (Youngner, 1961; Shearman and Beard, 1975), but these studies investigated cultivars that are rarely used today. Trappe et al. (2008, 2009) investigated traffic tolerance of newer bermudagrass cultivars but did not investigate their traffic tolerance in a side-by-side trial with commonly used zoysiagrass cultivars. Research is needed comparing traffic tolerance of newer cultivars of bermudagrass and zoysiagrass. The objective of this study was to evaluate those cultivars and species that have the best turfgrass coverage in response to continuous shade as well as simulated traffic.

Materials and Methods

Five cultivars of bermudagrass and seven cultivars of zoysiagrass were established in the summer of 2007 (Table 1). Plots were maintained under golf course fairway or sports field conditions, with a mowing height of 0.5 inch and monthly applications of 1.0 lb N/1000ft^2 for bermudagrass and 0.5 lb N/1000ft^2 for zoysiagrass during the growing season. For each replication, there was one shaded and one nonshaded plot. A shade fabric reducing light by 50% was installed on the plots continuously beginning April 2008. Shade tolerance was evaluated using digital image analysis to determine percent green turf cover as affected by shade (Richardson et al, 2001). Images of turf were taken monthly, and three sampling dates were used to distinguish shade tolerance among cultivars and species.

Traffic was applied weekly using the Cady traffic simulator (Henderson et al., 2005). Once each week for five consecutive weeks starting on 25 July, four passes in the forward direction were made to half of each plot in both full-sun and shaded plots. Four passes were intended to simulate two football games from within the hash marks (Henderson et al., 2005). Digital images were taken prior to each traffic application and after the final traffic application to evaluate damage. Digital image analysis was used to evaluate the amount of green turfgrass cover that was affected by the traffic simulator (Richardson et al, 2001), and a total of three evaluation dates were used to distinguish traffic tolerance among cultivars and species.

Results and Discussion

Non Trafficked Plots. Of the three sampling dates used to distinguish differences in coverage in shaded vs. full-sun plots, an interaction between shade treatment and cultivar existed for two sampling dates (11 July and 2 October) (Table 1). For both of these dates, Patriot and Zenith had less turf coverage in the shaded plots but their coverage was similar to other cultivars in full-sun plots. Additionally, Tifsport had reduced coverage in the shaded plots on 2 October compared to coverage in full sun. On 29 August, differences existed between cultivar and shade treatments, but no interaction existed between these two variables. Patriot had decreased coverage across light environments on 29 August. For all three evaluation dates, full-sun treatments had significantly more turfgrass coverage than shaded plots.

Trafficked Plots. Significant differences in coverage existed in trafficked plots between cultivars for two of the three collection dates; however, only on 12 August was there an interaction between shade treatment and cultivar (Table 2). This interaction indicates that some cultivars perform better at a particular shade treatment (shade or full sun) when trafficked while others perform similar in the shade and full sun. Patriot and Zenith both had a reduction in turf coverage in shaded plots after two weeks of traffic treatment, while other cultivars had similar coverage in shade and full-sun plots indicating that Zenith and Patriot were not shade tolerant, especially under traffic stress. There were no differences in coverage between species in shaded plots on 12 August.

There were no differences in coverage between cultivars on 22 August, but there was more coverage in full-sun plots than in shaded plots indicating better traffic tolerance for turf grown in sunny areas. Across cultivars, zoysiagrass and bermudagrass had similar coverage in full-sun trafficked plots, although zoysiagrass had more coverage than bermudagrass in shaded plots indicating better resistance to traffic under shade conditions.

On 29 August, there were differences in turf coverage in shade treatments and among cultivars across both shade treatments, although no interaction existed between shade treatments and cultivar. Cavalier, El Toro, Princess-77, Riviera, Tifsport, Tifway and Zorro had the greatest turf coverage across shade treatments when evaluated on 29 August, while Meyer, Palisades, Patriot, and Zenith had the least turf coverage across shade treatment on the same date. Bermudagrass traffic tolerance of Princess-77, Riviera and Tifsport agree with previous work done be Trappe et al. (2008); however, the cultivar Patriot was relatively less traffic tolerant in this study. This may be due to the poor performance of Patriot in shaded plots. Across cultivars, bermudagrass had more coverage in full-sun trafficked plots on 29 August, and coverage was similar for each species in the shade. The results on 29 August indicate that under traffic and full sun, bermudagrass retained its coverage longer indicating that it has better traffic tolerance than zoysiagrass. Additionally, these results suggest that under shading and traffic, zoysiagrass coverage will be decreased in a similar fashion to bermudagrass.

Zoysiagrass had significantly more turfgrass coverage in shaded plots than bermudagrass for two of the six sampling dates in both the trafficked and nontrafficked plots (Tables 1 and 2). This agrees with previous research that determined Meyer zoysiagrass has superior shade tolerance than Tifway, Celebration or Tifsport bermudagrass (Bunnell et al., 2005).

The ultimate goal of this study is to help golf course and sports field managers select cultivars and species that have excellent shade and traffic tolerance. Selecting the best cultivar adapted for a particular location will ultimately help to reduce maintenance inputs and reduce costs. This research will be completed again in the summer of 2009.

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Table 1. Percent green coverage of various bermudagrass and zoysiagrass cultivars grown in two environments (shade or full sun) without traffic stress.

		7/11/2008			8/29/2008			10/2/2008		
Cultivar	Species	Sun	Shade	Avg.	Sun	Shade	Avg.	Sun	Shade	Avg.
						%				
Cavalier	ZM[z]	100.0 A[y]	100.0 A	100.0	99.0	99.6	99.3 a[x]	97.8 AB	98.6 A	98.2
Diamond	ZM	99.7 A	99.5 A	99.6	99.8	99.8	99.6 a	100.0 A	99.5 A	99.7
El Toro	ZJ	99.9 A	97.5 A	98.7	98.1	97.6	97.6 a	98.9 A	98.5 A	98.8
Meyer	ZJ	99.8 A	98.6 A	99.2	97.1	98.3	97.7 a	98.6 A	90.2 B	94.4
Palisades	ZJ	99.9 A	99.6 A	99.8	98.8	98.0	98.4 a	98.9 A	98.8 A	98.8
Patriot	CDT	99.7 A	82.2 B	91.0	86.7	70.2	78.4 b	95.9 AB	54.1 D	75.0
Princess-77	CDT	99.9 A	99.1 A	99.0	97.8	96.8	97.6 a	99.7 A	99.5 A	99.6
Riviera	CD	99.8 A	95.9 A	97.9	99.0	94.6	96.8 a	99.9 A	98.2 AB	99.0
Tifsport	CDT	100.0 A	96.1 A	98.0	99.3	88.2	93.8 a	99.8 A	53.3 D	76.5
Tifway	CDT	99.9 A	98.6 A	99.3	99.1	85.7	92.4 a	97.7 AB	97.3 AB	97.5
Zenith	ZM	98.7 A	53.5 C	76.1	98.9	96.4	97.7 a	97.7 AB	80.9 C	89.3
Zorro		100.0 A	100.0 A	100.0	98.5	99.6	99.1 a	99.9 A	97.3 AB	98.6
Average		99.8	93.4		97.7 A	93.7 B		98.7	88.9	
Species										
Bermuda	C	99.9	94.2		96.4	87.1 b		98.6	80.5	
Zoysia	Z	99.7	92.8		98.5	98.5 a		98.8	94.8	

[z] ZJ = *Zoysia japonica*; ZM = *Zoysia matrella*; CD = *Cynodon dactylon*; CDT = *Cynodon dactylon* × *C. transvaalensis*; C = *Cynodon* spp.; Z = *Zoysia* spp.
[y] When comparing coverage means on an evaluation date, within columns and across rows, means followed by the same uppercase letter are not significantly different according to Fisher's protected LSD (α= 0.05).
[x] Within columns, means followed by the same letter are not significantly different according to Fisher's protected LSD (α= 0.05).

Table 2. Percent green coverage of various bermudagrass and zoysiagrass cultivars grown in two environments (shade or full sun) with traffic stress.

		8/12/2008			8/22/2008			8/29/2008		
Cultivar	Species	Sun	Shade	Avg.	Sun	Shade	Avg.	Sun	Shade	Avg.
Cavalier	ZM[z]	96.3 A[y]	97.3 A	96.8	40.7	16.1	28.4	70.2	38.4	54.3 abc[x]
El Toro	ZM	95.8 A	92.3 A	94.0	71.6	20.8	46.2	73.6	20.6	47.1 abc
Meyer	ZJ	91.3 A	91.2 A	91.2	39.0	23.7	31.4	72.6	15.2	43.9 bcd
Palisade	ZJ	96.4 A	90.9 A	93.6	49.6	43.1	46.4	71.6	17.9	44.8 bcd
Patriot	ZJ	99.9 A	60.1 B	80.0	78.3	15.0	46.7	62.4	4.9	33.7 d
Princess-77	CDT	99.9 A	93.1 A	96.5	87.4	12.0	49.7	81.1	16.1	48.6 abc
Riviera	CDT	99.9 A	89.5 A	94.7	60.9	10.5	35.7	85.5	24.5	55.0 ab
Tifsport	CD	99.8 A	87.2 A	93.5	85.0	30.1	57.6	89.2	24.8	57.0 a
Tifway	CDT	99.8 A	90.7 A	95.2	54.4	23.8	39.1	90.4	20.5	55.5 ab
Zenith	CDT	91.0 A	53.3 B	72.1	28.6	17.3	45.9	71.5	14.0	42.8 cd
Zorro	ZM	96.8 A	96.2 A	96.5	59.3	52.4	55.9	78.5	30.2	54.4 abc
Average		97.0	85.6		59.5 A	24.4 B		77.0 A	20.6 B	
Species										
Bermuda	C	99.8	84.1		74.5	18.5 b		81.7 a	18.2	
Zoysia	Z	94.6	86.9		47.9	28.9 a		73.0 b	22.7	

[z] ZJ = *Zoysia japonica*; ZM = *Zoysia matrella*; CD = *Cynodon dactylon*; CDT = *Cynodon dactylon* × *C. transvaalensis*; C = *Cynodon* spp.; Z = *Zoysia* spp.
[y] When comparing coverage means on an evaluation date, within columns and across rows, means followed by the same uppercase letter are not significantly different according to Fisher's protected LSD (α= 0.05).
[x] Within columns, means followed by the same letter are not significantly different according to Fisher's protected LSD (α= 0.05).

Evaluation of Japanese Beetle Oviposition Behavior among Transition Zone Turfgrasses

Tara Wood[1], Mike Richardson[2], Lauren Flowers[1], and Don Steinkraus[1]

Additional index words: *Popillia japonica, Festuca arundinacea, Zoysia japonica, Cynodon dactylon, C. dactylon x C. transvaalensis*, tall fescue, zoysiagrass, common bermudagrass, hybrid bermudagrass, cultivar, preference, resistance, cultural control, integrated pest management


Photo by anonymous

Adult Japanese beetle

Wood, T., M. Richardson, L. Flowers, and D. Steinkraus. 2009. Evaluation of japanese beetle oviposition behavior among transition zone turfgrasses. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:163-167.

Summary. Japanese beetles were evaluated for ovipositional preferences among four turfgrasses commonly used in the transition zone. In a choice experiment with the cool-season turfgrass tall fescue (cultivar Millennium), and three warm-season turfgrasses, zoysiagrass (cultivar Zenith), common bermudagrass (cultivar Yukon), and hybrid bermudagrass (cultivar Tifway), females oviposited almost no eggs in the hybrid bermudagrass, and significantly fewer in common bermudagrass than zoysiagrass and tall fescue. In a second-choice experiment with only the three warm-season turfgrasses, significantly fewer eggs were oviposited in both hybrid and common bermudagrass than in zoysiagrass. In a no-choice experiment comparing the same four turfgrasses, hybrid bermudagrass again received the fewest number of eggs, indicating that although Japanese beetle females will burrow beneath the surface of Tifway hybrid bermudagrass, a chemical or physical characteristic is discouraging oviposition. The potential for using Tifway or similar turfgrasses as a cultural control component in an integrated pest management plan for Japanese beetle grubs is discussed.

Abbreviations: AAREC, Arkansas Agricultural Research and Extension Center

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Most research on Japanese beetle grubs, *Popillia japonica*, has focused on cool-season turfgrass common in northeastern and midwestern states. Less is known about how Japanese beetles affect and interact with turfgrasses common in southern regions. Although its establishment in northwest Arkansas in the late 1990s has led to increased economic damage to fruit, ornamental plants, and turf (Johnson, 2005; Gu et al., 2008), recent surveys suggest that grub densities in northwest Arkansas are much lower (<2 grubs per 1.0 ft^2) (Wood and Steinkraus, unpublished data) than those farther north which can exceed the highest economic thresholds (Vittum et al., 1999). Climatic and environmental differences might account for the pattern, but the types of turfgrasses grown in transitional climate zones such as northwestern Arkansas, could also play a role.

We hypothesized that one or more warm-season turfgrasses, which are common in the south, may express certain chemical or growth characteristics that deter or repel Japanese beetle oviposition. Choice and no-choice experiments were conducted to compare ovipositional response among three warm-season turfgrasses, and a cool-season turfgrass, tall fescue (*Festuca arundinacea*), known to be suitable for Japanese beetles (Potter et al., 1992; Crutchfield and Potter, 1995). The discovery of a resistant turfgrass to Japanese beetle ovipostion would provide an opportunity to proactively reduce grub infestations by altering oviposition habitat.

Materials and Methods

All experiments were conducted in June 2008. Turfgrasses tested were obtained from mature field plots at the Arkansas Agricultural Research and Extension Center (AAREC) in Fayetteville, Ark. The turfgrasses included tall fescue (cultivar Millennium), zoysiagrass, *Zoysia japonica* (cultivar Zenith), common bermudagrass, *Cynodon dactylon* (cultivar Yukon), and hybrid bermudagrass, *C. dactylon* x *C. transvaalensis* (cultivar Tifway). In choice experiments, 2-inch diam, 4-inch deep turfgrass cores were removed from turf fields and placed into 2-inch inner diam, 4-inch tall PVC pipes (choice cages). In the no-choice experiment, 4.25-inch diam, 5.5-inch deep turfgrass cores were removed from turf fields and placed into 5-inch inner diam, 8-inch tall PVC pipes (no-choice cages). The soil was a silt loam with an average pH of 6.2.

Japanese beetles were collected from traps placed at the AAREC. To ensure that females had mated, males and females were held together in 12.6-gal plastic tubs in the laboratory (72–77 °F, 16:8 L:D). Adults were fed Red Delicious apples and grape leaves, but given no oviposition medium. After 3 d, adults were removed and separated by sex, with only females found *in copula* being used in the experiments.

Four-choice and 3-choice assays were conducted in plastic tubs approximately 11 by 11.5 by 13 inches; hereafter termed arenas (Fig. 1). The arenas we used were modified from those in Szendrei and Isaacs (2005). In the 4-choice experiment, cores of each of the four turfgrasses were randomly inserted into arenas through holes in foam board which served as the floor for female Japanese beetles to walk across in search of an oviposition site. The 3-choice experiment was assembled in the same fashion with the exception of using only the three warm-season turfgrasses in the arena. To begin an assay, one mated female beetle was placed on a slice of Red Delicious apple (food source) in the center of each arena. Once a mated female was placed into an arena, mesh screen was secured to the top of the arena using hot glue. Both the 4-choice and 3-choice experiments were conducted as randomized complete block designs, consisting of 20 replications on 21 June (Block 1), and ten replications on 2 July (Block 2).

Choice cages were removed from the arenas after 7 d. Before removing the cages from the arenas, we recorded the condition of the turfgrasses, and examined the turfgrass cores for signs of female digging activity. All cores were visually inspected for eggs by gently breaking apart the soil and roots, and then the number of eggs found was recorded.

The no-choice experiment was conducted in no-choice cages that held only one of the four turfgrass treatments, giving the mated females no choice but to oviposit in the one turfgrass provided. At the start of the assay, a fresh slice of Red Delicious apple was added to each no-choice cage along with five mated Japanese beetle females. Then, the tops of the cages were covered with mesh screen held on with rubber bands. The treatments were arranged as a randomized complete block design. Five replications of the four turfgrasses were arranged into five rows (4 by 5 grid). The experiment was replicated in three time blocks beginning on 26, 27, and 30 June (Block 1, Block 2, and Block 3, respectively), giving a total of 15 replications per treatment. No-choice cages were removed after 7 d, and visually inspected for eggs as described above. The number of eggs was recorded.

Results and Discussion

All turfgrass cores appeared healthy, with sufficient moisture and good plant growth throughout all experiments. Block effects and treatment by block interactions were found in some analyses, but differences in rank among treatments were nearly identical in all experiments, so data were pooled for analyses in all cases.

Mean number of eggs differed significantly among treatments in all experiments (Tables 1, 2, and 3). Oviposition choice experiments showed that both common and hybrid bermudagrasses were nonpreferred for Japanese beetle oviposition. When females were confined on the particular turfgrasses in the no-choice experiment, they again oviposited fewer eggs in hybrid bermudagrass than the other treatments, suggesting that factors other than simply nonpreference are involved. Insight into mechanisms of a possible resistance in Tifway hybrid bermudagrass to Japanese beetle oviposition can be gained from observations and analyses of female activity (presence of female or eggs, or signs of female digging) within turfgrass cores in relation to the percentage of cores with eggs.

Analysis of the percentage of turfgrass cores with female activity did not differ significantly among the turfgrass treatments in either choice experiment (Tables 1 and 2), suggesting females did not initially reject a turfgrass based solely on above-ground visual or olfactory cues. Therefore, a wide array of turfgrasses may be, at first, viewed suitable to ovipositing Japanese beetles, and close-range contact stimuli are involved in females' choice of oviposition site.

Analysis of the percentage of turfgrass cores with eggs, on the other hand, did reveal significant differences among turfgrass treatments in both choice experiments (Table 1 and 2). Significantly fewer hybrid bermudagrass cores had eggs in the 4-choice experiment, meaning most females left hybrid bermudagrass cores after digging, but without ovipositing. A similar pattern occurred in the 3-choice experiment with both hybrid and common bermudagrass having significantly fewer cores with eggs, but no significant difference among the three turfgrasses in the percentage of cores with female activity.

Conclusion

This study suggests a previously undocumented mechanism by which turfgrasses may gain resistance to white grubs (physical barrier preventing oviposition). Previous research on resistance mechanisms of turfgrasses to *P. japonica* and other white grubs has focused on suitability of the roots for larval development, or tolerance to root herbivory (Potter et al., 1992; Crutchfield and Potter, 1994, 1995; Braman and Raymer, 2006; Bughrara et al., 2008). Our study suggests that hybrid bermudagrass has potential to reduce incidence of Japanese beetle grubs in lawns and golf courses by deterring oviposition. However, further studies are needed to determine the mechanism of this resistance to Japanese beetle oviposition, if that resistance carries over to the grubs, and how it affects other insects in the turfgrass system before recommending its use as a cultural control component in an integrated pest management plan.

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Table 1. Oviposition activity by mated female Japanese beetles given a choice between the cool-season turfgrass tall fescue, and three warm-season turfgrasses (4-choice oviposition experiment), or between just the three warm-season turfgrasses (3-choice oviposition experiment), or no-choice between tall fescue and the three warm-season turfgrasses (no-choice oviposition experiment).

Turfgrass	Mean ± SE no. eggs per core[z]			Mean ± SE % of cores with				
				Female activity[y]		Eggs		
	4-choice	3-choice	No-choice	4-choice	3-choice	4-choice	3-choice	No-choice
Hybrid bermudagrass	0.2 ± 0.2a	0.6 ± 0.4a	14.7 ± 4.2a	40.0 ± 9.1a	63.3 ± 8.9a	3.3 ± 3.3a	10.0 ± 5.6a	93.3 ± 6.7a
Common bermudagrass	1.5 ± 0.5b	1.8 ± 0.7a	39.1 ± 3.6b	53.3 ± 9.3a	66.7 ± 8.8a	33.3 ± 8.8b	26.7 ± 8.2a	100.0 ± 0.0a
Zoysiagrass	3.2 ± 1.6c	4.7 ± 0.8b	39.5 ± 4.6b	66.7 ± 8.8a	83.3 ± 6.9a	46.7 ± 9.3b	70.0 ± 8.5b	100.0 ± 0.0a
Tall fescue	3.8 ± 1.0c	--	50.3 ± 4.8c	63.3 ± 8.9a	--	53.3 ± 9.3b	--	93.3 ± 6.7a

[z]Values within a column followed by the same letter are not significantly different

[y]Female activity included presence of female, eggs, and/or evidence of digging in turfgrass cores

Fig. 1. Assembled oviposition arenas.

2008 Weather Summary for Fayetteville, Arkansas

Mike Richardson[1] and Chris Stiegler[1]

Richardson, M., and C. Stiegler 2009. 2008 weather summary for Fayetteville, Arkansas. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:168-169.

Photo by Mike Richardson

Weather station at the Fayetteville U of A research center

Summary. Summary data on air temperature, soil temperature (1-inch depth), and monthly rainfall totals at the University of Arkansas Agricultural Research and Extension Center, Fayetteville, Ark., are presented (Fig. 1) as a supplement to the 2008 Arkansas Turfgrass Report. All data were collected using a weather station (WatchDog, Model 2700, Spectrum Technologies, Plainfield, Ill.) located near the turfgrass research plots at the Fayetteville research station (36° 06' 04.06" N, 94° 10' 24.89" W, Elevation – 1266 ft). The most unusual weather pattern that was observed in 2008 was a higher than average rainfall, especially during the spring months and again in late summer. The rainfall total for the year was 54 inches, which is approximately 8 inches over the normal amount for this site. The Fall was slightly drier than the 30-year average. The temperature patterns somewhat mimicked rainfall, in that the Spring was slightly cooler than normal and the Fall was slightly warmer than the 30-year average.

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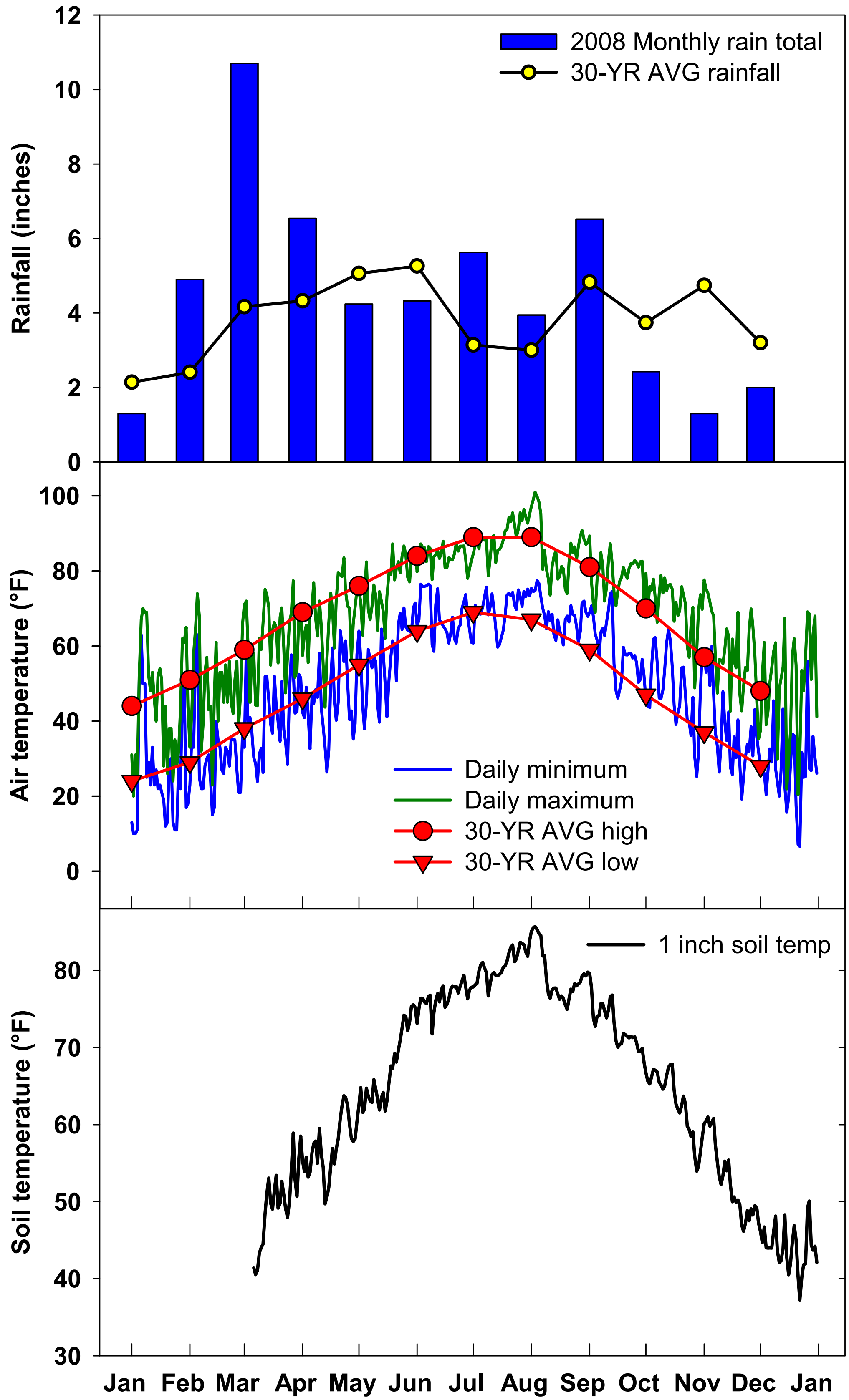

Fig. 1. Monthly rainfall, daily high and low temperatures, and soil temperatures at Fayetteville, Ark. The 30-yr average for rainfall and temperature is presented for reference.

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