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Arkansas Turfgrass Report 2009

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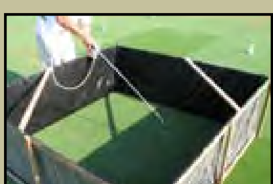

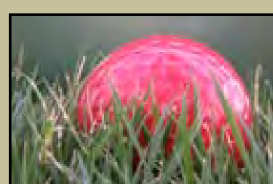
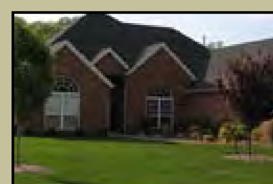
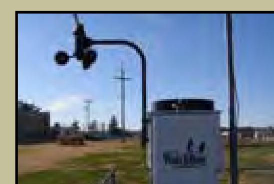

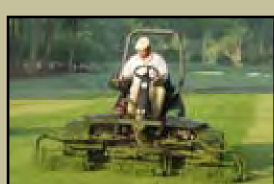

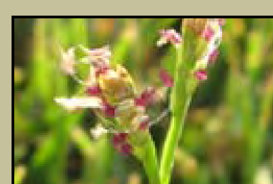
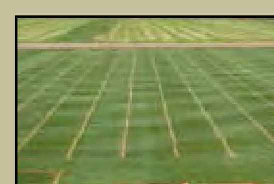

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Arkansas Turfgrass Report 2009

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Conversion Table

Conversions for commonly-used units in papers:

1 ft = 0.30 meters = 30.48 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 = 4.9 g / 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 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 during 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 third installment of the Arkansas Turfgrass Report, which includes 34 papers from faculty, staff, and graduate students. We hope these findings will enhance your ability to conduct business in an efficient and productive manner. The content of this edition of the Arkansas Turfgrass Report has been organized into categories in the Table of Contents ("Cultivar Trials," "Turf Culture," "Pest Control," etc.) for your convenience.

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 extremely grateful 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.

Doug Karcher	Aaron Patton	Mike Richardson
Associate Professor	Assistant Professor	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.

Andersons Golf Products
Aquatrols, Inc.
Arkalite
Arkansas Farm Bureau
Arkansas Turfgrass Association
BASF
Bayer Environmental Science
Pat Berger, University of Arkansas Athletics
Casey Crittenden, Bella Vista POA
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Jason Cuddy, Springdale Country Club
DeWitt Company
Double Springs Grass Farm
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Dr. Wayne Hanna, University of Georgia
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Todd Towery, Pinnacle Country Club
Turfgrass Producers International
United States Golf Association
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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Cultivar Trials

Turf Culture

Pest Control

Miscellaneous

Summary of the 2008 NTEP Bentgrass Tee/ Fairway Trial–1st Year Data

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

Additional index words: *Agrostis stolonifera, Agrostis capillaris,* turfgrass, cultivars, quality, color, texture

Karcher, D., M. Richardson, A. Patton, and J. Summerford. 2010. Summary of the 2008 NTEP bentgrass tee/fairway trial–1st year data. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:10-14.

Photo by Josh Summerford

2008 NTEP Bentgrass Tee/Fairway Trial at Fayetteville, Ark. The colonial bentgrass plots have a lighter appearance than the creeping bentgrass plots.

Summary. Creeping bentgrass continues to be the prevailing turfgrass species used for golf course putting greens throughout northern and central Arkansas. However, it is rarely used for tees or fairways in this region. Identifying cultivars that are well-adapted to Arkansas under tee/fairway conditions may provide viable alternatives for golf course superintendents with shaded tees in northern regions of Arkansas. A bentgrass cultivar trial, including selections of creeping and colonial bentgrass was planted in the fall of 2008 at the University of Arkansas Research and Extension Center (Fayetteville, Ark.). Turfgrass quality was evaluated monthly and turfgrass color and density were evaluated once in 2009. Significant differences existed among the cultivars for all evaluations. Towards the end of the 2009 growing season, Benchmark DSR and T-I were the commercially available cultivars that had the best quality, darkest color, and finest leaf texture. This trial will be evaluated for the next several years as these cultivars mature.

Abbreviations: NTEP, National Turfgrass Evaluation Program

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

Creeping bentgrass (*Agrostis stolonifera*) provides the most uniform and fastest surface for golf course putting greens in northern and central Arkansas; however, use on golf course tees and fairways has not been evaluated. Over the past several decades, improvements in heat tolerance and disease resistance of bentgrass warrant the evaluation of this species for golf course tees and fairways in the transition zone. Identifying bentgrass cultivars that are well-adapted to Arkansas under tee or fairway conditions may provide a viable alternative for golf course superintendents with shaded tees, approaches, or collars in the more northern regions of the state.

The National Turfgrass Evaluation Program (NTEP) is an organization within the United States Department of Agriculture that administers turfgrass cultivar evaluation experiments at various sites throughout the United States and Canada each year. Each commonly-used 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 awarded to the University of Arkansas. This report will summarize quality, color, and texture data from 2009, the first full growing season for these cultivars.

Materials and Methods

This cultivar trial was planted on 1 October 2008 at the University of Arkansas Research and Extension Center in Fayetteville on a native silt loam soil with an average pH of 6.2. Twenty-three cultivars 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 (Table 1). Each entry was broadcast seeded into four replicate 6 by 6 ft plots at a seeding rate of 1 lb/1000 ft^2. Following establishment, the trial was maintained at a mowing height of 0.5 inch using a walk mower and 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. Fungicides and insecticide applications were applied on a curative basis.

Cultivars were visually rated for turfgrass quality monthly throughout the 2009 growing season using a 1 to 9 scale, where 9 represents ideal dark green, dense, uniform turf, 6 represents acceptable quality, and 1 represents dead turf. Turf color and texture were evaluated on 25 September 2009. Color was visually rated using a 1 to 9 scale, where 9 represents ideal dark green color and 1 represents yellow/brown color. Texture was visually rated on a 1 to 9 scale, where 9 represents extremely fine-texture (narrow leaf blade width) and 1 represents very coarse texture (wide leaf blade width).

Results and Discussion

Turf quality. There were significant differences in seasonal average turf quality among bentgrass cultivars in 2009 (Table 1). In addition, there were significant differences in turf quality among cultivars in each month except May. In April, which was only six months following seeding, the top performing cultivars that are commercially available were Tiger II (colonial bentgrass) and 007 (creeping bentgrass). Although these cultivars were the fastest to approach an acceptable level of turf quality following seeding, by the end of the growing season only 007 was among the top cultivars with regard to turf quality. In September, at approximately one year following seeding, the top performing cultivars that are commercially available were T-1, 007, Tyee, Benchmark DSR, Crystal Bluelinks, Declaration, and Authority. Towards the end of the growing season, on the September evaluation date, all of the top performing cultivars were creeping bentgrass. However, all of the colonial bentgrass cultivars tested in this trial had acceptable turf quality in September. When averaging turf quality across the 2009 season, the top performing cultivars that are commercially available were T-1, Pennlinks II/Penneagle II, Tiger II, CY-2, Authority, Crystal Bluelinks, 007, and Benchmark DSR.

Turf color. There were significant differences in color among bentgrass cultivars on the 25 September 2009 evaluation date (Table 2). Average color for the cultivars ranged from a high of 9.0 for T-1 to a low of 5.0 for the experimental cultivar, A08-EBM; Benchmark DSR was the only other cultivar as dark green as T-1. As a species, the creeping bentgrass cultivars were darker than the colonial bentgrass cultivars. The 19 darkest green cultivars were creeping bentgrass; whereas 7 of 8 lightest green cultivars were colonial bentgrass.

Turf texture. There were significant differences in leaf texture among bentgrass cultivars on the 25 September 2009 evaluation date (Table 2). Cultivar leaf texture ratings ranged from a high of 8.3 for 007 and the experimental cultivar MSV-Ap-101, to a low of 5.7 for Penncross. Among the bentgrass cultivars with the finest leaf texture, those that are commercially available include 007, Benchmark DSR, Crystal Bluelinks, Declaration, T-1, Tyee, Authority, and CY-2 (Table 2). It is important to note that the turf evaluated in this trial was less than one year old and that the relative texture of the cultivars is likely to change as this trial is evaluated over the next several years and the turf matures.

Significant differences were present among creeping and colonial bentgrass cultivars in turfgrass quality, color, and texture when managed at fairway or tee height. There are likely to be shifts in how the cultivars rank in quality, color, and texture as they mature. As such, this trial will continue to be evaluated over the next several growing seasons. Although bentgrass fairways and tees are rare in Arkansas, all of the cultivars tested performed at, or above, an acceptable level in 2009. If some of the cultivars in this trial demonstrate acceptable quality over the next several years, they may be a viable option for tee or fairway use in northern Arkansas, especially in environments where heavy shade may preclude the use of warm-season grasses.

Table 1. Turf quality ratings throughout the 2009 growing season for creeping and colonial bentgrass cultivars in the 2008 NTEP Bentgrass Fairway/Tee Trial. Cultivars are listed by rank, from highest to lowest quality when averaged across the season.

Entry	Species	April	May	June	July	Aug.	Sept.	Avg.
		Turfgrass quality (1 to 9 scale)						
T-1	Creeping	5.7	7.7	7.7	7.7	8.0	8.7	7.6
PennlinksII/Penneagle II[y]	Creeping	6.0	7.3	7.5	7.7	8.0	7.7	7.4
Tiger II	Colonial	6.7	7.2	8.0	7.3	7.7	7.3	7.4
CY-2	Creeping	5.7	7.3	7.7	7.5	7.8	7.8	7.3
Authority	Creeping	5.7	7.5	7.3	7.5	7.7	8.0	7.3
SRP-1WM[z]	Creeping	5.7	7.7	6.8	7.7	7.5	8.2	7.3
A08-EBM[z]	Colonial	7.0	7.8	6.7	7.5	7.0	7.3	7.2
Crystal Bluelinks	Creeping	5.7	7.3	7.5	7.2	7.3	8.3	7.2
007	Creeping	6.3	7.8	7.0	6.5	7.0	8.5	7.2
BCD[z]	Colonial	6.7	7.8	7.5	6.8	7.3	7.0	7.2
Benchmark DSR	Creeping	5.3	7.2	7.7	7.2	7.5	8.3	7.2
HTM[z]	Creeping	6.3	7.3	7.2	6.7	7.5	8.2	7.2
MVS-Ap-101[z]	Creeping	6.0	7.7	6.7	6.8	7.0	8.7	7.1
A08-FT12[z]	Colonial	6.0	7.5	7.5	7.3	7.2	7.0	7.1
LTP-FEC[z]	Creeping	5.3	7.7	6.5	7.3	7.5	8.2	7.1
Declaration	Creeping	6.0	7.2	7.2	6.8	7.0	8.2	7.1
Greentime	Colonial	5.7	6.7	7.8	7.2	7.8	7.2	7.1
Memorial	Creeping	5.3	7.0	7.8	7.3	7.2	7.7	7.1
A08-TDN2[z]	Creeping	6.0	7.7	6.3	6.8	7.3	8.0	7.0
L-93	Creeping	5.7	7.3	7.3	6.3	7.5	7.8	7.0
PST-OJD[z]	Creeping	6.0	7.2	6.5	6.8	7.3	8.2	7.0
SR-1020[y]	Creeping	5.7	7.2	7.5	6.7	7.5	7.5	7.0
Tyee[y]	Creeping	5.7	7.2	6.8	6.8	7.0	8.3	7.0
PST-R9D7[z]	Colonial	6.3	6.8	7.3	7.3	7.0	6.3	6.9
Alister[y]	Colonial	5.3	7.0	7.3	7.2	7.7	6.5	6.8
Penncross	Creeping	5.7	7.2	7.2	7.3	7.0	6.7	6.8
Princeville	Creeping	5.0	6.8	7.3	6.5	6.5	6.7	6.5
	$LSD_{(0.05)}$[x]	*0.8*	*NS*	*0.8*	*0.8*	*0.8*	*0.8*	*0.4*

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

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

[x] Fisher's protected least significant difference value (α = 0.05); NS = not significant.

Table 2. Turf color and texture ratings for creeping and colonial bentgrass cultivars in the 2008 NTEP Bentgrass Fairway/Tee Trial. Evaluations were done in September 2009.

Entry	Species	Color	Texture
		—— Rating value (9=high, 1=low) ——	
007	Creeping	7.0	8.3
A08-EBM[z]	Colonial	5.0	7.3
A08-FT12[z]	Colonial	6.2	7.3
A08-TDN2[z]	Creeping	7.7	7.7
Alister[y]	Colonial	5.8	7.0
Authority	Creeping	7.0	7.8
BCD	Colonial	6.0	7.5
Benchmark DSR	Creeping	8.7	8.0
Crystal Bluelinks	Creeping	7.2	8.0
CY-2	Creeping	8.0	7.8
Declaration	Creeping	7.0	8.0
Greentime	Colonial	6.7	7.3
HTM	Creeping	7.5	8.0
L-93	Creeping	7.2	7.7
LTP-FEC[z]	Creeping	7.2	8.2
Memorial	Creeping	7.2	7.0
MVS-Ap-101[z]	Creeping	7.3	8.3
Penncross	Creeping	6.8	5.7
PennlinksII/Penneagle II[y]	Creeping	7.2	7.5
Princeville	Creeping	6.2	6.2
PST-OJD[z]	Creeping	8.0	7.8
PST-R9D7[z]	Colonial	5.8	6.8
SR-1020[y]	Creeping	7.5	7.2
SRP-1WM[z]	Creeping	7.3	8.0
T-1	Creeping	9.0	8.0
Tiger II	Colonial	6.0	7.5
Tyee[y]	Creeping	7.0	8.0
	$LSD_{(0.05)}$[x]	*0.7*	*0.6*

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

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

[x] Fisher's protected least significant difference value (α = 0.05); NS = not significant.

Summary of the 2008 NTEP Bentgrass Putting Green Trial–1st Year Data

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

Additional index words: *Agrostis stolonifera, Agrostis canina,* turfgrass, cultivars, quality, color, texture

Karcher, D., M. Richardson, A. Patton, and J. Summerford. 2010. Summary of the 2008 NTEP bentgrass putting green trial–1st year data. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:15-19.

Photo by Josh Summerford

2008 NTEP Bentgrass Putting Green Trial at Fayetteville, Ark. The four plots with severe stress symptoms are all velvet bentgrass.

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 Arkansas remains a goal of the University of Arkansas turfgrass research program. A bentgrass cultivar trial, including 30 selections of bentgrass (creeping or velvet) was planted in the fall of 2008 at the University of Arkansas Research and Extension Center (Fayetteville, Ark.). Following establishment, the trial was maintained using typical golf course putting green management practices for the region. Turfgrass quality was evaluated monthly and turfgrass color and density were evaluated once in 2009. Significant differences existed among the cultivars for all evaluations. Towards the end of the 2009 growing season, T-1, Tyee, and Shark were the commercially-available cultivars that had the best quality, darkest color, and finest leaf texture. This trial will be evaluated for the next several years as these cultivars mature.

Abbreviations: NTEP, National Turfgrass Evaluation Program

[1] University of Arkansas, Department of Horticulture, Fayetteville, Ark. 72701

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

Creeping bentgrass (*Agrostis stolonifera*) provides the most uniform and fastest surface for golf course putting greens in northern and central Arkansas and in other 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 United States Department of Agriculture that administers turfgrass cultivar evaluation experiments at various sites throughout the U.S. and Canada each year. Each commonly-used 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 includes both creeping bentgrass and velvet bentgrass (*Agrostis canina*) cultivars. This report will summarize quality, color, and texture data from 2009, the first full growing season for these cultivars.

Materials and Methods

This cultivar trial was planted on 30 September 2008 at the University of Arkansas Research and Extension Center in Fayetteville on a sand-based rootzone that was constructed according to United States Golf Association recommendations. Nineteen cultivars were officially included in the 2008 NTEP Bentgrass Putting Green Trial 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 (Summerford et al., 2009). Each cultivar was broadcast seeded into four replicate 6 by 6 ft plots at a seeding rate of 1 lb/1000 ft^2. Following establishment, the trial was maintained under golf course putting green conditions, with a mowing height of 0.125 inch and nitrogen applications of 0.5 lb N/1000 ft^2 per month of active growth. Irrigation was applied during establishment as needed to promote germination and thereafter to avoid drought stress. Pesticides were applied on a curative basis.

Cultivars were visually rated for turfgrass quality monthly throughout the 2009 growing season using a 1 to 9 scale, where 9 represents ideal dark green, dense, uniform turf and 1 represents dead turf. Turf color and texture were evaluated on 25 September 2009. Color was visually rated using a 1 to 9 scale, where 9 represents ideal dark green color and 1 represents yellow/brown color. Texture was visually rated on a 1 to 9 scale, where 9 represents extremely fine-texture (narrow leaf blade width) and 1 represents very coarse texture (wide leaf blade width).

Results and Discussion

Turf quality. There were significant differences in seasonal average turf quality among bentgrass cultivars in 2009 (Table 1). In addition, there were significant differences in turf quality among cultivars in each month. In April, which was only six months following seeding, the top performing cultivars that are commercially available were Penn G-2, Authority, Crystal Bluelinks, MacKenzie, CY-2, Declaration, Penn G-1, Penncross, Shark, and Villa. Although these cultivars were the fastest to approach an acceptable level of turf quality following seeding, by the end of the growing season many were no longer among the top cultivars with regard to turf quality. In September, at approximately one year following seeding, the top performing cultivars that are commercially available were Tyee, T-1, Shark, CY-2, Authority, Penn G-6, MacKenzie, Declaration, and Alpha. At that time the two velvet bentgrass cultivars, SR 7200 and Villa, had significantly lower quality than all of the other cultivars in the trial. Early results from this trial and results from previous trials (Karcher et al., 2008) suggest that velvet bentgrass is not well-adapted to Arkansas. When averaging turf quality across the 2009 season, the top performing cultivars that are commercially available were Shark, Authority, MacKenzie, Penn G-2, CY-2, Penn G-6, Declaration, and Tyee.

Turf color. There were significant differences in color among bentgrass cultivars on the 25 September 2009 evaluation date (Table 2). Average color for the cultivars ranged from a high of 9.0 for T-1 to a low of 5.0 for SR 7200. No other cultivars were as dark as T-1. Of the remaining commercially-available cultivars, Alpha, CY-2, Tyee, and Shark had the darkest green color. On average, the creeping bentgrass cultivars had significantly darker color than the two velvet bentgrass cultivars, which were the bottom two cultivars with regard to dark green color. The ten cultivars with the darkest green color were all either relatively new releases (within the last 10 years) or experimental varieties, indicating that breeding efforts have been successful in producing darker green color in bentgrass varieties.

Turf texture. There were significant differences in leaf texture among bentgrass cultivars on the 25 September 2009 evaluation date (Table 2). Cultivar leaf texture ratings ranged from a high of 8.7 for Villa to a low of 5.8 for Penncross. The two velvet bentgrass cultivars, Villa and SR 7200 had the finest leaf texture. However, these cultivars do not seem to be well-adapted to Arkansas, based on their poor turf quality throughout 2009 (Table 1). Among the creeping bentgrass cultivars with the finest leaf texture, those that are commercially available include Shark, Tyee, and T-1 (Table 2). It is important to note that the turf evaluated in this trial was less than one year old and that the relative texture of the cultivars is likely to change as this trial is evaluated over the next several years as the turf matures. Similar to the color evaluations, all of the top creeping bentgrass cultivars with regard to fine-leaf texture are newer releases or experimental cultivars, indicating the successful breeding efforts in producing finer-leaf textures in creeping bentgrass.

Significant differences exist among creeping bentgrass cultivars in turfgrass quality, color, and texture. Many of the newer cultivars have improved quality components, especially when compared to older cultivars, like Penncross. It is important to note that these data represent only a few rating dates during the first full growing season for these cultivars. There are likely to be shifts in how the cultivars rank in quality, color, and texture as they mature. As such, this trial will continue to be evaluated over the next several growing seasons.

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Summerford, J., D. Karcher, M. Richardson, and A. Patton 2009. Summary of the 2008 NTEP bentgrass putting green trial-establishment. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:132-136.

Table 1. Turf quality ratings throughout the 2009 growing season for creeping and velvet bentgrass cultivars in the 2008 NTEP Bentgrass Putting Green Trial. Cultivars are listed by rank, from best to worst quality when averaged across the season.

Entry	Species	April	May	June	July	Aug.	Sept.	Avg.
		Turfgrass quality (1 to 9 scale)						
V8[z]	Creeping	5.3	7.7	7.3	7.8	7.8	8.2	7.4
A08-TDN2[z]	Creeping	5.0	7.5	7.7	7.7	8.0	8.0	7.3
Shark[y]	Creeping	5.3	7.7	7.2	7.3	7.8	7.7	7.2
Authority	Creeping	6.3	7.3	7.2	7.3	7.2	7.5	7.1
PST-OJO[z]	Creeping	4.3	7.3	8.0	6.8	7.7	7.8	7.0
MacKenzie[y]	Creeping	5.7	7.2	6.7	7.3	7.5	7.3	6.9
CY-2[y]	Creeping	5.7	6.7	6.7	7.2	7.5	7.7	6.9
MVS-AP-101[z]	Creeping	5.3	7.5	7.0	7.7	6.0	7.8	6.9
Penn G-2[y]	Creeping	6.3	6.8	6.8	7.3	7.2	6.8	6.9
SRP-1GMC[z]	Creeping	5.0	7.3	7.2	7.0	7.0	7.3	6.8
Declaration	Creeping	5.7	7.5	6.7	6.7	6.8	7.3	6.8
Penn G-6[y]	Creeping	4.7	7.7	7.2	6.7	7.2	7.3	6.8
Tyee[y]	Creeping	4.0	6.5	6.7	7.3	7.8	8.0	6.7
Crystal Bluelinks[y]	Creeping	5.7	7.0	6.8	6.7	6.8	7.0	6.7
T-1	Creeping	4.3	7.0	6.7	7.2	7.2	7.7	6.7
Penn A-4[y]	Creeping	5.0	6.8	6.5	7.3	7.2	7.0	6.6
LTP-FEC[z]	Creeping	5.0	7.0	6.7	6.7	6.8	7.3	6.6
Alpha	Creeping	4.7	6.7	6.8	7.0	6.5	7.2	6.5
HTM[z]	Creeping	4.3	7.2	6.5	6.7	7.0	7.2	6.5
Penn A-1	Creeping	4.7	6.7	6.7	6.8	7.0	7.0	6.5
Penn G-1[y]	Creeping	5.3	6.8	6.2	7.2	6.5	6.7	6.4
AFM[z]	Creeping	4.7	6.7	6.3	6.8	7.0	7.0	6.4
L-93	Creeping	5.0	6.5	6.0	6.7	6.5	6.5	6.2
SRP-1BLTR3[z]	Creeping	5.0	6.2	6.0	6.3	6.5	7.0	6.2
Penn A-2	Creeping	5.0	6.7	6.0	6.3	6.3	6.5	6.1
Crenshaw[y]	Creeping	5.0	6.0	5.8	6.5	6.5	6.2	6.0
SR 1020[y]	Creeping	5.3	6.3	5.3	6.3	5.7	5.8	5.8
Penncross	Creeping	5.3	5.5	4.8	6.5	5.5	5.8	5.6
Villa	Velvet	5.3	7.0	5.8	3.8	3.8	4.3	5.0
SR 7200	Velvet	3.0	4.8	3.5	2.2	1.5	1.7	2.8
	$LSD_{(0.05)}$[x]	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*1.0*	*0.6*

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

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

[x] Fisher's protected least significant difference value (α = 0.05).

Table 2. Turf color and texture ratings for creeping and velvet bentgrass cultivars in the 2008 NTEP Bentgrass Putting Green Trial. Evaluations were done on 25 September 2009.

Entry	Species	Color	Texture
		—— Rating value (9=high, 1=low) ——	
V8[z]	Creeping	8.0	7.7
A08-TDN2[z]	Creeping	6.7	7.0
Shark[y]	Creeping	7.8	7.0
Authority	Creeping	6.2	7.2
PST-OJO[z]	Creeping	6.7	6.3
MacKenzie[y]	Creeping	6.5	6.8
CY-2[y]	Creeping	7.3	7.3
MVS-AP-101[z]	Creeping	6.8	7.3
Penn G-2[y]	Creeping	8.0	7.3
SRP-1GMC[z]	Creeping	7.0	6.3
Declaration	Creeping	7.2	7.0
Penn G-6[y]	Creeping	6.7	7.3
Tyee[y]	Creeping	6.7	7.7
Crystal Bluelinks[y]	Creeping	6.3	6.8
T-1	Creeping	6.3	6.7
Penn A-4[y]	Creeping	7.0	6.8
LTP-FEC[z]	Creeping	6.3	6.7
Alpha	Creeping	6.0	7.0
HTM[z]	Creeping	7.0	7.2
Penn A-1	Creeping	6.0	5.8
Penn G-1[y]	Creeping	7.2	8.0
AFM[z]	Creeping	7.2	7.7
L-93	Creeping	6.0	6.0
SRP-1BLTR3[z]	Creeping	5.0	8.2
Penn A-2	Creeping	6.8	7.0
Crenshaw[y]	Creeping	7.8	7.0
SR 1020[y]	Creeping	9.0	7.5
Penncross	Creeping	7.3	7.7
Villa	Velvet	6.8	8.0
SR 7200	Velvet	5.3	8.7
	$LSD_{(0.05)}$[x]	*0.7*	*0.6*

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

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

[x] Fisher's protected least significant difference value (α = 0.05).

2007 NTEP Bermudagrass Trial – Year 3 Results

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, seedheads

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Photo by Aaron Patton

Bermudagrass cultivars perform differently in Arkansas.

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 (NTEP) 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, turf density, and seedhead formation were collected during 2009. Average turf quality across months for the year was highest for Premier, OKC 1119, Tiftsport, Tifway, Patriot, Tifgreen, SWI-1113, Tift-11, Midlawn, OKC 1134, OKS 2004-2, and SWI-1057. Turf quality for the year was lowest for PSG-91215, PSG-94524, Sunsport, and Numex Sahara, which is similar to 2008 data. Evaluations over the next two years will provide a more complete picture of cultivars that perform best under these management and climate conditions.

Abbreviations: NTEP, National Turfgrass Evaluation Program

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

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 2009 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 2007 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/1000ft^2. Plots were maintained under lawn, sports field, and golf course rough conditions, with a mowing height of 1.5 inch, and monthly applications of 1.0 lb N/1000ft^2 during the growing season. Irrigation was applied as needed to prevent drought stress.

Overall turf quality was evaluated monthly during the growing season. 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. 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

Spring green-up was similar among vegetatively established cultivars and seeded cultivars when evaluated in April (Table 1). Spring green-up was greatest for a large group of cultivars including PSG 9Y2O, Riviera, Premier, RAD-CD1, PSG 91215, OKC 1134, SWI-1083, IS-CD10, GN-1, PSG 94524, OKS 2004-2, SWI-1117, SWI-1081, PSG 9BAN, Tifgreen, SWI-1070, SWI-1122, PSG PROK, SWI-1113, J-720, and OKC 1119 and least for Patriot, BAR 7CD5, Princess 77, Celebration, Tift-11, and Veracruz.

Turf density was highest for cultivars established vegetatively compared to those established by seed (Table 1). Turfgrass density was greatest for OKC 1119 and OKC 1134 and least for PSG 9BAN, SWI-1083, PSG 94524, Sunsport, BAR 7CD5, PSG-91215, and Numex Sahara.

Seed heads were present in greatest quantities for Tift-11 (Table 1). No seed heads were present in OKC 1134 or Patriot, and few seed heads were present in OKC-1119, Premier, and GN-1 (Table 1). As expected, cultivars established by seed had more seed heads present than those established vegetatively, although some vegetatively established cultivars such as Tift-11 did produce high numbers of seed heads.

On four of the five rating dates in 2009 and when averaged over the year, turf quality was statistically higher for vegetatively established cultivars (Table 2). However, turf quality was similar among establishment types in August. Turf quality in 2009 varied for each cultivar by month. Average turf quality across months for the year was highest for Premier, OKC 1119, Tiftsport, Tifway, Patriot, Tifgreen, SWI-1113, Tift-11, Midlawn, OKC 1134, OKS 2004-2, and SWI-1057. Among this top grouping, SWI-1113, OKS 2004-2, and SWI-1057 were the only seeded common bermudagrass cultivars. The seeded bermudagrass cultivar SWI-1113 is the only one of these seeded bermudagrass cultivars to be statistically similar to the top performing cultivar in all three years. Turf quality for the year was lowest for PSG-91215, PSG-94524, Sunsport, and Numex Sahara similar to 2008.

These ratings were collected on two-year old plots and should be reliable, but use caution as shifts in cultivar performance are typical in these trials as the plots age and are subjected to various stresses. Additionally, these plots are maintained at 1.5 inch, 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 two years will provide a more complete picture of the cultivars that perform best under these management and climate conditions.

Literature Cited

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Table 1. Spring green-up, density, and seed head ratings in 2009 for various bermudagrass cultivars in Fayetteville, Ark.

	Spring green-up [z]	Density [y]	Seed heads [x]
Cultivar	April 30	July 31	June 23
	------------------visually rated on a 1-9 scale------------------		
BAR 7CD5 [w]	5.3	4.3	5.0
Celebration	5.0	7.0	4.7
GN-1	6.7	6.7	8.0
IS-01-201 [w]	6.0	6.0	4.7
IS-CD10 [w]	6.7	6.0	5.7
J-720 [w]	6.3	5.3	6.0
Midlawn	5.7	7.0	5.0
NuMex -Sahara [w]	6.0	4.0	7.3
OKC 1119	6.3	9.0	8.3
OKC 1134	7.0	8.3	9.0
OKS 2004-2 [w]	6.7	6.0	5.3
Patriot	5.3	7.3	9.0
Premier	7.3	7.7	8.7
Princess 77 [w]	5.3	6.3	5.0
PSG 91215 [w]	7.0	4.0	6.7
PSG 94524 [w]	6.7	5.0	6.0
PSG 9BAN [w]	6.7	5.0	4.7
PSG 9Y2O [w]	7.3	6.7	5.7
PSG PROK [w]	6.3	5.7	6.3
PST R6EY [w]	6.0	5.3	4.3
PST R6LA [w]	5.7	5.3	3.3
PST R6ON [w]	5.7	6.0	3.7
PST-R6FLT [w]	6.0	7.0	3.3
Quickstand	6.0	6.7	6.0
RAD-CD1 [w]	7.0	5.7	5.7
Riviera [w]	7.3	6.0	5.7
Sunsport [w]	5.7	4.3	5.7
SWI-1057 [w]	5.7	6.7	4.7
SWI-1070 [w]	6.3	6.0	4.3
SWI-1081 [w]	6.7	5.7	5.3
SWI-1083 [w]	7.0	5.0	4.7
SWI-1113 [w]	6.3	7.3	5.3
SWI-1117 [w]	6.7	5.3	6.7
SWI-1122 [w]	6.3	5.3	6.0
Tifgreen	6.7	7.7	6.7
Tifsport	6.0	7.7	7.3
Tift-11	4.3	6.7	2.0
Tifway	6.0	7.7	7.3
Veracruz [w]	4.3	6.3	5.0
Yukon [w]	5.7	6.0	5.0
Average	6.2	6.2	5.7
LSD (P=0.05)	1.0	1.0	1.1
Propagation type			
Seeded	6.2	5.6	5.3
Vegetative	6.0	7.4	6.8
P – value	0.24	<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] Density was rated on a scale of 1 to 9, with 9 representing maximum density.

[x] Seed-head density was evaluated using a scale of 1 to 9, with 9 representing no visible seed heads.

[w] Seeded bermudagrass cultivar.

Table 2. Turf quality ratings in 2009 for various bermudagrass cultivars in Fayetteville, Ark.

	Turfgrass quality [z]					
Cultivar	May	June	July	August	September	Average
	---visually rated on a 1-9 scale---					
OKC 1119	7.0	7.0	7.0	7.3	7.0	7.1
Premier	7.7	7.0	6.7	7.7	6.7	7.1
Tifsport	6.0	7.0	7.0	8.0	7.3	7.1
Tifway	6.3	7.3	7.0	7.7	7.0	7.1
Patriot	6.3	7.3	6.3	7.7	7.3	7.0
Tifgreen	6.3	7.0	6.7	7.3	7.0	6.9
SWI-1113 [y]	5.3	7.0	7.3	7.7	6.7	6.8
Midlawn	5.7	7.0	7.0	7.3	6.3	6.7
OKC 1134	5.7	6.3	6.7	7.3	7.3	6.7
OKS 2004-2 [y]	5.0	6.7	6.7	8.0	7.0	6.7
SWI-1057 [y]	5.3	6.3	7.3	7.7	6.7	6.7
Tift-11	6.0	6.0	6.7	7.7	7.3	6.7
GN-1	6.0	7.0	6.3	7.3	6.3	6.6
Riviera [y]	4.7	6.7	6.7	7.7	7.3	6.6
Yukon [y]	5.0	6.7	7.0	8.0	6.3	6.6
Celebration	5.3	6.7	6.3	7.0	7.0	6.5
PSG 9Y2O [y]	4.3	6.3	7.3	7.7	6.7	6.5
Quickstand	5.3	6.7	6.7	7.7	6.0	6.5
Princess 77 [y]	4.7	6.0	6.7	7.7	6.7	6.3
SWI-1122 [y]	5.0	6.7	6.7	7.0	6.0	6.3
J-720 [y]	4.0	6.3	6.7	7.3	6.7	6.2
Veracruz [y]	4.0	6.0	6.7	7.7	6.7	6.2
PSG 9BAN [y]	4.3	6.0	6.0	7.7	6.3	6.1
RAD-CD1 [y]	4.7	6.0	6.7	7.3	6.0	6.1
SWI-1070 [y]	4.0	6.0	6.7	7.7	6.3	6.1
IS-01-201 [y]	5.0	5.3	6.3	7.3	6.0	6.0
PST R6LA [y]	4.7	6.0	6.3	6.7	6.3	6.0
PST-R6FLT [y]	5.0	6.0	6.3	6.7	6.0	6.0
IS-CD10 [y]	4.7	6.0	6.0	7.0	6.0	5.9
PST R6ON [y]	4.3	5.7	6.7	6.7	6.0	5.9
SWI-1081 [y]	4.0	5.7	6.3	7.3	6.3	5.9
PST R6EY [y]	4.7	5.3	5.7	7.0	6.3	5.8
SWI-1083 [y]	4.0	5.0	6.0	7.3	6.7	5.8
SWI-1117 [y]	4.7	5.7	5.7	7.7	5.3	5.8
PSG PROK [y]	4.0	5.7	5.7	7.0	6.0	5.7
BAR 7CD5 [y]	3.3	5.7	5.3	7.0	6.0	5.5
PSG 94524 [y]	3.7	5.0	6.0	7.0	5.3	5.4
Sunsport [y]	3.7	5.0	5.0	7.3	5.0	5.2
PSG 91215 [y]	3.7	5.0	5.0	6.3	5.0	5.0
NuMex -Sahara [y]	3.3	4.7	5.0	6.7	5.0	4.9
Average	4.9	6.2	6.4	7.4	6.4	6.2
LSD (P=0.05)	0.8	0.9	0.9	0.8	0.8	0.4
Propagation type						
Seeded	4.4	5.9	6.3	7.3	6.2	6.0
Vegetative	6.1	6.9	6.7	7.5	6.9	6.8
P - value	<0.0001	<0.0001	0.0067	0.07	0.0059	0.0025

[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 3 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

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Photo by Aaron Patton

Seashore paspalum is a relatively new turfgrass being evaluated for use in Arkansas.

Summary. Seashore paspalum is a relatively 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 (NTEP) is the predominant means by which cultivars are tested throughout North America. A seashore paspalum cultivar trial was planted in the summer of 2007 in Fayetteville, Ark. This trial is maintained under typical golf course fairway conditions and data on spring green-up, winterkill, coverage, overall quality, leaf color, and fall color retention were collected in 2009. Overall, there are subtle differences between the turf quality of the cultivars, and they all perform similarly and provide acceptable turf quality in Northwest Arkansas. 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

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

Several 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 2009 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/1000ft^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/1000ft^2 during the growing season. Irrigation was applied as needed to prevent drought stress.

Turf quality was evaluated monthly on a 1 to 9 scale, with 9 representing ideal dark green, uniform, fine-textured turf and 1 representing dead turf. Turfgrass coverage was monitored on 21 July as a visual estimate. 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. Fall color retention was evaluated on a scale of 1 to 9, with 9 representing turf with green coverage and 1 representing tan or brown turf. Cultivars were visually evaluated for spring green-up in April using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand. Winterkill was monitored in the spring with visual estimates of the percent of the plots that was dead and did not green-up after winter. Density was rated on a scale of 1 to 9, with 9 representing maximum density.

Results and Discussion

Spring green-up was greatest for UGA 22, Salam, and Seaspray (Table 1). Spring green-up was slowest for UGA 31, SeaIsle 1, UGA 7, and SRX9HSCP. There was up to 23% winterkill in some plots in the spring of 2009, but there was no difference in winterkill among cultivars or in July coverage of these cultivars following winter injury (Table 1). Air temperatures were as low as 8 °F during the winter (Richardson and Stiegler, 2010). This trial was planted in Fayetteville, Ark., which will help determine the northern adaptation of this turf species as well as determine if there are differences in winter hardiness among cultivars. Although there was little winterkill in 2008 or 2009, seashore paspalum is not thought to be well-adapted to Northwest Arkansas based on previous work with this species in Fayetteville. Additionally, there has not been significant winter damage in Arkansas since 2001 as a significant winterkill event typically occurs only once every ten years.

Turfgrass genetic color was darkest green for UGA 31 and least green for Salam, SRX9HSCP, UGA 22, Seaspray, and Sea Isle 1 (Table 1). Fall color retention and turf density were similar among the cultivars in October (Table 1).

There were no differences in turf quality among cultivars in May, June, August, or September 2009, but there were differences in turf quality among cultivars in July 2009 (Table 2). In July, turf quality was greatest for UGA 7, UGA 22, and UGA 31. Overall, there were subtle differences between the turf quality of the cultivars, and they all perform similarly at producing acceptable turf quality during the summer months in Northwest Arkansas.

These ratings were collected on plots that were two years old and should be reliable, but shifts in cultivar performance are typical in these trials as the plots age and are subjected to various stresses. Future rating over the next two years will provide a more complete picture of the cultivars that perform best under these management conditions in our climate and whether this turf species will be a viable option for Arkansas golf courses.

Literature Cited

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Table 1. Seashore paspalum spring green-up, winterkill, coverage, color, fall color retention, and density for various cultivars in Fayetteville, Ark. in 2009.

Cultivar	Spring green-up [z] April 30	Winterkill [y] April 30	Coverage July 21	Color [x] July 18	Fall color retention [w] October 28	Density [v] June 23
	-1-9 scale-	----------------%----------------		---------visually rated on a 1-9 scale---------		
Salam	5.3	23	95	6.7	6.3	5.7
Sea Isle 1	4.0	22	96	6.3	6.0	6.7
Seaspray [u]	5.7	15	97	6.3	6.0	6.0
SRX9HSCP [u]	4.7	18	96	6.3	6.0	6.7
UGA 22	6.0	13	98	6.3	6.3	6.7
UGA 31	4.0	20	97	8.0	6.3	7.0
UGA 7	4.3	10	97	7.3	6.3	7.0
Average	4.9	17	97	6.8	6.2	6.5
LSD (P=0.05)	1.2	NS	NS	0.5	NS	NS

[z] Spring green-up was visually evaluated using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand.
[y] Winterkill was visually evaluated as the percent of the plot that did not green-up in the spring.
[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] Fall color retention was rated on a scale of 1 to 9, with 9 representing maximum green cover.
[v] Density was rated on a scale of 1 to 9, with 9 representing maximum density.
[u] Seeded seashore paspalum cultivar.

Table 2. Seashore paspalum turf quality ratings for various cultivars in Fayetteville, Ark. in 2009.

Cultivar	Turfgrass quality [z] May	June	July	August	September	Mean
	----------visually rated on a 1-9 scale----------					
UGA 31	5.0	6.0	7.3	7.7	7.7	6.7
UGA 7	5.0	6.0	7.3	7.3	7.7	6.7
UGA 22	4.3	5.7	6.7	8.0	7.7	6.5
Sea Isle 1	4.7	5.3	6.0	7.3	7.0	6.1
Seaspray [y]	4.3	5.7	6.0	7.3	7.3	6.1
SRX9HSCP [y]	4.0	5.3	6.3	7.3	7.7	6.1
Salam	3.7	5.0	6.0	7.3	7.0	5.8
Average	4.4	5.6	6.5	7.5	7.4	6.3
LSD (P=0.05)	NS	NS	0.9	NS	NS	NS

[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.

2007 Arkansas Zoysiagrass Trial – Year 3 Results

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Additional index words: *Zoysia japonica*, *Zoysia matrella*, Manilagrass, Japanese lawngrass, turfgrass, cultivars, quality, color, spring green-up, leaf texture, seed heads

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Photo by Aaron Patton

Spring green-up is just one factor that varies by zoysiagrass cultivar.

Summary. Zoysiagrass has become an increasingly popular turfgrass for golf courses and home lawns in Arkansas due to its excellent turfgrass quality, persistence under adverse conditions, and low maintenance requirements. A zoysiagrass cultivar trial was planted in the summer of 2007 at Fayetteville, Ark. and was maintained under typical golf course fairway conditions. Data on spring green-up, winterkill, mowing quality, texture, color, and overall quality were collected in 2009. When analyzed across dates, Himeno, Meyer, and Victoria had the highest turf quality and Compadre and Zenith had the lowest turf quality among *Zoysia japonica* cultivars and PristineFlora and Diamond had the highest turf quality among *Zoysia matrella* cultivars. Results from this study are intended to help residents of Arkansas make informed decisions when selecting turfgrass cultivars. Planting well-adapted cultivars will improve turfgrass quality, and reduce reestablishment costs from winterkill or drought and ultimately increase sustainability.

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Zoysiagrass (*Zoysia japonica* and *Zoysia matrella*) has become an increasingly popular turfgrass for golf courses and home lawns in the transition zone due to its excellent turfgrass quality, persistence under adverse conditions, and low maintenance requirements. Currently, approximately 13% of lawns in Arkansas are zoysiagrass (Patton, 2009). The popularity of the species is due to its enhanced cold tolerance, slow growth rate, and competitiveness against weeds. Until recently, most of the zoysiagrass used in the United States and Arkansas has been the cultivar Meyer (sometimes referred to as Meyers or Z-52) which was first introduced in the 1950s. However, in the past twenty years, new germplasm has been collected and released and is starting to be used more frequently in the turfgrass industry.

An integral part of the turfgrass research program at the University of Arkansas is the testing of new and improved cultivars of turfgrass for adaptation to this geographic region. Arkansas was not chosen as an official location for the 2007 Zoysiagrass Trial with the National Turfgrass Evaluation Program; so researchers at the University of Arkansas obtained plant material of cultivars commonly used in Arkansas, other commercially available cultivars, and some experimental cultivars from Texas A&M University to evaluate the adaptability of these cultivars in Arkansas. The following report summarizes 2009 data from our 2007 Arkansas zoysiagrass cultivar evaluation trial at Fayetteville, Ark.

Materials and Methods

The entries were planted on 7 August 2007 at the University of Arkansas Research and Extension Center in Fayetteville. Plot size was 5 by 5 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/1000ft^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/1000ft^2 during the growing season. Irrigation was applied as needed to prevent moderate drought stress.

Overall turf quality was evaluated monthly beginning May 2009. 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. 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. 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. Winterkill was monitored in the spring with visual estimates of the percent of the plots that did not green-up after winter. Density was rated on a scale of 1 to 9, with 9 representing maximum density. 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. Mowing quality was rated using a 1 to 9 scale, with 9 representing optimum mowing quality and a clean cut of the leaf blades and 1 representing a poor mowing quality with a substantial level of shredded leaf blades. When differences were analyzed between or by species, Emerald (*Z. japonica* x. *Z. pacifica*) was grouped with *Z. matrella* because it is similar in color, texture, and density with *Z. matrella*.

Results and Discussion

The majority of zoysiagrass cultivar evaluation trials, including the National Turfgrass Evaluation Program, include both *Zoysia matrella* (Manilagrass or zoysiagrass) and *Zoysia japonica* (Japanese lawngrass or zoysiagrass) cultivars. *Zoysia matrella* has a distinct visual appearance mainly due to the narrower leaf blades compared to *Z. japonica*. As a result it is often difficult to compare the visual turf quality when rating among species since their appearance and their texture can skew the data towards *Z. matrella* cultivars having higher turf quality ratings. Additionally, turf managers who are searching cultivar evaluation trial data for a new cultivar to plant at their location typically are interested in either a finer (leaf) bladed cultivar or a coarse (leaf) bladed cultivar. Therefore, these results are analyzed across species and within species to allow useful comparisons for those wanting information about various zoysiagrass cultivars.

Across Species. Spring green-up was highest for Diamond, Emerald, Meyer, Royal, UltimateFlora and Zorro on both collection dates (30 March and 30 April) in 2009 (Table 1). Spring green-up was similar among species on these dates in April 2009. Spring green-up was lowest for Shadowturf on both dates and for Shadowturf and DALZ 0701 in 2009 and both of these cultivars had >31% winterkill when evaluated in May 2009 although both recovered by July 2009 (data not shown). Air temperatures were as low as 8 °F during the winter (Richardson and Stiegler, 2010). This trial was planted in Fayetteville, Ark. to help better determine if there were differences in winter hardiness among cultivars. Although there was little winterkill in 2009, some cultivars are not thought to be well-adapted to Northwest Arkansas based on previous research in Fayetteville (M.D. Richardson, data unpublished).

Turf color was highest (darkest green) among Himeno and Meyer, and least (yellow-green) among Cavalier, DALZ0102, Palisades, UltimateFlora, Victoria, and Zorro on one rating date in July 2009 (Table 1). There was no difference between leaf color of species although *Z. matrella* did have narrower leaves than *Z. japonica*. Leaf texture was highest (fine or narrow leaf blades) for DALZ 0501, DALZ 0701, and Diamond and lowest (coarse or wide leaf blades) for Crowne, DALZ 0102, El Toro, Himeno, and Palisades on one rating date in July 2009 (Table 1). In September, between routine adjustments of the mower (reel/bedknife) a visual rating was collected for mowing quality. Mowing quality was highest (cleanly cut leaf blades) for Compadre, Diamond, Himeno, Meyer, PristineFlora, and Zenith and lowest (shredded leaf blades) among Cavalier, DALZ 0702, and Zorro (Table 1). Mowing quality was significantly better for *Z. japonica* than *Z. matrella*.

Turf quality varied across the collection dates (May, June, July, August, September) (Table 2). Cavalier, DALZ 0102, Diamond, PristineFlora, and Royal had the highest turf quality in May. Throughout the trial, DALZ 0701 had the lowest turf quality from what appeared to be damage from take-all root rot (*Gaeumannomyces graminis* var. *graminis*). However, this disease did not appear to be present at significant levels in any of the other cultivars. Cavalier, DALZ 0501, DALZ 0702, Diamond, Emerald, PristineFlora, Royal, and Victoria had the highest turf quality in June. Meyer zoysiagrass was the only cultivar suffering mild drought stress during the June rating, which contributed to a decreased June turf quality rating, although Meyer was among the top group in July, August, and September. July turf quality was highest for DALZ 0501, Diamond, Meyer, PristineFlora, and Shadowturf. August turf quality was highest for Diamond, Himeno, Meyer, PristineFlora, Shadowturf, and Victoria. These same cultivars, with the exception of Shadowturf and Victoria, had the highest turf quality in September. When analyzed across dates, Diamond and PristineFlora had the highest turf quality.

Zoysia japonica. Spring green-up was highest for Compadre, El Toro, Meyer, UltimateFlora and Victoria and lowest for Himeno on 30 March 2009 (Table 3). Spring green-up was similar among all cultivars on 30 April 2009 and there was no difference in the winterkill among *Z. japonica* cultivars in 2009. *Zoysia japonica* cultivars are more winter hardy than *Z. matrella* (Patton and Reicher, 2007) and all *Z. japonica* cultivars should be adapted to Northwest Arkansas. However, there has not been significant winter damage in Arkansas since 2001 as a significant winterkill event typically occurs only once every ten years and there are known differences among the winter hardiness of *Z. japonica cultivars* (Patton and Reicher, 2007).

Turf color was highest (darkest green) among Himeno and Meyer, and least (yellow-green) among DALZ0102, El Toro, Palisades, UltimateFlora, and Victoria on one rating date in July 2009 (Table 3). Leaf texture was highest (fine or narrow leaf blades) for Meyer, Victoria, and UltimateFlora and lowest (coarse or wide leaf blades) Crowne, DALZ 0102, El Toro, Himeno, and Palisades on one rating date in July 2009 (Table 3). Mowing quality was highest (cleanly cut leaf blades) for Compadre, El Toro, Himeno, Meyer, Palisades, and Zenith and lowest (shredded leaf blades) among Crowne, DALZ 0102, UltimateFlora, and Victoria (Table 3).

Turf quality varied across the collection dates (May, June, July, August, September). Himeno, Meyer, UltimateFlora, and Victoria had the highest turf quality in May, whereas Compadre, Crowne, and Zenith had the lowest turf quality (Table 4). Victoria had the highest turf quality in June with Compadre and Zenith having the lowest turf quality. July turf quality was highest for Himeno, Meyer, and Victoria with all other cultivars in the lowest statistical group. August turf quality was highest for Crowne, Himeno, Meyer, Palisades, UltimateFlora, and Victoria. Meyer and Himeno had the highest turf quality in September. When analyzed across dates, Himeno, Meyer, and Victoria had the highest turf quality and Compadre and Zenith had the lowest turf quality. Compadre and Zenith are the only two cultivars in this trial that can be established by seed. These cultivars are more commonly used in lawns in Arkansas at mowing heights higher than 0.5 inches or in the northern transitional climatic zone (between warm-humid and cool-humid climates) or areas north of the transition zone because of their excellent winter hardiness (Patton and Reicher, 2007).

Zoysia matrella. Spring green-up was highest for Diamond, Emerald, Royal, and Zorro on both collection dates (30 March and 30 April) in 2009 (Table 5). Shadowturf and DALZ 0701 had >31% winterkill measured on May 2009 although both recovered by July 2009 (data not shown). Air temperatures were as low as 8 °F during the winter (Richardson and Stiegler, 2010). *Zoysia japonica* cultivars are more winter hardy than *Z. matrella*, and there are known differences among the winter hardiness of *Z. matrella* cultivars (Patton and Reicher, 2007). Observations in Fayetteville, Ark. in previous years and previous research (Patton and Reicher, 2007) would suggest that winter injury might be expected for other *Z. matrella* cultivars as well such as Diamond. Future evaluations may help determine which *Z. matrella* cultivars are best suited for Arkansas.

There were no differences in turf color among *Z. matrella* cultivars (Table 5). Leaf texture was highest (fine or narrow leaf blades) for Diamond and lowest (wider leaf blades) for Cavalier, Emerald, Royal, Shadowturf, and Zorro on one rating date in July 2009 (Table 5). Mowing quality was highest (cleanly cut leaf blades) for Diamond and PristineFlora and lowest (shredded leaf blades) among Cavalier, DALZ 0702, Royal, and Zorro (Table 5). Mowing quality was likely high for Diamond and PristineFlora because these cultivars have a slower growth rate.

Turf quality varied across the collection dates (May, June, July, August, September). Cavalier, DALZ 0702, Diamond, PristineFlora, and Royal had the highest turf quality in May (Table 6). Throughout the trial, DALZ 0701 had the lowest turf quality from what appeared to be damage from take-all root rot. However, this disease did not appear to be present at significant levels in any of the other *Z. matrella* cultivars. Cavalier, DALZ 0501, DALZ 0702, Diamond, Emerald, PristineFlora, and Royal had the highest turf quality in June. July and August turf quality was highest for Diamond, PristineFlora, and Shadowturf. Diamond and PristineFlora had the highest turf quality in September. When analyzed across dates, Diamond and PristineFlora had the highest turf quality.

Summary

In the early 1990s, Meyer was the main zoysiagrass cultivar being grown in Arkansas. Although Meyer is still produced at 25 sod farms in Arkansas (Patton et al., 2008), there are now ten other cultivars being grown in Arkansas, including Cavalier, Crowne, Diamond, Empire, El Toro, Empire, Himeno, Matrella (FC13521), Palisades, and Zorro. Some of these cultivars have improved characteristics or turf quality over Meyer zoysiagrass, but Meyer remains among the top performing *Z. japonica* cultivars in Arkansas and the transition zone. Results from this study are intended to help residents of Arkansas make informed decisions when selecting turfgrass cultivars. Planting well-adapted cultivars will improve turfgrass quality, and reduce reestablishment costs from winterkill or drought and ultimately increase sustainability.

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Table 1. Spring green-up, winterkill, color, leaf texture, and mowing quality ratings in 2009 for various zoysiagrass cultivars in Fayetteville, Ark.

Cultivar	Species	Spring green-up [z] March 30	Spring green-up [z] April 30	Winterkill [y]	Color [x]	Texture [w]	Mowing quality [v]
		-------1-9 scale-------		-----%-----	-------visually rated on a 1-9 scale-------		
Cavalier	*Z. matrella*	4.0	9.0	0.0	6.0	7.0	4.0
Compadre	*Z. japonica*	4.7	8.0	0.0	7.0	5.0	7.0
Crowne	*Z. japonica*	3.7	7.3	5.0	6.7	4.3	6.0
DALZ 0102	*Z. japonica*	4.0	8.3	0.0	5.3	3.7	6.0
DALZ 0501	*Z. matrella*	3.3	7.7	5.0	6.7	8.3	5.0
DALZ 0701	*Z. matrella*	3.0	5.7	31.7	6.3	8.3	5.3
DALZ 0702	*Z. matrella*	3.3	8.0	5.0	6.3	7.7	4.3
Diamond	*Z. matrella*	4.7	8.3	0.0	7.0	9.0	7.0
El Toro	*Z. japonica*	5.0	8.0	0.0	6.3	4.0	6.3
Emerald [u]	*Z. matrella*	4.7	8.3	1.7	6.3	7.0	6.0
Himeno	*Z. japonica*	2.0	8.0	3.3	8.0	4.3	6.7
Meyer (Z-52)	*Z. japonica*	4.7	8.7	0.0	7.7	5.7	7.0
Palisades	*Z. japonica*	4.3	8.3	0.0	6.0	4.0	6.3
PristineFlora	*Z. matrella*	3.7	7.7	5.0	6.7	8.0	7.3
Royal	*Z. matrella*	5.0	9.0	0.0	6.3	7.0	4.7
Shadowturf	*Z. matrella*	1.7	5.0	33.3	7.0	7.3	6.0
UltimateFlora	*Z. japonica*	5.3	9.0	0.0	5.7	6.0	5.7
Victoria	*Z. japonica*	5.0	7.7	0.0	5.7	6.0	5.3
Zenith	*Z. japonica*	4.0	7.7	0.0	7.0	5.0	6.7
Zorro	*Z. matrella*	5.0	9.0	0.0	6.0	7.0	3.7
Average		4.1	7.9	4.5	6.5	6.2	5.8
LSD (P=0.05)		0.7	0.8	7.3	0.7	0.8	0.8
	Z. japonica	4.3	8.1	0.8	6.5	4.8	6.3
	Z. matrella	3.8	7.8	8.1	6.5	7.7	5.3
P – value		NS	NS	0.0055	NS	<0.0001	0.0007

[z] Spring green-up was visually evaluated for zoysiagrass cultivars using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand.
[y] Winterkill was visually evaluated as the percent of the plot that did not green-up in the spring.
[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] 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.
[v] Mowing quality was rated using a 1 to 9 scale, with 9 representing optimum mowing quality and a clean cut of the leaf blades and 1 representing a poor mowing quality with a substantial level of shredded leaf blades.
[u] Formerly *Zoysia japonica* × *Zoysia tenuifolia*, now *Z. japonica* x. *Z. pacifica*. Emerald was grouped with *Z. matrella* because it is similar in color, texture, and density with other *Z. matrella* cultivars.

Table 2. Turf quality ratings in 2009 for various zoysiagrass cultivars in Fayetteville, Ark.

Cultivar	Species	Turfgrass quality [z]					
		May	June	July	August	September	Average
		------------------------------visually rated on a 1-9 scale------------------------------					
Diamond	*Z. matrella*	7.3	7.7	8.0	8.0	8.0	7.8
PristineFlora	*Z. matrella*	7.0	7.7	8.3	8.0	8.0	7.8
DALZ 0501	*Z. matrella*	6.3	7.0	7.7	7.0	7.0	7.0
Himeno	*Z. japonica*	6.3	6.7	7.3	7.3	7.3	7.0
Cavalier	*Z. matrella*	7.0	7.0	7.0	7.0	6.3	6.9
Emerald [y]	*Z. matrella*	6.7	7.0	7.0	7.0	7.0	6.9
Victoria	*Z. japonica*	6.0	7.7	7.3	7.3	6.3	6.9
DALZ 0702	*Z. matrella*	7.0	7.0	7.3	6.7	6.0	6.8
Meyer (Z-52)	*Z. japonica*	5.7	5.3	7.7	7.3	7.7	6.7
Shadowturf	*Z. matrella*	4.0	6.3	8.0	8.0	7.0	6.7
Zorro	*Z. matrella*	6.7	6.7	7.0	7.0	5.7	6.6
Royal	*Z. matrella*	7.7	7.0	6.3	6.0	5.7	6.5
UltimateFlora	*Z. japonica*	5.7	6.0	6.7	6.7	6.3	6.3
DALZ 0102	*Z. japonica*	5.0	6.3	6.3	6.0	6.3	6.0
Palisades	*Z. japonica*	5.0	5.7	6.3	6.3	6.0	5.9
El Toro	*Z. japonica*	5.0	6.0	6.3	6.0	5.7	5.8
Crowne	*Z. japonica*	4.0	5.3	6.7	6.3	6.3	5.7
Compadre	*Z. japonica*	4.0	4.3	6.0	5.7	6.0	5.2
Zenith	*Z. japonica*	4.0	4.0	6.0	5.3	5.3	4.9
DALZ 0701	*Z. matrella*	3.0	3.3	4.0	3.7	3.3	3.5
Average		5.7	6.2	6.9	6.6	6.4	6.3
LSD (P=0.05)		0.8	0.7	0.8	0.8	0.9	0.4
	Z. japonica	5.1	5.7	6.7	6.4	6.3	6.0
	Z. matrella	6.3	6.7	7.1	6.8	6.4	6.6
P – value		0.0006	0.0038	NS	NS	NS	<0.0105

[z] Turf quality rated on a scale of 1 to 9 (9= ideal dark green, uniform, dense, fine-textured turf, 1=dead).
[y] Formerly *Zoysia japonica* × *Zoysia tenuifolia*, now *Z. japonica* x. *Z. pacifica*. Emerald was grouped with *Z. matrella* because it is similar in color, texture, and density with other *Z. matrella* cultivars.

Table 3. Spring green-up, winterkill, color, leaf texture, and mowing quality ratings in 2009 for various *Zoysia japonica* cultivars in Fayetteville, Ark.

		Spring green-up [z]					
Cultivar	Species	March 30	April 30	Winterkill [y]	Color [x]	Texture [w]	Mowing quality [v]
		-------1-9 scale-------		-----%-----	-------visually rated on a 1-9 scale-------		
Compadre	*Z. japonica*	4.7	8.0	0.0	7.0	5.0	7.0
Crowne	*Z. japonica*	3.7	7.3	5.0	6.7	4.3	6.0
DALZ 0102	*Z. japonica*	4.0	8.3	0.0	5.3	3.7	6.0
El Toro	*Z. japonica*	5.0	8.0	0.0	6.3	4.0	6.3
Himeno	*Z. japonica*	2.0	8.0	3.3	8.0	4.3	6.7
Meyer (Z-52)	*Z. japonica*	4.7	8.7	0.0	7.7	5.7	7.0
Palisades	*Z. japonica*	4.3	8.3	0.0	6.0	4.0	6.3
UltimateFlora	*Z. japonica*	5.3	9.0	0.0	5.7	6.0	5.7
Victoria	*Z. japonica*	5.0	7.7	0.0	5.7	6.0	5.3
Zenith	*Z. japonica*	4.0	7.7	0.0	7.0	5.0	6.7
Average		4.3	8.1	0.8	6.5	4.8	6.3
LSD (P=0.05)		0.89	NS	NS	0.78	0.97	0.78

[z] Spring green-up was visually evaluated for zoysiagrass cultivars using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand.
[y] Winterkill was visually evaluated as the percent of the plot that did not green-up in the spring.
[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] 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.
[v] Mowing quality was rated using a 1 to 9 scale, with 9 representing optimum mowing quality and a clean cut of the leaf blades and 1 representing a poor mowing quality with a substantial level of shredded leaf blades.

Table 4. Turf quality ratings in 2009 for various *Zoysia japonica* cultivars in Fayetteville, Ark.

		Turfgrass quality [z]					
Cultivar	Species	May	June	July	August	September	Average
		------------------------------visually rated on a 1-9 scale------------------------------					
Himeno	*Z. japonica*	6.3	6.7	7.3	7.3	7.3	7.0
Victoria	*Z. japonica*	6.0	7.7	7.3	7.3	6.3	6.9
Meyer (Z-52)	*Z. japonica*	5.7	5.3	7.7	7.3	7.7	6.7
UltimateFlora	*Z. japonica*	5.7	6.0	6.7	6.7	6.3	6.3
DALZ 0102	*Z. japonica*	5.0	6.3	6.3	6.0	6.3	6.0
Palisades	*Z. japonica*	5.0	5.7	6.3	6.3	6.0	5.9
El Toro	*Z. japonica*	5.0	6.0	6.3	6.0	5.7	5.8
Crowne	*Z. japonica*	4.0	5.3	6.7	6.3	6.3	5.7
Compadre	*Z. japonica*	4.0	4.3	6.0	5.7	6.0	5.2
Zenith	*Z. japonica*	4.0	4.0	6.0	5.3	5.3	4.9
Average		5.1	5.7	6.7	6.4	6.3	6.0
LSD (P=0.05)		0.69	0.74	0.96	1.02	1.08	0.54

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

Table 5. Spring green-up, winterkill, color, leaf texture, and mowing quality ratings in 2009 for various *Zoysia matrella* cultivars in Fayetteville, Ark.

Cultivar	Species	Spring green-up[z] March 30	Spring green-up[z] April 30	Winterkill[y]	Color[x]	Texture[w]	Mowing quality[v]
		-------1-9 scale-------		-----%-----	-------visually rated on a 1-9 scale-------		
Cavalier	*Z. matrella*	4.0	9.0	0.0	6.0	7.0	4.0
DALZ 0501	*Z. matrella*	3.3	7.7	5.0	6.7	8.3	5.0
DALZ 0701	*Z. matrella*	3.0	5.7	31.7	6.3	8.3	5.3
DALZ 0702	*Z. matrella*	3.3	8.0	5.0	6.3	7.7	4.3
Diamond	*Z. matrella*	4.7	8.3	0.0	7.0	9.0	7.0
Emerald[u]	*Z. matrella*	4.7	8.3	1.7	6.3	7.0	6.0
PristineFlora	*Z. matrella*	3.7	7.7	5.0	6.7	8.0	7.3
Royal	*Z. matrella*	5.0	9.0	0.0	6.3	7.0	4.7
Shadowturf	*Z. matrella*	1.7	5.0	33.3	7.0	7.3	6.0
Zorro	*Z. matrella*	5.0	9.0	0.0	6.0	7.0	3.7
Average		3.8	7.8	8.1	6.5	7.7	5.3
LSD (P=0.05)		0.59	0.83	9.0	NS	0.59	1.02

[z] Spring green-up was visually evaluated for zoysiagrass cultivars using a scale of 1 to 9, with 9 representing complete green color and 1 representing a completely dormant turf stand.
[y] Winterkill was visually evaluated as the percent of the plot that did not green-up in the spring.
[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] 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.
[v] Mowing quality was rated using a 1 to 9 scale, with 9 representing optimum mowing quality and a clean cut of the leaf blades and 1 representing a poor mowing quality with a substantial level of shredded leaf blades.
[u] Formerly *Zoysia japonica* × *Zoysia tenuifolia*, now *Z. japonica* x. *Z. pacifica*. Emerald was grouped with *Z. matrella* because it is similar in color, texture, and density with other *Z. matrella* cultivars.

Table 6. Turf quality ratings in 2009 for various *Zoysia matrella* cultivars in Fayetteville, Ark.

Cultivar	Species	Turfgrass quality[z] May	June	July	August	September	Average
		------------------------------visually rated on a 1-9 scale------------------------------					
Diamond	*Z. matrella*	7.3	7.7	8.0	8.0	8.0	7.8
PristineFlora	*Z. matrella*	7.0	7.7	8.3	8.0	8.0	7.8
DALZ 0501	*Z. matrella*	6.3	7.0	7.7	7.0	7.0	7.0
Cavalier	*Z. matrella*	7.0	7.0	7.0	7.0	6.3	6.9
Emerald[y]	*Z. matrella*	6.7	7.0	7.0	7.0	7.0	6.9
DALZ 0702	*Z. matrella*	7.0	7.0	7.3	6.7	6.0	6.8
Shadowturf	*Z. matrella*	4.0	6.3	8.0	8.0	7.0	6.7
Zorro	*Z. matrella*	6.7	6.7	7.0	7.0	5.7	6.6
Royal	*Z. matrella*	7.7	7.0	6.3	6.0	5.7	6.5
DALZ 0701	*Z. matrella*	3.0	3.3	4.0	3.7	3.3	3.5
Average		6.3	6.7	7.1	6.8	6.4	6.6
LSD (P=0.05)		0.96	0.73	0.62	0.70	0.81	0.36

[z] Turf quality rated on a scale of 1 to 9 (9= ideal dark green, uniform, dense, fine-textured turf, 1=dead).
[y] Formerly *Zoysia japonica* × *Zoysia tenuifolia*, now *Z. japonica* x. *Z. pacifica*. Emerald was grouped with *Z. matrella* because it is similar in color, texture, and density with other *Z. matrella* cultivars.

Report from the 2006 NTEP Tall Fescue Trial – 2009 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

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Photo by Mike Richardson

Cool-season cultivar trials at Fayetteville, Ark.

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 54 are now commercially-available cultivars, was planted in the fall of 2006 at Fayetteville, Ark. Cultivars were rated for turf color, overall turf quality, and turfgrass coverage several times during the 2009 growing season. The cultivars that rated highest for overall turfgrass quality during the 2009 growing season included Spyder LS, 3rd Millennium SRP, Cezanne RZ, Padre, Speedway, Gazelle II, Justice, and Falcon IV. However, the study experienced relatively mild environmental conditions during the 2009 growing season and very low disease pressure, so many cultivars performed well during this season.

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 2009 performance data, including turfgrass color, turfgrass quality, and turfgrass coverage for the NTEP 2006 National Tall Fescue Test at Fayetteville, Ark.

Materials and Methods

This cultivar experiment is being conducted at the University of 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 pre-plant fertilizer (10-20-20) was applied at 10 lb/1000 ft^2 prior to seeding. One-hundred and thirteen tall fescue cultivars and experimental lines were broadcast planted on 2 Oct. 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 inch 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 is evaluated monthly from March through October, but is presented as the yearly 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 bi-monthly from March through November and is presented as the yearly 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. Turfgrass coverage was determined three times during the season using digital image analysis (Richardson et al., 2001). For this report, the only data that will be presented and discussed are from those cultivars (54 total) that were commercially available at the time this paper was published.

Results and Discussion

The 2009 growing season was noteworthy, in that Fayetteville experienced relatively mild conditions throughout the summer and extremely wet and cool conditions late in the summer and through the early fall (Richardson and Stiegler, 2010). Typically, brown patch (*Rhizoctonia solani*) pressure is very high on these types of trials (Richardson et al., 2009), but we did not record any significant outbreaks of brown patch during the 2009 season. Significant differences in turf quality were present among cultivars on every rating date in 2009 (data not shown), but were also significantly different when averaged over the entire season (Table 1). Some of the cultivars with the highest turf quality during the 2009 season included Spyder LS, 3rd Millennium SRP, Cezanne RZ, Padre, Speedway, Gazelle II, Justice, and Falcon IV (Table 1). Interestingly, many of these cultivars were not in the top statistical group over the 2007 and 2008 growing seasons (Richardson et al., 2009). The first two seasons of this trial were more typical with regard to summer stress, and the cultivars that performed best during the 2009 season may have rated higher since this season was milder and there was less disease pressure. Regardless, the change in ranking of cultivars across seasons justifies the evaluation of these trials over a 5-6 year period.

Significant differences in turfgrass color have also been documented in this trial, with cultivars such as Toccoa, Faith, AST9001, Compete, Hudson, Reunion, AST7002, AST7001, Renovate, AST9003, and AST7003 having the darkest green genetic color, while Ky-31 had the lowest (Table 1). As mentioned, brown patch disease was not observed during the 2009 season due to the unseasonably cool weather. As such, there was minimal loss of turf cover in any of the plots and all plots maintained an average turfgrass coverage percentage of over 98% (Table 1).

These data represent ongoing 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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Table 1. Average turfgrass quality, color, and coverage for commercially-available tall fescue cultivars for the 2009 season.

Entry	Avg. quality		Color		Cover	
	------- 1-9, with 9 = highest quality or color -----				%	
Spyder LS	7.1	a[z]	5.9	n-v	99.2	a-i
3rd Millennium SRP	6.9	ab	6.0	k-u	99.2	a-p
Cezanne RZ	6.6	a-g	5.7	s-w	99.1	c-t
Padre	6.6	a-g	6.4	d-p	99.2	a-o
Speedway	6.6	a-f	5.8	q-w	99.3	a-d
Gazelle II	6.6	a-f	6.2	i-t	99.2	a-l
Justice	6.6	a-g	6.0	m-v	99.1	c-s
Falcon IV	6.6	a-g	5.8	p-w	99.2	a-q
Raptor II	6.5	b-h	5.9	n-v	99.2	a-l
Talladega	6.5	b-h	5.9	n-v	99.2	a-o
Escalade	6.5	b-h	5.6	t-w	99.2	a-p
Wolfpack II	6.5	b-h	6.0	k-u	99.1	c-s
AST9001	6.5	b-h	6.8	a-h	99.0	g-v
Monet	6.4	b-i	5.7	s-w	99.2	a-j
Hemi	6.4	b-i	6.3	e-r	99.0	g-v
Firecracker LS	6.4	b-j	5.9	o-w	99.1	c-s
Mustang 4	6.4	b-j	6.2	i-t	99.2	a-k
Magellan	6.4	b-j	6.1	k-t	98.9	r-v
Faith	6.4	b-j	6.8	a-h	99.1	c-s
Rebel IV	6.4	b-j	6.2	h-t	99.1	d-u
Rhambler SRP	6.4	b-j	5.9	n-v	99.4	a
Van Gogh	6.3	c-l	5.3	w	99.4	a
Bullseye	6.3	c-k	5.9	o-w	99.2	a-o
Essential	6.3	c-k	6.0	l-u	99.2	a-j
Titanium LS	6.3	c-l	6.0	l-u	99.1	d-u
Hunter	6.3	c-l	6.5	d-o	99.1	c-t
Biltmore	6.3	c-k	6.5	d-n	98.8	uv
Tulsa Time	6.3	c-l	6.1	j-t	99.1	d-u
AST9002	6.3	c-l	6.6	c-m	99.0	d-v
Traverse SRP	6.3	c-k	6.0	m-v	99.2	a-l
Firenza	6.3	c-k	6.4	d-p	99.2	a-p
Skyline	6.2	e-m	6.2	i-t	98.9	q-v
SR 8650	6.2	e-m	6.2	i-t	99.1	d-u
Darlington	6.2	d-l	6.7	b-k	99.0	g-v
Compete	6.2	d-l	6.9	a-f	99.1	d-u
Hudson	6.2	d-l	6.9	a-g	99.0	i-v
Reunion	6.2	e-m	6.8	a-j	98.9	o-v
Aristotle	6.1	g-m	6.4	d-p	99.2	b-s
Turbo RZ	6.1	g-m	6.3	g-s	99.0	f-v
Turbo	6.1	f-m	6.5	d-n	99.2	a-o
Honky Tonk	6.1	g-m	6.2	h-t	99.0	j-v
Rembrandt	6.1	f-m	5.9	n-v	99.1	c-t
AST 7002	6.1	g-m	6.8	a-j	99.1	d-u
AST 7001	6.1	g-m	7.2	abc	99.2	a-p
Einstein	6.0	h-m	5.9	o-w	99.0	e-v
Toccoa	5.9	j-n	6.9	a-g	99.2	a-r
Tahoe II	5.9	j-n	6.0	k-u	99.0	l-v
Renovate	5.9	i-n	7.3	ab	98.8	v
AST9003	5.9	i-n	6.8	a-j	99.0	d-v
Lindbergh	5.8	k-n	6.0	l-u	99.3	a-f
AST 7003	5.8	lmn	6.9	a-g	99.0	d-v
Plato	5.7	mno	5.8	p-w	99.0	e-v
Silverado	5.4	no	5.4	uvw	99.1	d-u
Ky-31	4.3	p	4.3	x	99.1	d-v

[z]Means followed by same letter do not significantly differ (P=.05, LSD)

Ball Lie of Creeping and Colonial Bentgrass Cultivars Under Fairway Conditions

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Additional index words: *Agrostis stolonifera*, *Agrostis capillaris*, digital image analysis, mowing

Strunk, D., J. Young, D. Karcher, M. Richardson, and A. Patton. 2010. Ball Lie of Creeping and Colonial Bentgrass Cultivars Under Fairway Conditions. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:40-45.

Photo by Dan Strunk

Equipment used to evaluate ball lie on creeping bentgrass and colonial bentgrass cultivars.

Summary. The position of a golf ball in the canopy of turf, or ball lie, can have a significant effect on a golf shot. As turf breeders develop improved cultivars for use on golf course fairways and tees, the National Turfgrass Evaluation Program oversees the testing of these improved cultivars in differing climatic regions throughout North America. The University of Arkansas was selected as a test site for the 2008 bentgrass fairway/tee trial which included 27 bentgrass cultivars (colonial or creeping bentgrass). Ball lie was measured on 23, 24, and 25 September in 2009. Plots were maintained at a 0.5 inch height of cut, and data were collected at zero, one, and two days after mowing. Average ball lie was affected by bentgrass cultivar on each day of evaluation. Ball lie was considerably better directly after mowing than after one and two days of growth. When ball lie measurements were averaged for each cultivar across evaluation days, 12 creeping bentgrass cultivars were in the top statistical group.

Abbreviations: NTEP, National Turfgrass Evaluation Program

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Fairways are an integral part of a golf course and serve as a reward to accurately placed golf shots. Following a stroke into a fairway, a ball should sit high in the turf giving the golfer the most control on the subsequent shot. This position in the canopy, or ball lie, can have a significant effect on the golfer's ability to accurately hit controlled shots, and is dependent on a variety of factors such as mowing height, uniformity, and shoot density (Cella and Voigt, 2001). Poor ball lie is associated with an increased probability of an errant shot. There are several turf species available that produce adequate shoot density and tolerate close mowing for use in fairways (Morris, 2008). Among these species are numerous cultivars with differing growth characteristics. It is important to understand the variability of ball lie among cultivars of the same species for proper selection of cultivars that are better suited for optimal playing conditions.

In 2001, researchers at the University of Illinois developed a tool, the Lie-N-Eye, which was capable of measuring ball lie in of a turf canopy at a height range of 0.6 to 1.0 inch (Cella and Voigt, 2001). The Lie-N-Eye uses a platform, which is set on top of a mown canopy, and an adjustable digital caliper to measure the distance between the top of the ball and the turf canopy. Cella and coworkers also developed the Lie-N-Eye II in 2004 to measure ball lie on turf mown at 0.5 inch (Cella et al., 2004). However, with recent applications of digital image analysis in agriculture, and more specifically turf, the University of Arkansas constructed a tool utilizing a digital camera mounted on a platform to measure ball lie (Richardson et al., 2010). Adjustable legs on the platform allow for precise positioning at a variety of mowing heights. Digital images are taken of a golf ball sitting in the canopy, and then analyzed to determine the total number of pixels of the ball visible. The number of pixels of the golf ball in the treated image is compared to the total number of pixels possible of a completely visible golf ball to determine the ball lie of the turf.

The National Turfgrass Evaluation Program (NTEP), a part of the U.S. Department of Agriculture, conducts turfgrass cultivar evaluations at numerous sites throughout North America. In 2008, the University of Arkansas was selected as a test site for a bentgrass fairway/tee trial. There were 23 cultivars officially included in the trial along with four additional cultivars selected due to common use in Arkansas or performance in previous trials (Summerford et al., 2009). The objective of this research was to evaluate ball lie and the change of ball lie over time following a mowing event of 20 cultivars of creeping bentgrass (*Agrostis stolonifera*) and seven cultivars of colonial bentgrass (*Agrostis capillaris*) included in the 2008 NTEP bentgrass fairway/tee trial in Fayetteville, Ark.

Materials and Methods

The evaluation of ball lie was conducted at the University of Arkansas Research and Extension Center in Fayetteville in September 2009 on 27 cultivars of bentgrass (Table 1). The experimental area was established on a native silt loam soil on 1 October 2008, and contained three replicates of 27 cultivars in a randomized complete block design. The experimental area was maintained under typical fairway conditions with a height of cut at 0.5 inch (Table 2).

Three balls were rolled onto each plot using a ramp that consistently released the ball at a similar height and speed. Ball lie was then measured using a device developed by the University of Arkansas (Richardson et al., 2010). The device, which is comprised of a digital camera mounted on a platform, was used to take digital images of the golf balls. A midpoint wire on the device prevented changing the focal length between images. Images were captured using an Olympus SP-510UZ Digital Camera (Olympus Corporation, Center Valley, Pennsylvania). The digital camera was set with an exposure time of 1/250 s and an aperture of F4.5. Analysis of digital images using SigmaScan Pro (v5.0, SPSS, Chicago, Ill.) determined the percentage of total golf ball visible above the turf canopy (Fig. 1). Ball lie was measured on 23, 24, and 25 September 2009, corresponding to zero, one, and two days after mowing, respectively.

Results and Discussion

There were differences in average ball lie at zero, one, and two days after mowing, when averaged across cultivars (Table 3). Average ball lie decreased 2.4% and 4.0% after one and two days of growth, respectively. This confirms that ball lie on a bentgrass fairway declines as the turf recovers and grows following mowing. In addition, changes in the height of the turf canopy has a significant effect on ball lie, as suggested in previous studies on bermudagrass (McCalla et al., 2008) and Kentucky bluegrass (Cella and Voight, 2001).

There were also differences present in ball lie among cultivars when averaged over the three measurement dates (Table 4). There were twelve high-performing cultivars regarding ball lie, all of which were creeping bentgrass. The highest ranking cultivars included CY-2, Declaration, A08-TDN2, SR-1020, HTM, Pennlinks II / Penneagle II, T-1, Memorial, Tyee, LTP-FEC, MVS-Ap-101, and PST-OJD. The highest ranking colonial bentgrass cultivars were A08-FT12, BCD, and Tiger II, but they were significantly less than the highest creeping bentgrass cultivar. Lower ball lie ratings for the colonial bentgrass cultivars, as compared to creeping bentgrass, may have resulted from the more open canopy and upright growth characteristics inherent to colonial bentgrass. When cultivars were contrasted, creeping bentgrass cultivars had two percent more ball exposed on average than the colonial bentgrass cultivars ($P < 0.0001$). No significant interactions were found between days after mowing and bentgrass cultivar.

In summary, creeping bentgrass is a better choice for fairway turf than colonial bentgrass based upon ball lie. In this study, twelve cultivars of creeping bentgrass out-performed the remaining colonial and creeping bentgrass cultivars, indicating that there are differences among cultivars. Although overall quality and stress resistance may be more important when selecting a cultivar for golf course fairway or tee use, ball lie should be considered and may aid in the differentiation of cultivars with similar quality and resistance.

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Table 1. Bentgrass cultivars in the 2008 NTEP bentgrass fairway/tee trial in Fayetteville, Ark.

Entry	Species	Entry	Species
Penncross	Creeping	SRP-1WM[z]	Creeping
007	Creeping	T-1	Creeping
CY-2	Creeping	BCD	Colonial
LTP-FEC	Creeping	Benchmark DSR	Creeping
PennlinksII/PenneagleII[y]	Creeping	Declaration	Creeping
Princeville	Creeping	MVS-Ap-101[z]	Creeping
A08-EBM[z]	Colonial	Tyee[y]	Creeping
A08-TDN2[z]	Creeping	A08-FT12[z]	Colonial
Authority	Creeping	HTM	Creeping
L-93	Creeping	PST-R9D7[z]	Colonial
Memorial	Creeping	Tiger II	Colonial
Crystal Bluelinks	Creeping	Alister[y]	Colonial
PST-OJD[z]	Creeping	Greentime	Colonial
SR-1020[y]	Creeping		

[y] Not an official entry of the 2008 NTEP bentgrass trial but included as an Arkansas standard.
[z] Entry is experimental and at this time not commercially available.

Table 2. Management of plots in the 2008 NTEP Bentgrass fairway/tee trial.

Management	Description
Mowing	Three times/week at 0.5 inch with a Toro Greensmaster 1600 (Toro Company, Bloomington, MN)
Fertility	0.5 lbs Nitrogen/1000 ft^2 per month during active growth
Irrigation	Summer – 3x/week or as needed to prevent drought stress Spring/Fall – as needed to prevent drought stress
Cultivation	None
Sand Topdressing	As needed to smooth plots
Wetting Agents	None
Plant Growth Regulators	Primo Maxx (trinexipac-ethyl) at 6 oz/acre on 3 July 2009 and 4 September 2009.
Pesticides	Applied as needed for curative purposes

Table 3. Average ball lie at 0, 1, and 2 days after mowing, averaged across cultivars, in September 2009 on the 2008 NTEP bentgrass fairway/tee trial in Fayetteville, Ark.

Days after mowing[y]	Measurement date	Average ball lie
		----------(%)----------
0	23 September	94.2 A[z]
1	24 September	91.8 B
2	25 September	90.2 C

[y] Plots were mown with a Toro Greensmaster 1600 at 0.5 inch.
[z] Means followed by the same letter do not differ significantly at α=0.05.

Table 4. Ball lie of colonial and creeping bentgrass cultivars in the 2008 NTEP bentgrass fairway/tee trial in Fayetteville, Ark. Measurements were averaged across 0, 1 and 2 days after mowing in September 2009.

Entry	Species	Average ball lie	
		------------(%)------------	
CY-2	Creeping	93.4	A[x]
Declaration	Creeping	93.3	AB
A08-TDN2[z]	Creeping	93.2	ABC
SR-1020[y]	Creeping	93.1	ABCD
HTM	Creeping	93.0	ABCD
PennlinksII/Penneagle II[y]	Creeping	93.0	ABCD
T-1	Creeping	92.7	ABCD
Memorial	Creeping	92.7	ABCDE
Tyee[y]	Creeping	92.5	ABCDEF
LTP-FEC	Creeping	92.5	ABCDEF
MVS-Ap-101[z]	Creeping	92.5	ABCDEF
PST-OJD[z]	Creeping	92.3	ABCDEFG
L-93	Creeping	92.2	BCDEFGH
Crystal Bluelinks	Creeping	92.1	CDEFGHI
Authority	Creeping	92.1	CDEFGHI
Benchmark DSR	Creeping	92.1	CDEFGHI
007	Creeping	92.1	DEFGHI
SRP-1WM[z]	Creeping	92.0	DEFGHI
A08-FT12[z]	Colonial	91.6	EFGHI
BCD	Colonial	91.5	FGHI
Tiger II	Colonial	91.5	FGHI
Penncross	Creeping	91.5	FGHI
Princeville	Creeping	91.2	GHI
A08-EBM[z]	Colonial	91.1	HI
Greentime	Colonial	91.0	I
Alister[y]	Colonial	91.0	IJ
PST-R9D7[z]	Colonial	89.8	J
$LSD_{(0.05)}$		**1.1**	

[x] Means followed by the same letter do not differ statistically at $P < 0.05$.
[y] Not an official entry of the 2008 NTEP bentgrass trial but included as an Arkansas standard.
[z] Entry is experimental and at this time not commercially available.

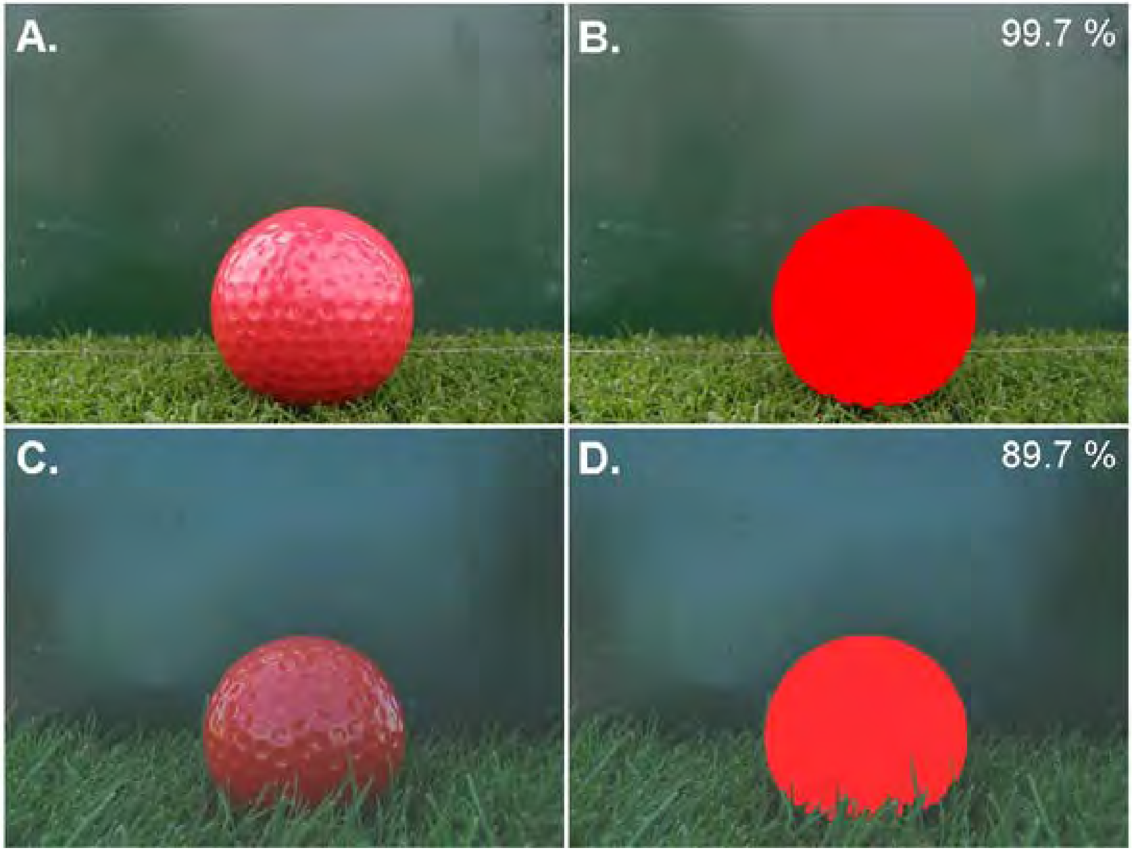

Fig. 1. Creeping bentgrass cultivar 'CY-2' ball lie image (A) and software analysis overlay (B). Colonial bentgrass cultivar 'PST-R9D7' ball lie image (C) and software analysis overlay (D). Percentages listed on pictures (B) and (D) indicate the number of red pixels visible out of the total number of red pixels possible.

Organic Matter Accumulation of Bentgrass Cultivars Following Establishment on a Sand-Based Putting Green

Liu Yang[1], Doug Karcher[1], and Josh Summerford[1]

Additional index words: *Agrostis stolonifera*, National Turfgrass Evaluation Program

Yang, L., D. Karcher, and J. Summerford. 2010. Organic matter accumulation of bentgrass cultivars following establishment on a sand-based putting green. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:46-49.


Photo by Doug Karcher

Organic matter accumulation of creeping bentgrass in a sand-based rootzone during the first year of growth.

Summary. Managing organic matter near the surface in sand-based putting greens is a concern for many golf course superintendents. Newer cultivars of creeping bentgrass have improved density over older cultivars and may accumulate organic matter more rapidly. The objective of this study was to determine the organic matter content for 29 cultivars of one-year-old bentgrass that were established on a sand-based putting green. Four-inch diameter samples were extracted for each cultivar and the surface 0.5 inch of the rootzone sectioned for organic matter analysis. At one year following establishment, there were significant differences in organic matter content among the cultivars. Newer and experimental cultivars had higher organic matter content than older cultivars such as L-93, SR 1020, and Crenshaw. Golf course superintendents should closely monitor organic matter accumulation and select appropriate management practices for putting greens established with newer, denser cultivars.

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Excessive organic matter accumulation can be a problem on sand-based, creeping bentgrass (*Agrostis stolonifera*) putting greens, especially during prolonged periods of high temperatures and humidity. The accumulation of organic matter, which is formed by roots, stems, nodes, leaf sheaths, and other tissues, decreases the saturated hydraulic conductivity and atmospheric gas exchange near the rootzone surface as the putting green matures and can increase moisture content near the surface. This may manifest as summer stress decline during periods of high temperature and humidity, especially if the turf is predisposed from other stresses, such as excessively low mowing heights. In the quest for higher green speeds, the selection of creeping bentgrass cultivars with high density and fine leaf texture has become one way superintendents are attempting to achieve the highest possible green speed, since these cultivars tolerate lower mowing heights than older cultivars. Though the new cultivars have been shown to have high shoot density and good uniformity, they may produce more organic matter near the rootzone surface, which may be contributing to summer stress or localized dry spot. Since the more dense cultivars are relatively new releases, there is little known about the amount of organic matter they produce. Therefore, the objective of this research was to determine the amount of organic matter accumulated over time by various creeping bentgrass cultivars.

Materials and Methods

This experiment was conducted in October 2009 at the University of Arkansas Research and Extension Center in Fayetteville on a pre-existing cultivar trial, the 2008 NTEP Bentgrass Putting Green Trial. The trial was established on 30 September 2008 on a sand-based rootzone constructed according to United States Golf Association specifications. Nineteen cultivars were officially included in the 2008 NTEP Bentgrass Putting Green Trial 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 (Summerford et al., 2009). One cultivar in the trial, SR 7200, which is a velvet bentgrass (*Agrostis canina*), was not included in this experiment due to very poor turf coverage following the summer of 2009. Each cultivar was broadcast seeded into four replicate, 6 by 6 ft plots at a seeding rate of 1 lb/1000 ft^2. Following establishment, the trial was maintained under golf course putting green conditions (Table 1), with a mowing height of 0.125 inch and monthly nitrogen applications of 0.5 lb N/1000 ft^2 per month of active growth.

The experimental design was a randomized complete block design with 29 cultivars replicated 3 times for a total of 87 plots. One core sample was taken from each plot using a standard size cup cutter at a depth of 3.5 inches. Verdure was removed and the samples were cut to a thickness of 0.5 inch to include all surface organic matter. Samples were then placed into numbered, pre-weighed crucibles and moved into a drying oven and allowed to dry at 100 °C for 24 h and then weighed. Samples were then placed into a muffle furnace at 440 °C to ash for 8 h, to combust the organic matter in the sample, and then weighed again. The percent organic matter was calculated for each sample by dividing its decrease in weight during combustion (organic matter lost by ignition) by its weight after drying at 100 °C.

Results and Discussion

There were significant differences among cultivars with regard to their organic matter accumulation (Fig. 1). There were eight cultivars, MVS-AP-101, Shark, A09-TDN2, CY-2, PST-OJO, V8, Authority and Penn A-2, that had more organic matter than the three cultivars with the least organic matter, L-93, SR 1020 and Crenshaw. Those cultivars accumulating the most organic matter were mostly newer cultivars (except Penn-G2) or experimental cultivars with improved density compared to older cultivars such as Penncross, L-93, SR 1020, and Crenshaw. Although not directly measured in this experiment, the denser cultivars likely produce more shoots, roots, stems, nodes, and leaf sheaths per unit area than less dense cultivars. These data provide some initial evidence that there are differences among creeping bentgrass cultivars in their organic matter accumulations rates. Furthermore, cultivars with high shoot densities seem to accumulate organic matter faster than the less dense cultivars. Therefore, when newer, denser cultivars of creeping bentgrass are used in sand-based putting greens, organic matter accumulation should be carefully monitored and appropriate core aerification and sand topdressing practices implemented to ensure adequate atmospheric gas exchange. It is important to note that these data represent a single sampling date from relatively immature turf (approximately one year old). These cultivars will continue to be monitored for organic matter accumulation over the next several years.

Literature Cited

Summerford, J., D. Karcher, M. Richardson, and A. Patton 2009. Summary of the 2008 NTEP bentgrass putting green trial-establishment. Arkansas Turfgrass Report 2008, Ark. Ag. Exp. Stn. Res. Ser. 568:132-136.

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	Approximately every 3 days, or as needed to prevent drought stress.
Growth regulation	Primo Maxx (trinexapac-ethyl) applied at 1/8 oz. per 1000 ft^2 per month of active growth.
Wetting agent application	Revolution applied at 6oz per 1000ft^2 per month from May through September.
Cultivation	The experimental area had not been core aerified prior to organic matter evaluations.
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.

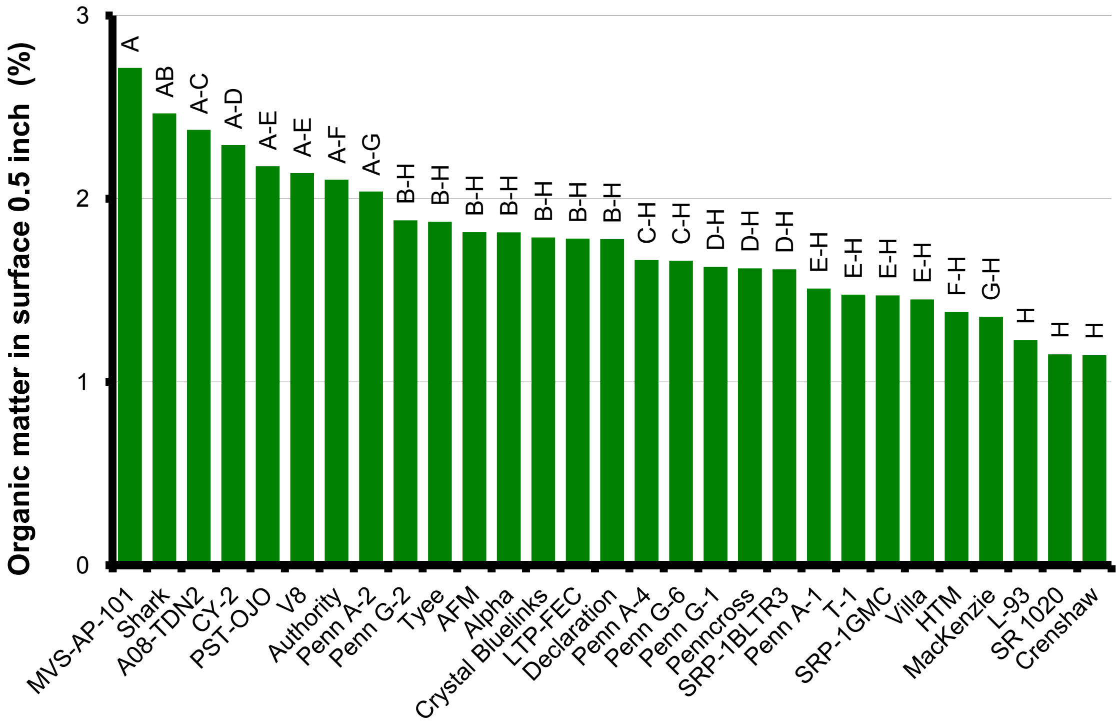

Fig. 1. Organic matter accumulation in the surface 0.5 inch of a sand-based putting green rootzone at approximately one year following establishment. Cultivars that do not share a letter are significantly different (α = 0.05).

Wetting Agent Effects on Rootzone Moisture Distribution Under Various Irrigation Regimes – Year 2 Summary

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

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

Karcher, D., M. Richardson, A. Patton, and J. Summerford. 2010. Wetting agent effects on rootzone moisture distribution under various irrigation regimes–year 2 summary. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:50-56.

Photo by Doug Karcher

Localized dry spot with minimal dew formation on untreated plots and border areas surrounding a wetting agent trial.

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 content and uniformity were affected by the application of five commercially available wetting agents. Wetting agents were applied during the 2008 and 2009 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 following a prolonged period of infrequent irrigation. 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 compared to the untreated turf during periods of moderate and infrequent irrigation. These results suggest that these wetting agents can be used to effectively manage LDS and improve root-zone moisture distribution.

Abbreviations: LDS, localized dry spot

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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 localized dry spot (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 applications affect soil moisture distribution throughout the putting green rootzone. A common belief is 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. This report summarizes the second year of treatments and evaluations for this project.

Materials and Methods

This experiment was conducted from June through August in 2008 and 2009 at the University of Arkansas 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 week 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 8 June through 3 August, except for Cascade Plus, which was applied only on 8 and 15 June. Each treatment was applied to four replicate plots, measuring 6 by 6 ft each. Treatments were applied to the same plots in 2008 and 2009. 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 and resultant soil moisture conditions.

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 inch) within each plot with time domain reflectometry moisture probes (TDR 300, Spectrum Technologies, Plainfield, Ill., USA). From the moisture data, average rootzone moisture content and soil moisture variance (measured by standard deviation; n = 36) were calculated for each wetting agent at each sampling depth.

Results and Discussion

LDS incidence. Wetting agent treatment did not affect LDS incidence from June through mid July, while the experimental area received judicious and moderate irrigation. However as the irrigation regime transitioned from moderate to sparing in late July, wetting agent treatments significantly affected LDS incidence from then until the end of study (Fig. 1 and 2). From 29 July through the end of the study, all of the wetting agent products significantly reduced LDS incidence compared to the untreated control, except for Tricure on 29 July. After 29 July, there were no significant differences among wetting agents in LDS incidence.

Turf quality. Turf quality was significantly affected by treatments at the beginning of the trial (18 June) and from 6 August through the end of the study (Fig. 3). On 18 June, the untreated control had significantly lower quality than all of the wetting agent treatments, except for Cascade Plus. These differences were likely residual effects from the severe LDS formation that was present on the control plots during 2008. From 6 August through the end of the study, the untreated control had significantly lower quality than all of the wetting agent treatments, primarily due to high LDS incidence in the control plots (Fig. 2). There were no differences in turf quality among the wetting agent products throughout the study.

Soil moisture content. Soil moisture content was significantly affected by both sampling depth and wetting agent treatment. On average, volumetric soil moisture content at the 3, 5, and 8 inch depth was 21.5%, 15.0%, and 12.9%, respectively. The higher moisture content near the rootzone surface is most likely due to a higher concentration of organic material, which increases soil moisture retention.

There was a significant wetting agent treatment by evaluation date interaction with regard to soil moisture content. Since the wetting agent treatment by evaluation date by depth interaction was not significant, soil moisture content as affected by wetting agent will be discussed as averaged across sampling depths.

The only evaluation date on which wetting agent treatments significantly affected soil moisture content was 27 August, the final evaluation date, which followed a period of infrequent irrigation (Fig. 4). Earlier in the trial, when the experimental area was irrigated judiciously, turf treated with wetting agent had similar soil moisture content as untreated turf, regardless of the wetting agent product. Therefore, these wetting agents did not retain excessive moisture while the experimental area was kept relatively wet. On the final evaluation date, following a period when the experimental area was irrigated infrequently, the untreated control had significantly lower soil moisture content than all of the wetting agents, except Tricure.

Soil moisture variation. Soil moisture variation was significantly affected by both sampling depth and wetting agent treatment. On average, moisture was more uniform deeper in the rootzone. Soil moisture was significantly more variable at 3 inches than at 5 inches, and also at 5 inches than at 8 inches.

As with the soil moisture content evaluations, there was a significant wetting agent treatment by evaluation date interaction with regard to soil moisture variation, but the wetting agent treatment by evaluation date by depth interaction was not significant. Therefore, soil moisture variation, as affected by wetting agent, will be discussed as averaged across sampling depths.

Throughout the trial, the untreated turf had the highest variation in soil moisture, and was significantly more variable than all of the wetting agent treatments on the final three evaluation dates (Fig. 5). Although soil moisture content was not significantly affected by wetting agent treatments on 30 July and 13 August, soil moisture uniformity was significantly improved during that period. There were no differences among the wetting agent products with regard to soil moisture variability.

Conclusions

Based on the 2009 data, all wetting agent products appear to effectively reduce LDS incidence and increase soil moisture uniformity, over a wide range of depths (3 to 8 inch) compared to untreated turf. This should translate to more efficient irrigation management, allowing for longer periods between irrigation events and reduced hand-watering since isolated areas of drier rootzone conditions are less likely when using these wetting agents. 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.

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)

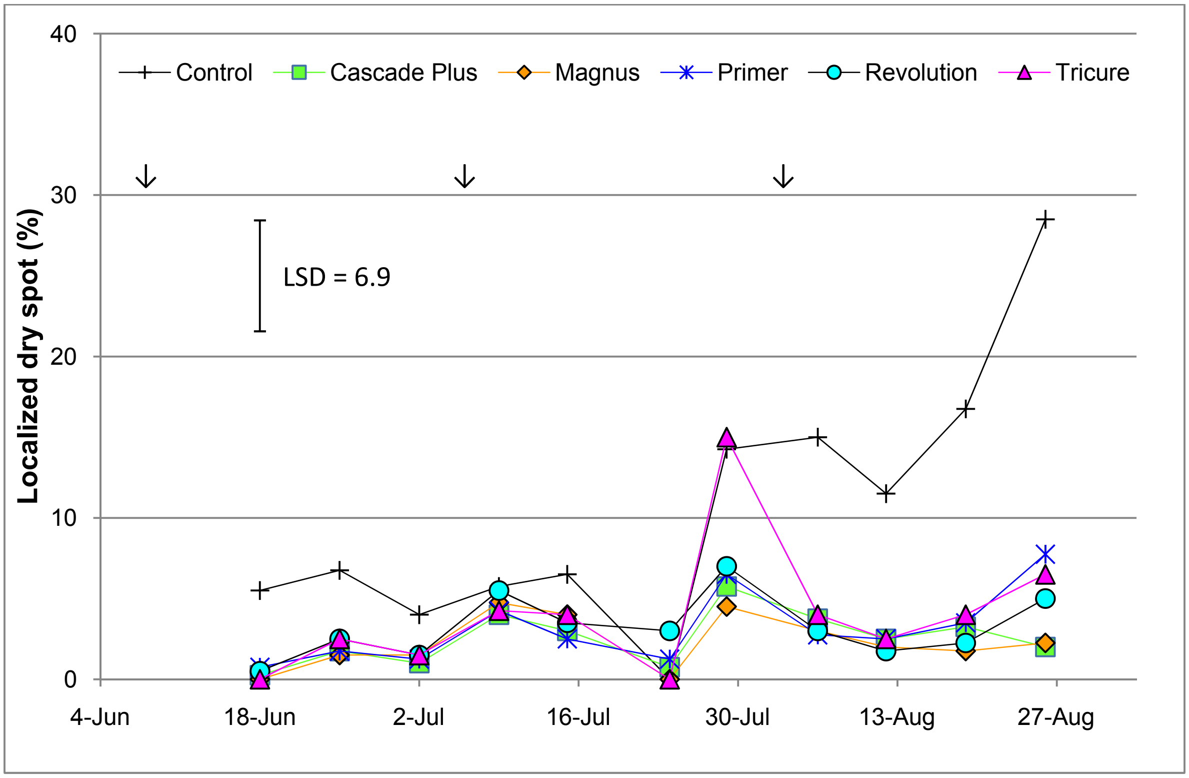

Fig. 1. Localized dry spot incidence as affected by wetting agent treatment. Arrows indicate wetting agent application dates (except for Cascade Plus, which was only applied on 8 and 15 June). Error bar represents Fisher's least significant difference (α = 0.05) for comparing treatments within evaluation dates.

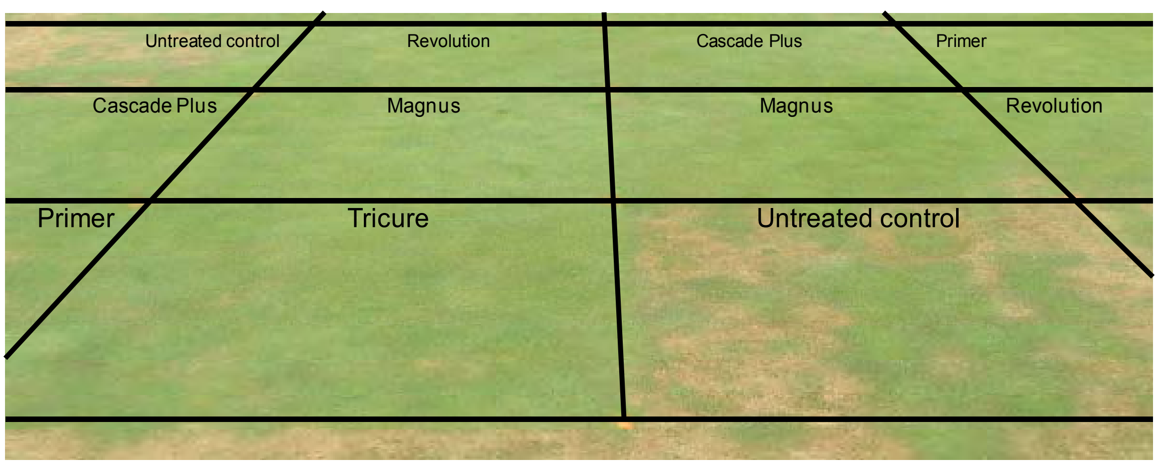

Fig. 2. Localized dry spot incidence on several plots in the trial following a prolonged period of drought stress. Note the LDS on the untreated control plots and the untreated border of the experimental area at the bottom of the photo. Photo taken on 26 August 2009.

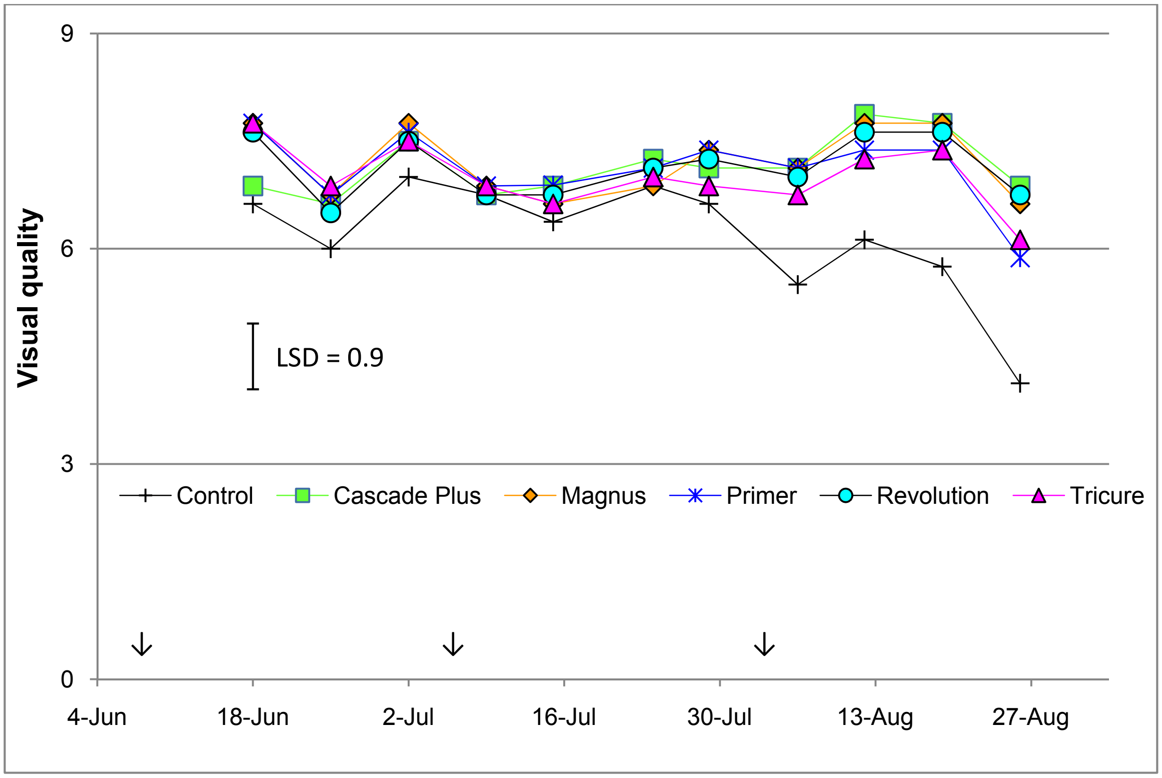

Fig. 3. Visual turf quality as affected by wetting agent treatment. Arrows indicate wetting agent application dates (except for Cascade Plus, which was only applied on 8 and 15 June). Error bar represents Fisher's least significant difference ($\alpha = 0.05$) for comparing treatments within evaluation dates.

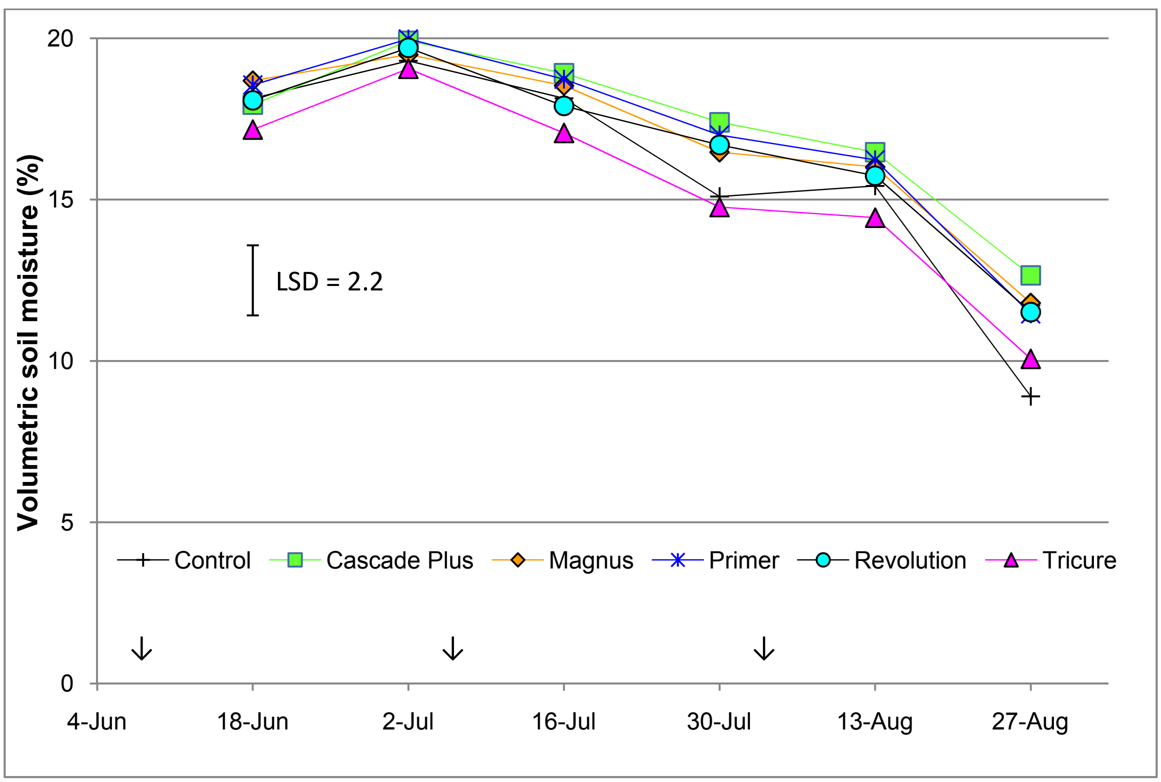

Fig. 4. Soil moisture as affected by wetting agent treatment. Arrows indicate wetting agent application dates (except for Cascade Plus, which was only applied on 8 and 15 June). Error bar represents Fisher's least significant difference ($\alpha = 0.05$) for comparing treatments within evaluation dates.

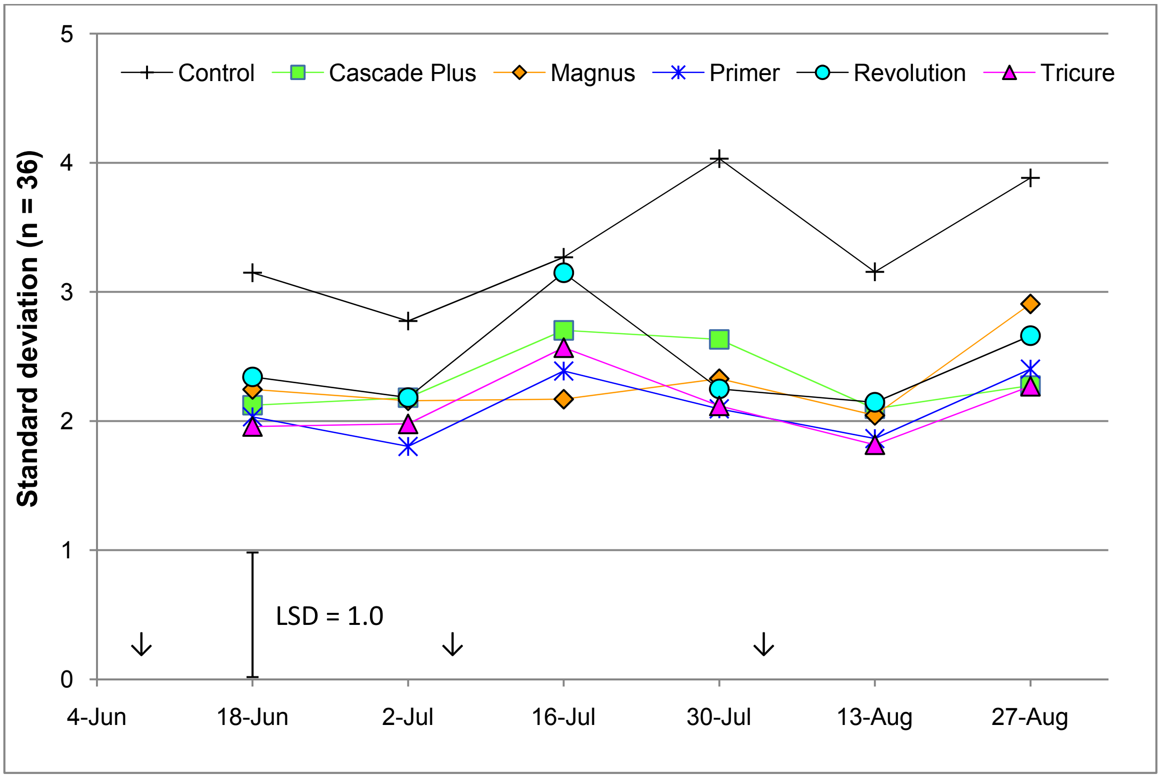

Fig. 5. Soil moisture variability, measured by standard deviation (n = 36), as affected by wetting agent treatment. Arrows indicate wetting agent application dates (except for Cascade Plus, which was only applied on 8 and 15 June). Error bar represents Fisher's least significant difference (α = 0.05) for comparing treatments within evaluation dates.

Effects of "Immerse GT" and "Immerse GT 2009" Wetting Agents on Localized Dry Spot Incidence and Rootzone Moisture Distribution

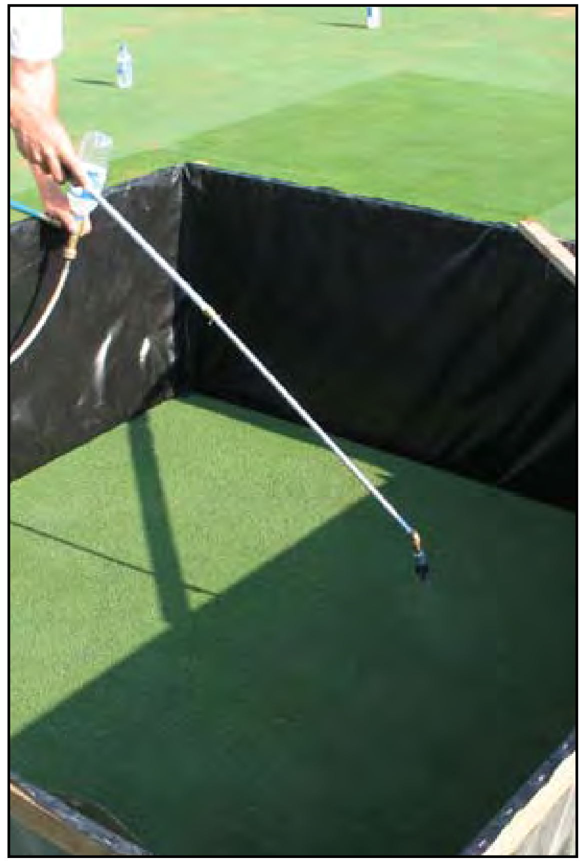

Photo by Doug Karcher

Wetting agent application to experimental putting green plots.

Doug Karcher[1] and Josh Summerford[1]

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

Karcher, D. and J. Summerford. 2010. Effects of "Immerse GT" and "Immerse GT 2009" wetting agents on localized dry spot incidence and rootzone moisture distribution under various moisture conditions. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:57-63.

Summary. As new wetting agents reach the market for putting green management, it is important to understand not only how they affect the incidence of localized dry spot (LDS), but also how they affect moisture retention and distribution throughout the putting green rootzone. The objective of this research was to determine how localized dry spot incidence, and soil moisture content and uniformity were affected by the application of "Immerse GT" and "Immerse GT 2009", two newer wetting agent products from Amega Sciences. Wetting agents were applied during the 2009 growing season and evaluated under conditions of moderate and infrequent irrigation application. Both wetting agents tested in this study significantly reduced LDS formation compared to the untreated control. In addition, neither wetting agent significantly increased soil moisture values under wet conditions, whereas both wetting agents significantly increased soil moisture content and uniformity, compared to the untreated turf, during periods of drought stress. It appears that these relatively new wetting agents can be used to effectively manage LDS and improve rootzone moisture distribution.

Abbreviations: LDS, localized dry spot

[1] University of Arkansas, Department of Horticulture, Fayetteville, Ark. 72701

Previous research on wetting agent application to sand-based putting greens has demonstrated that many commercially available products are effective in reducing soil hydrophobic properties and/or visual localized dry spot (LDS) symptoms. As new wetting agent products become available for use in the turf industry, it is important to understand not only how effective they are at reducing LDS symptoms, but also how they affect rootzone moisture following application. The objective of this research was to determine how two newer wetting agent products, "Immerse GT" and "Immerse GT 2009", control LDS and affect rootzone moisture distribution when applied to a sand-based putting green under varying moisture conditions.

Materials and Methods

This experiment was conducted from July through October in 2009 at the University of Arkansas 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 week and otherwise maintained under typical golf course conditions (Table 1).

Treatments consisted of two wetting agent products, Immerse GT and an experimental product, Immerse GT 2009 (Amega Sciences, USA, Saint Cloud, Fla.), and untreated control. Both wetting agents were applied at 6 fluid ounces per 1000 ft^2 and irrigated with 0.25 inch of water following application. Treatments were initially applied on 8 July and 14 days later on 22 July. Thereafter, treatments were applied monthly on 18 August and 16 September. Each treatment was applied to four replicate plots, measuring 6 by 6 ft each. Irrigation was applied moderately (every 2-3 d), in June and sparingly (only under severe drought stress) thereafter to compare the wetting agents under a range of moisture conditions. In addition, the experimental area was irrigated heavily the morning of 17 July to evaluate the wetting agents under wet conditions.

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 inch) within each plot using time domain reflectometry moisture probes (TDR 300, Spectrum Technologies, Plainfield, Ill., USA). From the moisture data, average rootzone moisture content and soil moisture variability (measured by standard deviation; n = 36) were calculated for each wetting agent at each sampling depth.

Results and Discussion

LDS incidence. Although no wetting agent had been applied to the experimental area prior to 8 July, there was a relatively low incidence of LDS across the plots at the beginning of the trial because the experimental area had been irrigated judiciously the previous month. There were no statistically significant differences in LDS incidence among treatments for the first five weeks of the trial (Fig. 1). However, from the 19 August evaluation date through the end of the trial, both wetting agent treatments resulted in significantly less LDS formation than the untreated control. From 26 August through the end of the study, untreated turf averaged over 40% LDS on all evaluation dates (except for 2 September), while turf treated with wetting agent averaged below 15% LDS during that same period (Figs. 1 and 2). There were no differences in LDS formation between Immerse GT and Immerse GT 2009.

Visual quality. Since LDS incidence had a strong influence on turf quality, treatment effects on visual quality were similar as for LDS incidence. However, there were significant differences among treatments by 6 August, less than one month following the initial wetting agent application (Fig. 3). From 6 August through the end of the trial, both wetting agent treatments resulted in significantly greater turf quality than the untreated control. Both wetting agent treatments resulted in turf quality that was above acceptable (>6.0) throughout the trial, with the exception of Immerse GT on 26 August. There were no significant differences in turf quality between Immerse GT and Immerse GT 2009.

Soil moisture content. Across the experimental area, soil moisture was highest (17.1%) on the first evaluation date, 17 July, nine days after the study began and a few hours after the experimental area received a heavy irrigation. After July, when the area was irrigated sparingly, average soil moisture values across the experimental area were never above 10% and fell to a low of 6.6% on 28 August during a period of extreme drought stress.

Wetting agent treatment had a significant effect on soil moisture content, especially towards the end of the study. Although measurement depth also affected soil moisture content (wetter near the surface), there was not a significant wetting agent treatment by depth interaction (i.e., wetting agent effects were consistent across all three measurement depths). Therefore, wetting agent treatment effects will be discussed as averaged across all three measurement depths. On 17 July, under relatively wet conditions due to a recent irrigation event, there were no differences among treatments in soil moisture content (Fig. 4), indicating that these wetting agents do not hold excessive moisture near the rootzone surface. On 31 July, and from 28 August through the end of the trial, when the experimental area was under drought stress, both wetting agent treatments resulted in higher soil moisture values than the untreated control. There were no significant differences in soil moisture content between Immerse GT and Immerse GT 2009.

Soil moisture variation. Across the experimental area, soil moisture variation was greatest early in the trial, on 31 July, as plots were drying out and the irrigation regime was transitioning from moderate to sparing. Prior to this date, plots were more uniformly moist, while after this date, the untreated control plots increased in moisture uniformity (from isolated dry areas to uniformly dry), and plots treated with wetting agent maintained relatively uniform soil moisture conditions.

Wetting agent treatment had a significant effect on soil moisture variability throughout the study and although measurement depth also affected soil moisture variability (more variability near the surface), there was not a significant wetting agent treatment by depth interaction (i.e., wetting agent effects were consistent across all three measurement depths). Therefore, wetting agent treatments effects will be discussed as averaged across all three measurement depths. Throughout the study, both wetting agents significantly decreased soil moisture variability compared to the untreated control, except for Immerse GT 2009 on 14 August (Fig. 5). The reduction in soil moisture variability resulting from wetting agent treatment peaked in late September, following a prolonged period of drought stress across the experimental area (Fig. 5). Mapping soil moisture values from that time shows a significant increase in moisture retention and uniformity, at all three depths, as caused by wetting agent application (Fig. 6). There were no significant differences between the two wetting agents throughout the study. These results indicate that Immerse GT and Immerse GT 2009 increase soil moisture uniformity across a range of soil moisture contents (Fig. 4). This should translate to more efficient irrigation management, allowing for longer periods between irrigation events and reduced hand-watering since isolated areas of drier rootzone conditions are less likely when using these wetting agents.

Conclusions

Immerse GT and Immerse GT 2009 were effective in reducing LDS symptoms and improving soil moisture uniformity during wet and dry periods. These wetting agents do not appear to retain excessive moisture near the rootzone surface under wet conditions and they were effective in retaining more moisture during drought periods than untreated turf. These wetting agents show promise for managing LDS and soil moisture in sand-based putting greens.

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	Moderate (July) – as needed to prevent moderate drought stress symptoms. Infrequent (August - October) – 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.
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.

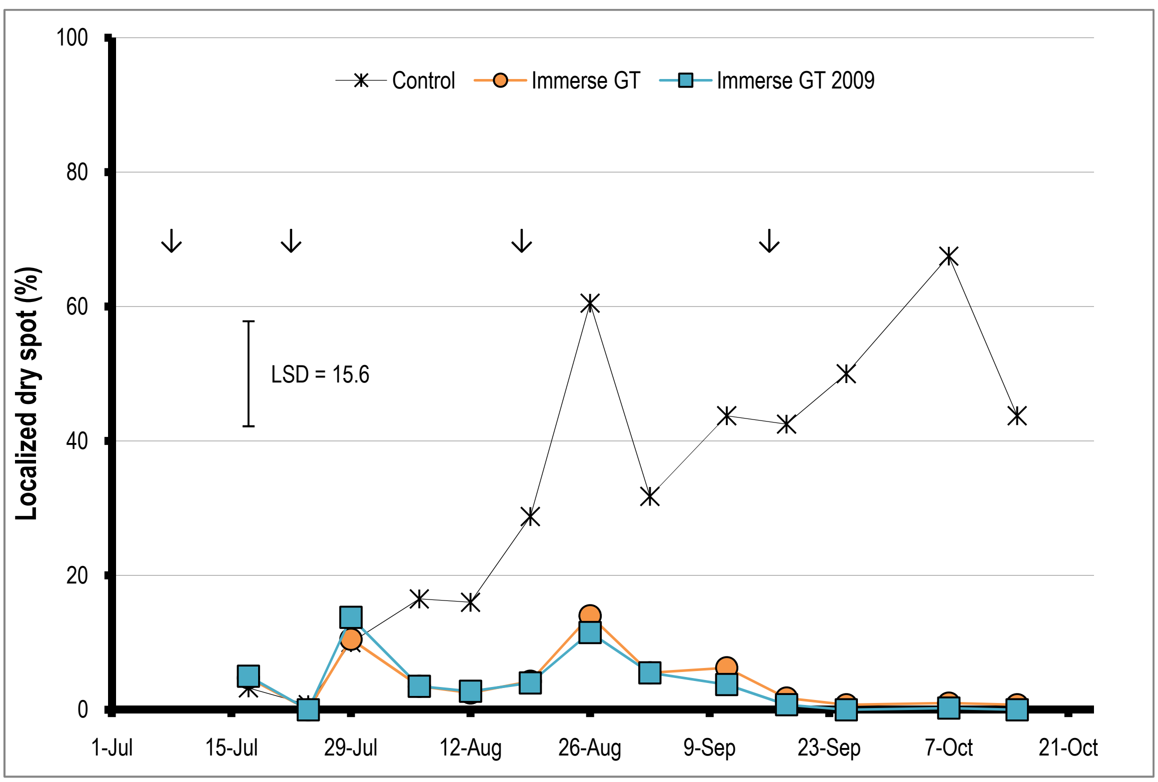

Fig. 1. Localized dry spot incidence as affected by wetting agent treatment. Arrows indicate wetting agent application dates. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing wetting agent treatments within dates.

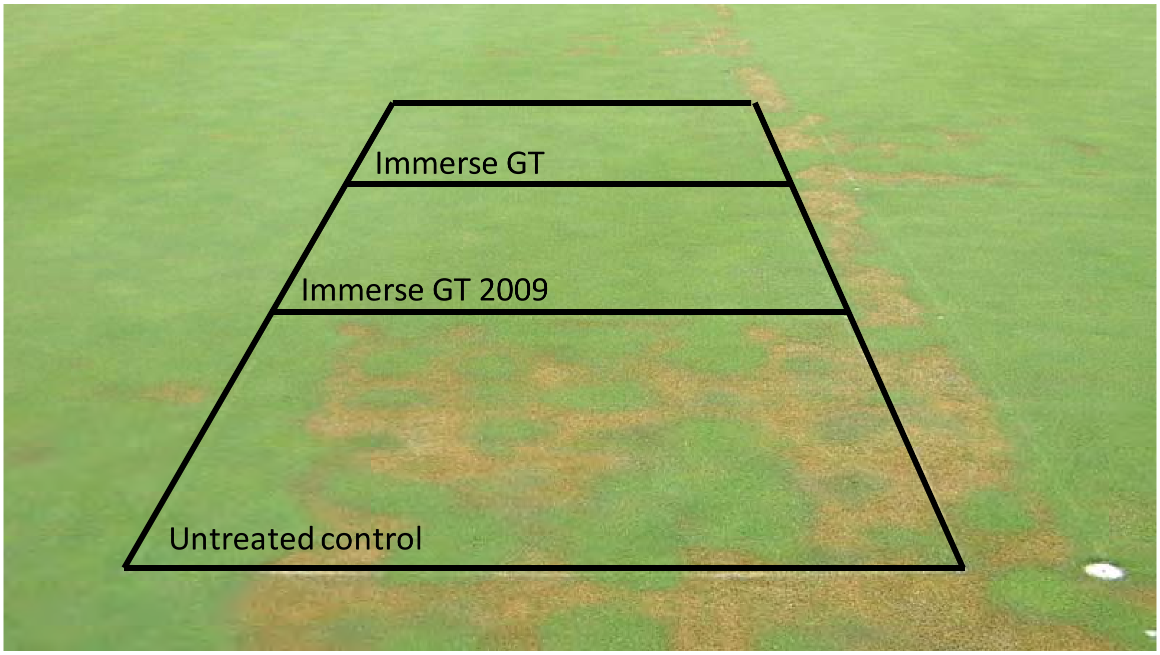

Fig. 2. A replicate of plots showing a reduction in LDS symptoms from wetting agent treatments. Note the LDS in the untreated border around the plots. Photo taken 18 August 2009.

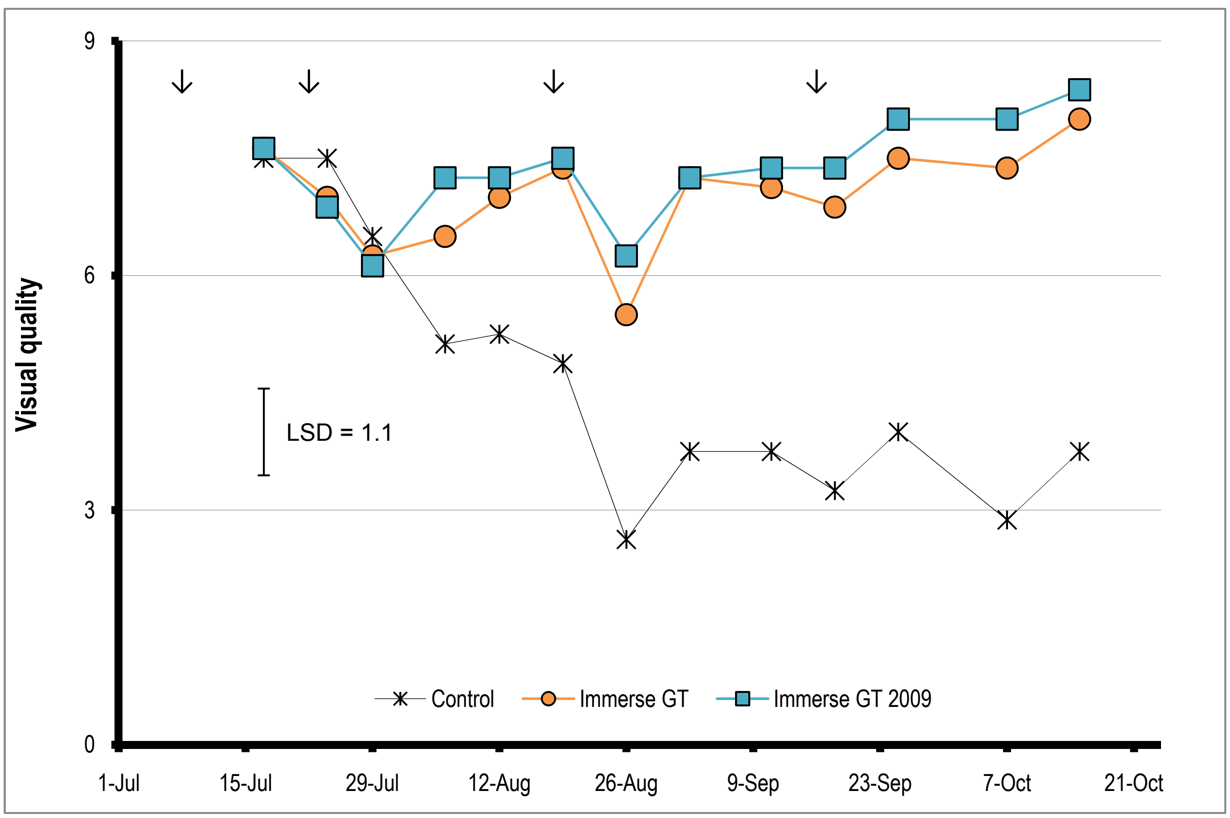

Fig. 3. Visual turf quality (9 = ideal, 6 = acceptable, 1 = dead) as affected by wetting agent treatment. Arrows indicate wetting agent application dates. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing wetting agent treatments within dates.

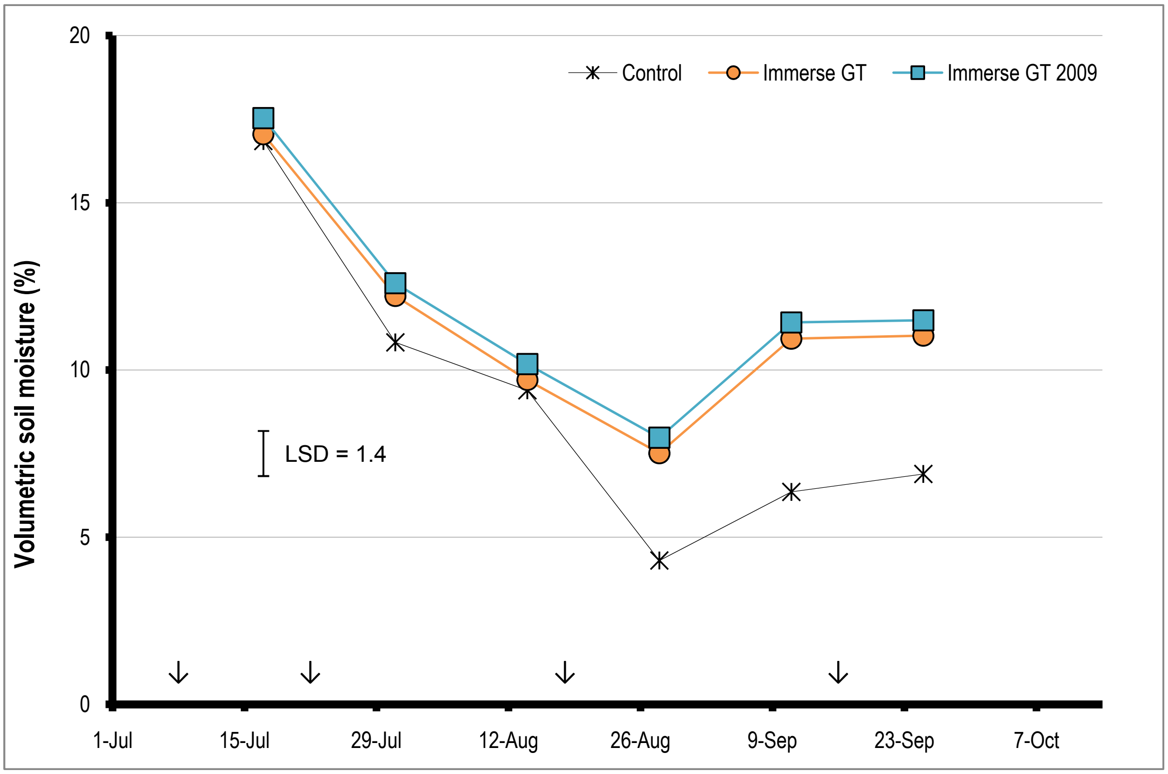

Fig. 4. Volumetric soil moisture (%) as affected by wetting agent treatment. Arrows indicate wetting agent application dates. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing wetting agent treatments within dates.

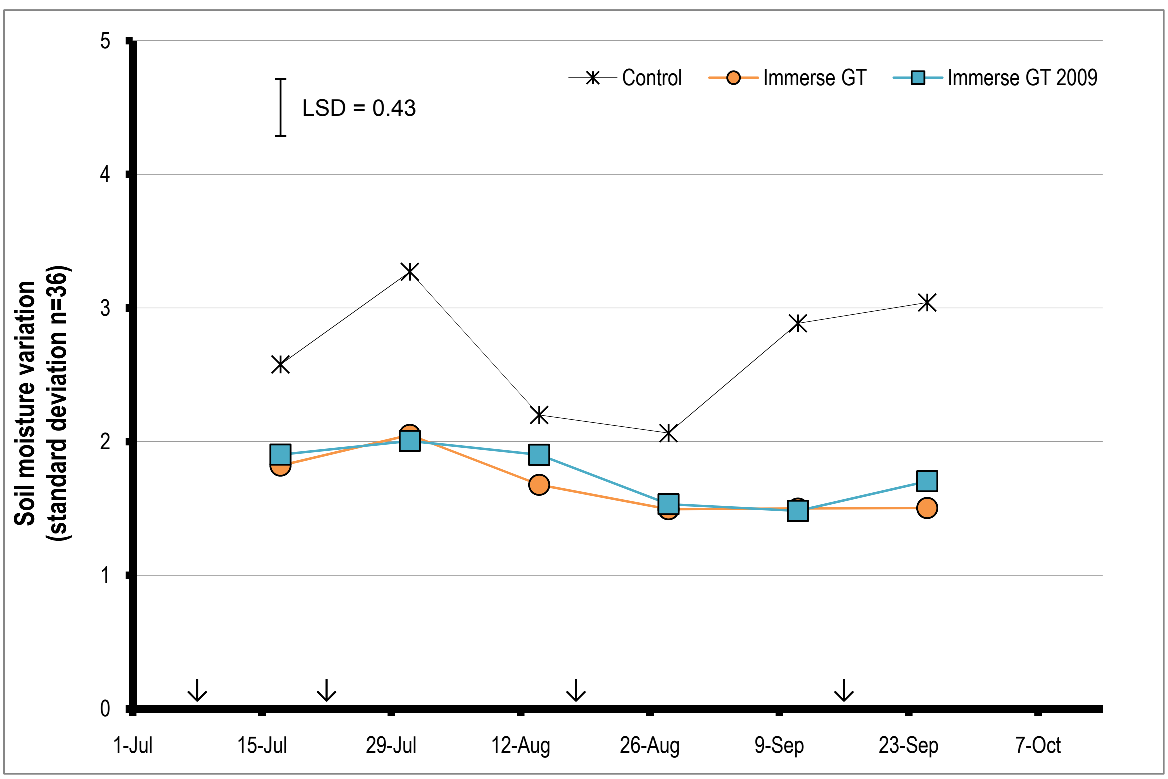

Fig. 5. Soil moisture variation as affected by wetting agent treatment. Arrows indicate wetting agent application dates. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing wetting agent treatments within dates.

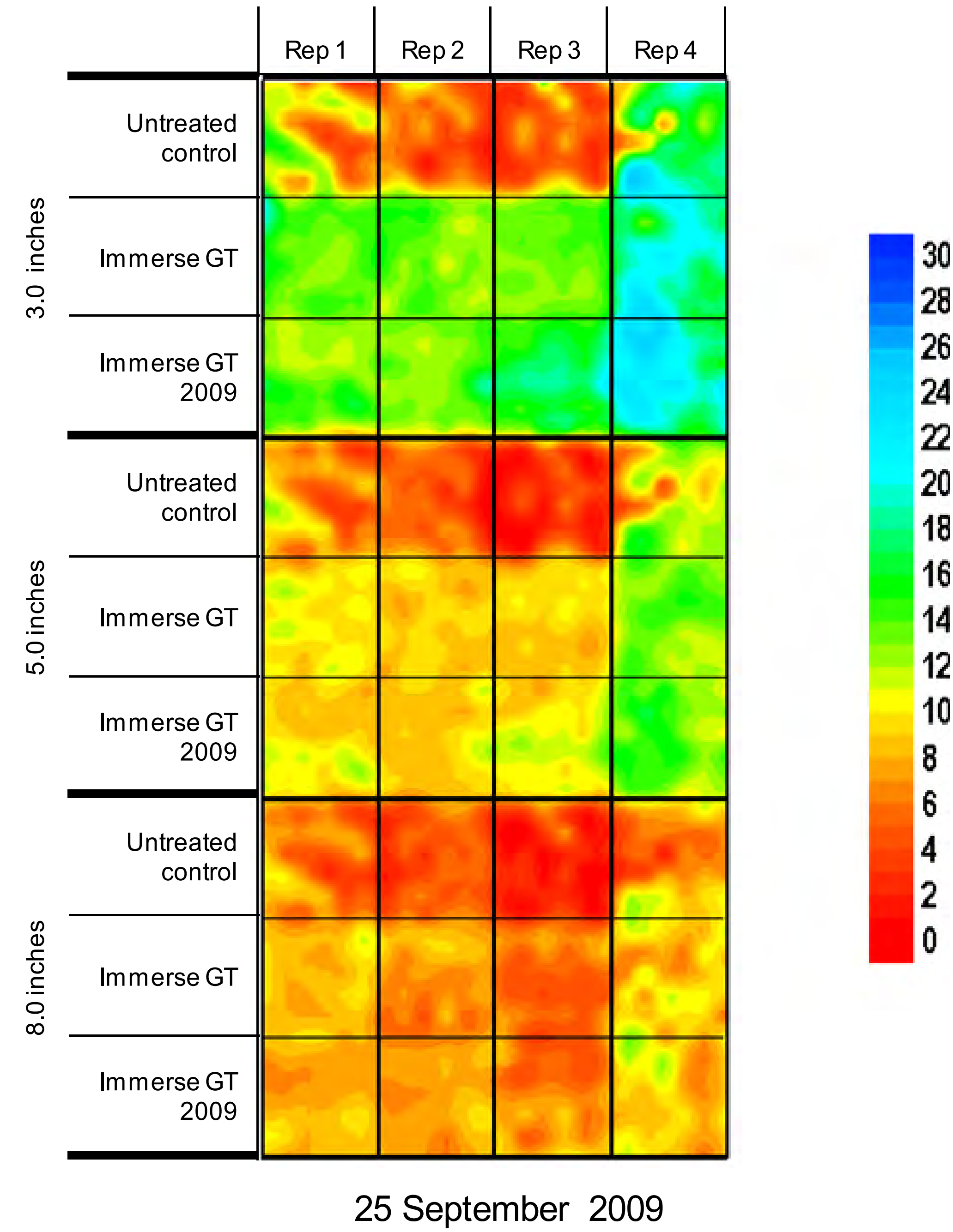

Fig. 6. Soil moisture maps of all plots at all three measurement depths from 25 September 2009.

Leaf and Stolon Characteristics of Commercially Available and Experimental St. Augustinegrass Cultivars

David Moseley[1], Aaron Patton[2], and Jon Trappe[2]

Additional index words: internode, color, Arkansas

Moseley, D., A. Patton, J. Trappe. 2010. Leaf and stolon characteristics of commercially available and experimental St. Augustinegrass cultivars. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:64-68.

Photo by Aaron Patton

Leaf and stolon characteristics vary for St. Augustinegrass cultivars.

Summary. Saint Augustinegrass is used on shaded lawns, as it is among the most shade tolerant warm season turfgrasses. Many new cultivars are being developed and are being considered for use in Arkansas but prior to their adoption more data is needed on their growth. The objective of this experiment was to quantify differences in growth characteristics among several commercially available cultivars as well as several experimental cultivars. Twenty commercially available cultivars and ten experimental genotypes were first grown as plugs in a greenhouse and then planted in research plots in Fayetteville, Ark. Leaf and stolon characteristics as well as color varied among cultivars. Many of the new cultivars tested in this study have desirable attributes such as improved winter hardiness, enhanced turf color, and faster establishment rates, which may make them desirable for future use among Arkansas turf producers. Results from this study are intended to help residents of Arkansas make informed decisions when selecting turfgrass cultivars.

Abbreviations: DIA, digital image analysis

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Saint Augustinegrass (*Stenotaphrum secundatum*) is a common lawn turf in Florida and Texas that has wide leaf blades and spreads by stolons. Saint Augustinegrass can make a quality lawn grass, but is undesirable for sports turf and golf due to its inability to tolerate low mowing heights, poor traffic resistance and recovery. The favored climate for this turf species is warm, subtropical, and tropical climate regions and it is well-adapted to irrigated areas. Currently, St. Augustinegrass is grown in central and southern Arkansas primarily in lawns that are shaded and not suited for bermudagrass. Several cultivars are known to be more winter hardy, disease resistant and chinch bug resistant than others (Busey, 2003). The objective of this study was to evaluate several commercially available and experimental cultivars of St. Augustinegrass in Fayetteville, Ark. to better understand their overall quality. This objective is part of a larger objective to identify winter hardy cultivars that might be well-suited for use in Arkansas.

Materials and Methods

Twenty commercially available cultivars and ten experimental cultivars were established on 30 June 2009. The 3 by 3 inch plugs were grown in the greenhouse from plant material provided by University of Florida, Texas A&M University, Mississippi State University, North Carolina State University, and Double Springs Grass Farm in Searcy, Ark. Raleigh St. Augustinegrass was obtained both from the University of Florida and North Carolina State University and will be referred to as either Raleigh (NC) or Raleigh (FL) throughout the paper. The experimental plots were 4 by 4 ft arranged in a randomized complete-block design with four replications. One plug was planted in the center of each plot. Plots were irrigated as needed to prevent wilting and were fertilized with 1 lb N/1000 ft^2. The plots were not mown so not to disturb stolon growth and weeds were manually removed during establishment. Leaf blade width, and length, and internode length and diameter were measured on the third oldest leaf (on three different tillers in each plot) with a 6-inch digital caliper on 24 August 2009, two months after planting. Digital images were taken using a portable light box to provide a consistent light source for collecting images. Turfgrass color from the images was determined by quantifying the dark green color index (DGCI) as described by Karcher and Richardson (2003). The blue hue levels for the color of each cultivar were analyzed to help differentiate cultivars as some cultivars appear to have a blue-green color whereas others typically have a yellow-green color.

Results and Discussion

Stolon internode length and diameter varied among cultivars (Table 1). Jade, 904AT2, Sunclipse, 106T3, and SV27 had the shortest stolon internodes, while Floratam, FX-10, and Mercedes had the longest stolon internodes. Captiva and Sunclipse had the smallest stolon diameter, while Bitterblue, Floralawn, and Floratam had the largest stolon diameter.

Leaf characteristics also varied among cultivars (Table 1). Seville, Sunclipse, 904AT2, Captiva, Deltashade, Palmetto, 106G3, SV27, DALSA0406, Jade, Majestic, Amerishade, and 106T3 had the shortest leaves, and Floratam had the longest leaves. Majestic, Raleigh (FL), Jade, 106G3, Sunclipse, Floraverde, Amerishade, 106T3, and Captiva were among the group with the narrowest leaves (finest texture). Delmar, Floralawn, Floratam, TAES5714, Bitterblue, FX-10, and Raleigh (NC) were among a group with the widest leaves (coarsest texture). Cultivars with short internode lengths and short leaves are typically grouped as dwarf types and are more popular among some homeowners because they usually tolerate lower mowing heights.

FX-10 had the darkest green color, while Texas Common, Deltashade, Sapphire, Raleigh (FL), GF, Raleigh (NC), TAES5714, Palmetto, and Mercedes were among the group with the lightest green color (Table 1). FX-10, SV27, Jade, Floratam, and 904AT2 were significantly similar with the highest blue color levels (Table 1). Texas Common, Classic, GF, TAES5714, Captiva, Raleigh (FL), MSA2-3-98, Raleigh (NC), Deltashade, Sapphire, Delmar, Mercedes, and Floraverde had the lowest blue color levels. A lighter blue color (higher blue levels) are evident in turf with a blue-green color rather than a yellow-green color. To help visualize these differences in color among St. Augustinegrass, the blue color levels of FX-10 and Floraverde as well as images of these cultivars are provided (Fig. 1). These represent the cultivars with the lowest and highest mean value for blue color levels.

Raleigh St. Augustinegrass is a cultivar known for its excellent cold tolerance (Philley et al., 1996). Raleigh was collected from a home lawn in Raleigh, N.C., developed by Dr. W.B. Gilbert at North Carolina State University, and released in the early 1980s (Milla-Lewis et al., 2009). The Raleigh St. Augustinegrass used in this study was obtained both from the University of Florida and North Carolina State University. Although both should be genetically identical, recent research has indicated that not all plant material sold as Raleigh St. Augustinegrass is genetically similar (Milla-Lewis et al., 2009). In our study, these two collections of Raleigh St. Augustinegrass did not have similar stolon diameter or internode length, but they did have similar leaf width and length as well as leaf color.

Raleigh St. Augustinegrass is available at four sod farms in Arkansas (Patton et al., 2008). It is unclear whether the Raleigh St. Augustinegrass being sold in Arkansas is genetically similar to that released by North Carolina State University, but it is very likely considering that it has performed well during winters in Little Rock. Palmetto, Majestic and Texas Common St. Augustinegrass are also grown in Arkansas (Patton et al., 2008). Many of the new cultivars tested in this study have desirable attributes such as improved winter hardiness, dark green color, and faster establishment rates, which may make them desirable for future use among Arkansas turf producers. Results from this study are intended to help residents of Arkansas make informed decisions when selecting turfgrass cultivars. Planting well-adapted cultivars will improve turfgrass quality, and reduce reestablishment cost from winterkill and ultimately increase sustainability. The winter survival of these cultivars will be assessed in spring 2010.

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Table 1. Stolon diameter, internode length, leaf width, length and color of St. Augustinegrass cultivars planted 30 June 2009 in Fayetteville, Ark.

Cultivar	Stolon diameter	Stolon internode length	Leaf width	Leaf length	Dark green color index	Blue color levels
	---------------------------mm---------------------------					0 to 255
106G3	3.0 j-m [x]	29.5 k-n	7.1f-j	45.5 e-j	0.720 b	62.2 b-e
106T3	3.4 efg	22.0 q	6.5ij	35.0 j	0.710 bcd	62.5 b-e
904AT2	2.9 klm	22.9 pq	7.4c-i	48.4 d-j	0.709 b-e	63.2 a-e
Amerishade [z]	2.9 lm	34.3 g-j	6.8hij	37.0 ij	0.702 b-h	61.7 b-f
Bitterblue [z]	4.3 a	37.9 e-h	8.2abc	70.9 b	0.715 bc	58.5 c-h
Captiva [z]	2.8 mn	27.4 mno	6.4j	48.1 d-j	0.704 b-g	53.9 g-k
Classic [z]	3.1 i-l	32.0 i-l	7.7b-g	57.9 b-g	0.683 e-j	54.6 f-k
DALSA 0406	2.9 klm	42.6 bcd	7.5c-h	41.6 g-j	0.688 c-j	58.6 c-h
Delmar [z]	3.8 cd	33.8 h-k	8.9a	66.0 bc	0.684 d-j	48.5 jk
Deltashade [z]	3.2 f-j	33.8 h-k	7.5c-h	46.1 d-j	0.675 h-k	51.5 ijk
FX-10	3.9 bc	46.2 ab	8.1a-d	57.9 b-g	0.759 a	70.1 a
Floralawn [z]	4.2 a	40.9 cde	8.4ab	69.4 bc	0.701 b-i	59.0 c-g
Floratam [z]	4.1 ab	48.3 a	8.4ab	87.5 a	0.692 c-j	63.6 a-d
Floratine [z]	3.3 f-j	31.2 j-n	7.7b-g	59.2 b-g	0.683 d-j	57.2 d-i
Floraverde [z]	2.9 klm	31.6 i-m	6.8g-j	54.5 c-h	0.690 c-j	48.0 k
GF	3.3 f-j	26.8 nop	7.5c-h	57.9 b-g	0.672 jk	54.4 g-k
Jade [z]	2.9 klm	23.5 opq	7.1f-j	40.6 hij	0.708 b-f	65.4 abc
MSA 2-3-98	3.3 f-i	32.1 i-l	7.4c-i	57.2 b-g	0.681 f-j	52.0 g-k
Majestic [z y]	3.1 h-k	32.5 ijk	7.2d-j	40.3 hij	0.689 c-j	59.0 c-g
Mercedes [z]	2.9 klm	44.0 abc	7.4c-i	53.0 c-i	0.653 k	48.1 jk
Palmetto [z y]	3.2 f-j	32.4 i-l	7.4c-h	45.8 d-j	0.667 jk	56.4 e-i
Raleigh [z y] (NC)	3.6 de	38.2 d-h	8.1a-e	62.1 bcd	0.670 jk	52.0 h-k
Raleigh [z y] (FL)	3.2 g-k	27.9 l-o	7.2e-j	61.4 b-e	0.672 jk	53.3 g-k
SV27	3.3 f-j	22.0 q	8.0b-e	42.5 f-j	0.701 b-i	68.6 ab
Sapphire [z]	3.3 f-j	43.6 bc	7.9b-f	63.7 bc	0.674 ijk	50.4 ijk
Seville [z]	3.3 f-j	34.5 g-j	7.6b-h	49.4 d-j	0.681 f-j	56.7 d-i
Sunclipse [z]	2.6 n	22.8 pq	7.0f-j	48.8 d-j	0.687 c-j	55.1 f-j
TAES 5714	3.4 ef	38.6 d-g	8.2abc	53.5 c-h	0.668 jk	54.1 g-k
Texas Common [z y]	3.6 de	36.1 f-i	7.7b-h	57.5 b-f	0.681 g-k	54.9 f-k
WS	3.4 e-h	39.7 c-f	7.8b-f	54.3 c-h	0.688 c-j	56.2 e-i
Average	3.3	33.6	7.6	53.8	0.690	57.0

[z] Commercially available in 2009.
[y] Commercially available in Arkansas in 2009.
[x] Within column, values followed by the same letter are similar (α=0.05).

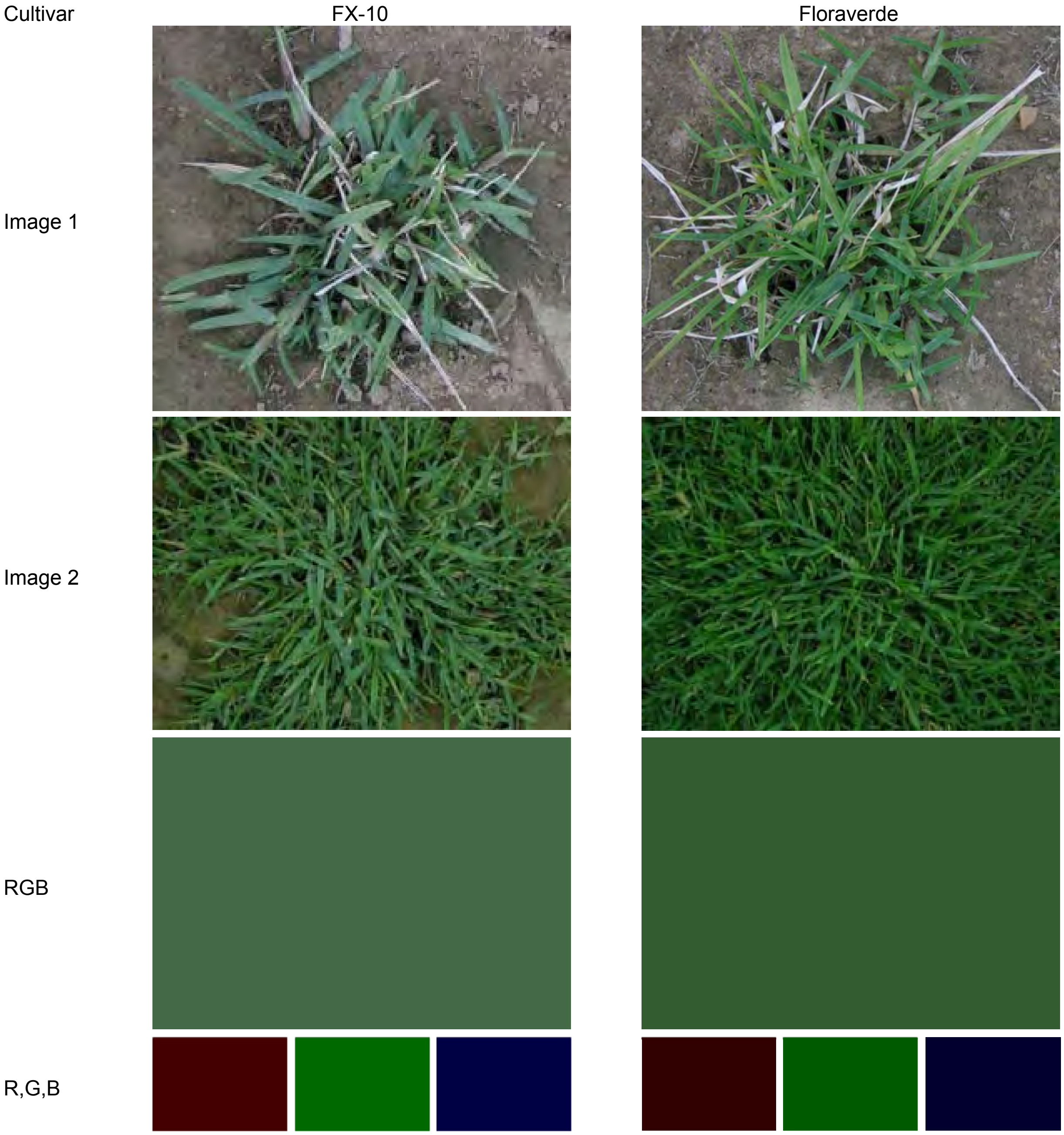

Fig. 1. Color of FX-10 compared to Floraverde St. Augustinegrass. Color is shown using plot images, the red, green, blue (RGB) index as well as showing the blue (B) color levels. Images are representative of one replication on one sampling date, whereas RGB and B values are means of four replications across three dates. A lighter blue color (higher B levels) are evident in turf with a blue-green color rather than a yellowgreen color.

Zoysiagrass Performance in Arkansas as Influenced by Nitrogen Rate, Mowing Height, and Cultivar

Aaron Patton[1] and Jon Trappe[1]

Additional index words: Cavalier, El Toro, fertilization, Meyer, *Zoysia japonica*, *Zoysia matrella*

Patton, A. and J. Trappe. 2010. Zoysiagrass performance in Arkansas as influenced by nitrogen rate, mowing height, and cultivar. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:69-73.

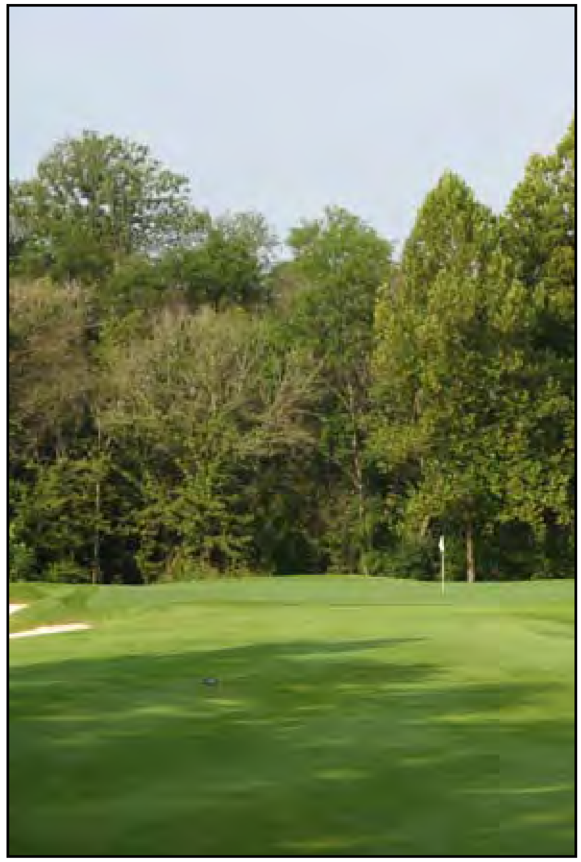

Photo by Aaron Patton

Nitrogen rate and mowing height influences zoysiagrass quality.

Summary. Zoysiagrass is a commonly used turf species in lawns and golf courses in Arkansas, but little information is available regarding the management of these cultivars on golf courses or lawns in Arkansas. The objective of this study was to characterize a general response (color, density, turf quality, and disease incidence) to nitrogen fertilization, mowing, and their interactions among zoysiagrass cultivars. Turf density was improved when fertilizing ≥2 lbs N/1000 ft^2/year. Spring green-up was highest for 0.5-inch mown plots. Among 1.5-inch mown plots, higher nitrogen rates (≥4 lbs N/1000 ft^2/year) decreased spring green-up. Scalping was greatest when mowing at 0.5-inch and fertilizing with 6 lbs N/1000 ft^2/year. There was no advantage to fertilizing more than 2 lbs N/1000 ft^2/year. Turf quality was never unacceptable for the unfertilized check plots.

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Zoysiagrass (*Z. japonica* or *Z. matrella*) is increasing in popularity and availability with over 30 cultivars now commercially available. Zoysiagrass has historically been more widely used on golf courses in the upper transition zone. However, due to better performance of newer cultivars, there has been a recent trend to plant zoysiagrass on golf courses in the lower transition zone and further south. While use has increased, zoysiagrass is typically considered an alternative to bermudagrass for many golf courses in the southern U.S. Therefore, knowledge regarding the management of these new cultivars is critical as they are marketed and recommended for use.

Previous research in Texas found that turfgrass quality during summer was improved with higher nitrogen (N) rates, especially at a lower mowing height, but there were no discernable effects of N and mowing height on winter and spring turf quality (Engelke et al., 1992). Additional research has focused on mowing heights or fertility, but not a combination of the two. In South Carolina, *Z. matrella* had excessive thatch and scalping at high N rates (>3 lb N/1000 ft^2), but thatch was not problematic in *Z. japonica* (Hale, 2006). Others concluded that 2 lb N/1000 ft^2 or less during the growing season was sufficient to maintain turf quality in Missouri (Dunn et al., 1995). However, more information is needed for recommending N rates for *Zoysia* spp. in Arkansas. The objective of this study was to characterize a general response (color, density, turf quality, and disease incidence) to nitrogen fertilization, mowing, and their interactions among zoysiagrass cultivars.

Materials and Methods

Experimental areas were sprigged in 2001 at the Arkansas Agricultural Research and Extension Center, Fayetteville, Ark. with El Toro, Meyer, and Cavalier zoysiagrass. Plots were maintained from 2002 to 2007 using 1 to 2 lb N/1000 ft^2/year on a Captina silt loam with pH of 6.2. Fertilization treatments were initiated in May 2008 using sulfur-coated urea applied at 0, 2, 4, and 6 lb N/1000 ft^2/year applied on May 1, June 1, July 1, August 1, and September 1. No supplemental phosphorus (P) or potassium (K) was applied in either 2008 or 2009 since soil test levels in both years indicated sufficient quantities of those nutrients. Plots were split by block and mown at either 0.5 or 1.5 inch as needed to allow for evaluation at a range of mowing heights. Responses of varying cultivars to fertility programs, and mowing heights were evaluated in 2008 and 2009 as turf quality, density, green-up, scalping, and disease. Turf 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. 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. Scalping and disease were evaluated as visual estimates.

Results and Discussion

Results after two years of this study indicate that turf density is improved through cultivar selection and N fertility (data not shown). Cavalier consistently had greater turf density than Meyer and El Toro. Increasing annual nitrogen applications ≥2 lb N/1000 ft^2 also improved turf density. In the spring of 2009 (after one year of fertility treatments), N rates ≥4 lb N/1000 ft^2/year resulted in a delay in spring green-up and a decline in turf quality at the 1.5 inch mowing height (Fig. 1). This lack of spring green-up and a reduction in turf quality in spring of 2009 did not appear to be damage from winter kill. Instead it appeared to be a delayed green-up possibly due to the fact that the higher nitrogen rates the previous fall produced a denser canopy that shaded emerging shoots in the spring of 2009 causing an apparent decrease in green cover and a decrease in turf quality.

Turf quality was highest in the summer for plots receiving ≥2 lb N/1000 ft^2/year at a 1.5 inch mowing height (Fig. 2), but turf quality was never unacceptable (<6) for the unfertilized check plots in either year. Turf quality was only improved at rates >2 lb N/1000 ft^2/year in the fall due to an improvement in fall color (Fig. 3). There was little scalping in our study; but on one collection date, mowing at 0.5 inch and fertilizing with 6 lb N/1000 ft^2/year resulted in increased scalping (data not shown). Turf quality was generally highest for Meyer and Cavalier across a range of evaluation dates, although all cultivars produced acceptable turf quality (Fig. 4).

These results are in agreement with previous results that zoysiagrass requires little N fertility to produce an acceptable quality turf. One exception might be when growing zoysiagrass on sandy soils with a longer growing season, such as in Florida. In Arkansas, a 2007 informal survey indicated that some golf course superintendents were using upwards of 3.5 lb N/1000 ft^2/year to maintain zoysiagrass fairways. Results for this study indicate that there is no advantage to using more than 2 lb N/1000 ft^2/year. Hopefully, these results, along with similar research in other states will provide necessary information to help fine-tune zoysiagrass management programs and reduce N inputs. This study will continue through 2010. Thatch accumulation and large patch severity will be evaluated in the future.

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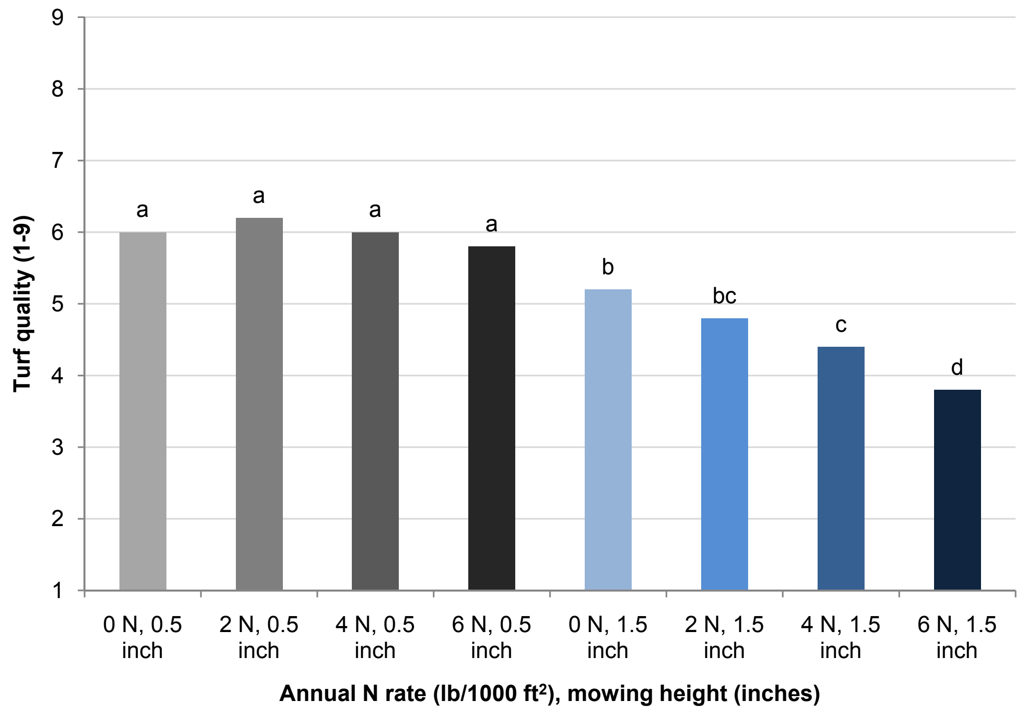

Fig. 1. Influence of mowing height and nitrogen fertility on zoysiagrass turf quality across three zoysiagrass cultivars on 15 May 2009. Means followed by the same letter are not significantly different according to Fisher's protected LSD, α = 0.05.

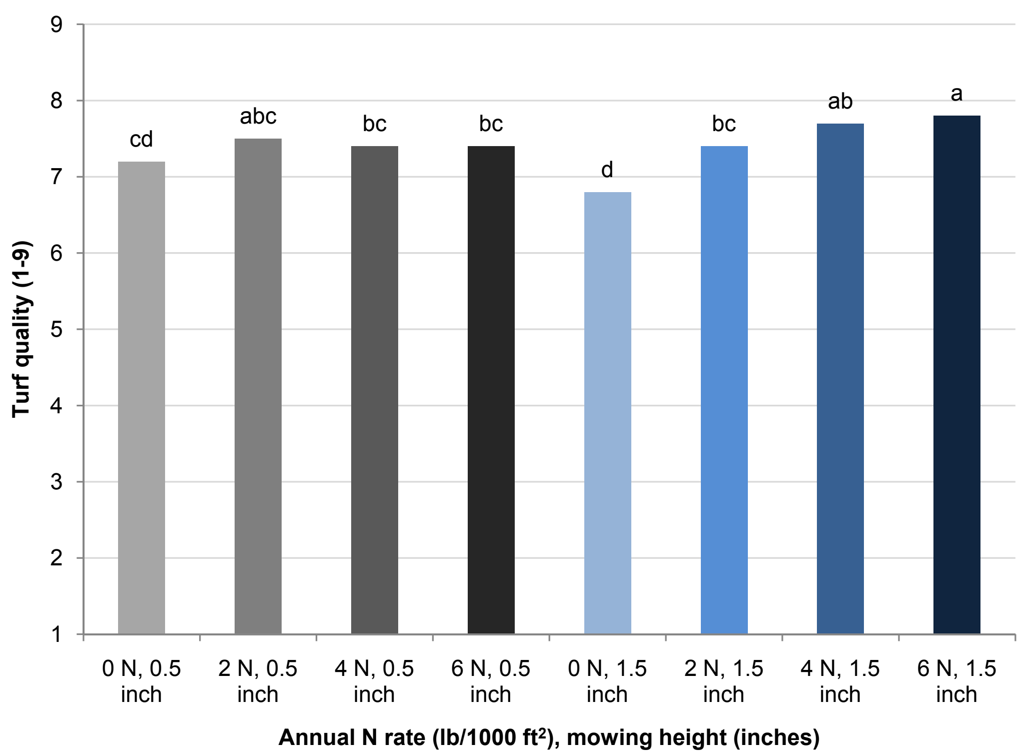

Fig. 2. Influence of mowing height and nitrogen fertility on zoysiagrass turf quality across three zoysiagrass cultivars on 26 August 2009. Means followed by the same letter are not significantly different according to Fisher's protected LSD, α = 0.05.

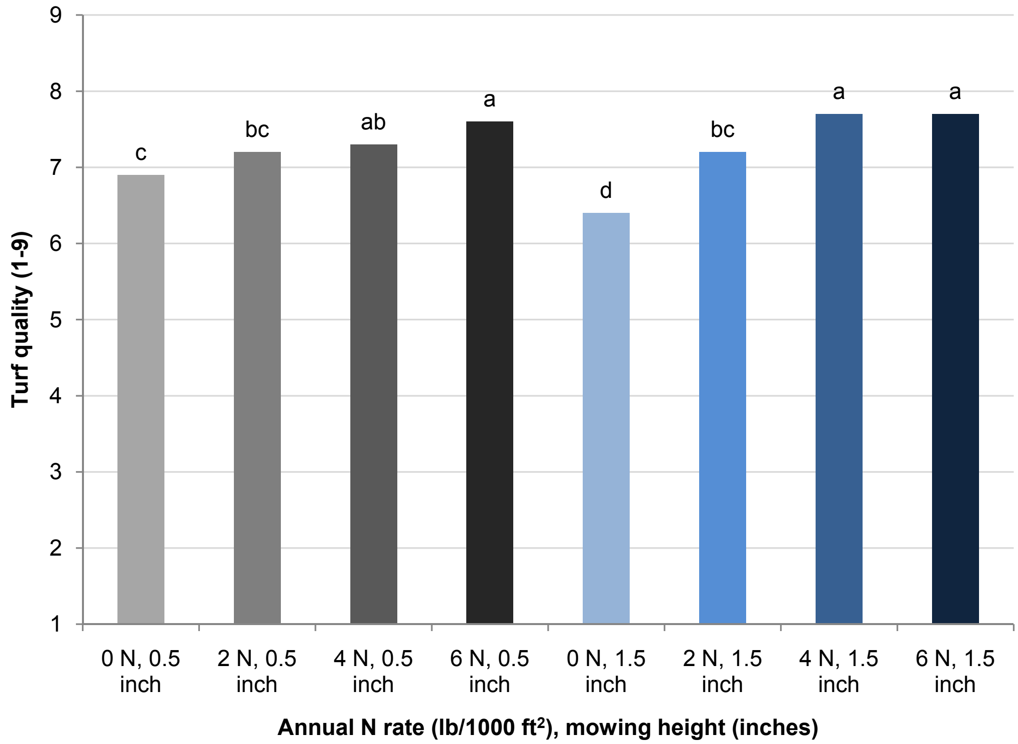

Fig. 3. Influence of mowing height and nitrogen fertility on zoysiagrass turf quality across three zoysiagrass cultivars on 16 October 2009. Means followed by the same letter are not significantly different according to Fisher's protected LSD, α = 0.05.

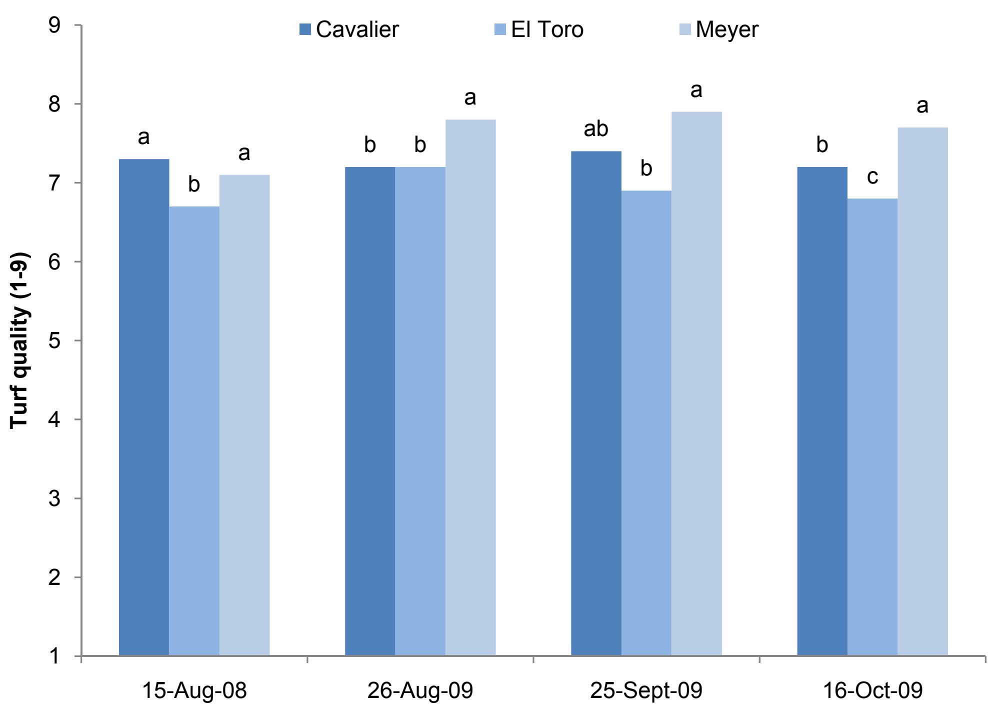

Fig. 4. Influence of cultivar on turf quality across four rating dates. Within date, means followed by the same letter are not significantly different according to Fisher's protected LSD, α = 0.05.

Zoysiagrass Growth as Influenced by Nitrogen Source in a Greenhouse Trial

Aaron Patton[1], Jon Trappe[1], and Antonio Pompeiano[2]

Additional index words: *Zoysia japonica*, *Zoysia matrella*, fertilization, nitrate, root, stem, urea

Patton, A., J. Trappe, and A. Pompeiano. 2010. Zoysiagrass growth as influenced by nitrogen source in a greenhouse trial. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:74-76.

Photo by Aaron Patton

Nitrogen source influences the growth of zoysiagrass in controlled environment conditions.

Summary. Zoysiagrass (*Zoysia* spp.) has a modest response to nitrogen (N) fertilization, especially during establishment, and there is no indication about its preference for mineral form. A greenhouse study was conducted to determine the effect of urea and nitrate as nitrogen sources on zoysiagrass. Plants were planted in sand and treatments were applied with a nutrient solution at five urea:nitrate ratios (100:0, 75:25, 50:50, 25:75, 0:100). Results of growth analysis indicate that zoysiagrasses prefer a solution with a 50:50, 75:25, or 100:0 ratio with ≥50% urea. Root and stem mass were higher in treatments with urea. This study demonstrates that zoysiagrass' preference for N form affects growth when grown in a sand rootzone, which could lead to reduced N inputs and/or improved establishment in these soils.

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Despite zoysiagrass (*Zoysia* spp.) having modest responses to nitrogen (N) fertilization, especially during establishment (Richardson and Boyd, 2001), no information about the preference for mineral form is available. Nitrogen source has been documented to influence growth in creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) (Glinski et al., 1990; Schlossberg and Schmidt, 2007). Fertilizing with the majority of N as nitrate improved growth and rooting of creeping bentgrass (Glinski et al., 1990), whereas an annual bluegrass/bentgrass mixture preferred applications with the majority of N as ammonium (Schlossberg and Schmidt, 2007). To date, no one has examined the effect of urea:nitrate ratio on zoysiagrass leaf growth, color, and rooting, but an anecdotal report found that urea and ammonium sulfate resulted in superior shoot growth compared to ammonium nitrate (Hwang et al., 1991), suggesting that zoysiagrass may favor ammonium and urea N sources. Fertilizing zoysiagrass with the appropriate urea:nitrate N source could have a dramatic effect on rooting, growth, and color that could lead to reduced N inputs. A greenhouse study was conducted with the objective to determine how nitrogen source affects the growth and rooting of zoysiagrass cultivars.

Materials and Methods

Based on previous research (Patton et al., 2007), one slow-growing and one fast-growing cultivar of both *Zoysia japonica* and *Z. matrella* were selected and assessed for this experiment. *Zoysia japonica* cultivars El Toro (fast-growing) and Meyer (slow-growing) and *Z. matrella* cultivars Zorro (fast-growing) and Diamond (slow-growing) were clonally propagated as phytomers (1- to 2-cm segment of stolon or rhizome) containing root tissue, crown, and shoot material. Cultivars were planted in USGA specification sand-filled 3.8-cm diameter cone-tainers. The growth medium was rinsed twice with deionized water before planting to flush any nitrogen prior to planting.

The experiment was conducted twice in the greenhouse. Experimental replication 1 was planted 24 October 2008 and experimental replication 2 was planted 23 February 2009. Plants were watered daily for 1 wk after planting to prevent wilt during establishment. One week after planting, uniform plants were selected and randomly assigned one of five N treatments. Each plant was supplied 3 times weekly with a half-strength modified Hoagland nutrient solution (pH 6.50 ± 0.05) containing the appropriate ratios of urea:nitrate (100:0, 75:25, 50:50, 25:75, 0:100) and equivalent concentrations of other minerals. Cone-tainers were arranged in a randomized complete block design with 4 cultivars, 5 nitrogen treatment ratios, and 10 replications per trial. Treatments were applied for 10 wk until harvesting.

Whole plants were harvested 10 wk after treatment initiation and separated into root fraction, leaf fraction, and stem fraction (inclusive of stems, crowns, rhizomes, and stolons). Root and stem tissues were washed with water to remove the majority of sand, and then all tissues were dried separately (at least 72 h at 60 °C) and weighed. Prior to drying, root tissues were analyzed with WinRhizo (Regent Instruments Inc., Quebec, Canada) for root morphological characteristics.

Results and Discussion

Cultivar had a significant impact on several measurements including leaf, stem, and root weight, root density, root length, root surface area, root diameter, root volume, root tips, and the proportion of long, short, fine, and coarse roots (data not shown). For all these effects, the relative cultivar rankings of the treatments were typically as follows: El Toro > Meyer > Zorro > Diamond, which are similar to previous reports on the leaf and stem growth of these cultivars (Patton et al., 2007).

Nitrogen source impacted stem, root, and whole plant mass with increased growth resulting from applications containing ≥50% urea (Table 1). There was a cultivar by N source interaction for stem weight measurements, where 100% urea or 75:25 (urea:nitrate) produced the highest amount of stems for all cultivars except El Toro (data not shown). This could be due to El Toro's reported preference for alkaline soils, as plants with a preference for alkaline soils are known to prefer nitrate N (Marschner, 1995).

Nitrogen source also impacted root diameter and the ratio of fine:coarse roots (Table 1). Applications containing ≥50% urea had the highest root diameter. Similarly, fine:coarse root diameter ratio was high from applications containing <50% urea. Nitrogen source did not affect leaf mass, root length, root surface area, root volume, root tips, short roots, long roots, fine roots, or coarse roots.

It is not clear why solutions with greater percentages of urea improved plant growth compared to 75 or 100% nitrate solutions. Uptake rate is known to differ among N form in some plant species (Marschner, 1995), but uptake was not measured in our study. Nitrogen source preference is known to vary by plant species (Marschner, 1995). This is the first report of a preference for urea nitrogen among zoysiagrass cultivars. Preliminary field research comparing ammonium nitrate, calcium nitrate, and urea indicates that increased zoysiagrass growth in sand in the greenhouse from applications of urea may not occur in native field soils.

Results of growth analysis indicate that zoysiagrasses prefer a solution with a urea:nitrate ratio with ≥50% urea. Whole plant, root and stem mass were higher in treatments with urea. No specific difference among treatments was noticed for root volume, number of root tips, or root density. This study demonstrates that zoysiagrass' preference for N form affects growth when grown in a sand rootzone, which could lead to reduced N inputs and/or improved establishment in these soils. Zoysiagrass growth (stem, root, whole plant, root diameter) was increased with a higher proportion of urea N instead of nitrate N when grown in sand, but preliminary field research indicates that this relationship may not occur in native field soils.

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Table 1. Effect of ratios of urea:nitrate (100:0, 75:25, 50:50, 25:75, 0:100) in a modified Hoagland's solution on whole plant mass, stem mass, and root characteristics across four zoysiagrass cultivars.

Nitrogen ratio	Whole plant mass	Stem mass	Root mass	Root diameter	Fine:coarse root diameter ratio
	-------------------	g	-------------------	mm	
100% nitrate	0.77 c[z]	0.436 c	0.083 b	0.249 c	0.804 a
25:75 (urea:nitrate)	0.85 bc	0.494 bc	0.090 b	0.253 bc	0.629 ab
50:50 (urea:nitrate)	1.02 ab	0.584 ab	0.100 ab	0.259 abc	0.616 b
75:25 (urea:nitrate)	1.08 a	0.615 a	0.115 a	0.267 ab	0.493 bc
100% urea	1.07 a	0.607 a	0.114 a	0.273 a	0.432 c

[z] Values in a column followed by the same letter are not significantly different (LSD, $\alpha = 0.05$).

High Frequency Rolling on a Sand-based Putting Green

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Additional index words: creeping bentgrass, *Agrostis stolonifera*, green speed, ball roll distance, quality, water infiltration.

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Photo by Jay Richards

Putting green turf quality declined significantly following six weeks of rolling the plots eight times per day.

Summary. Rolling putting greens is a cultural practice that many golf course superintendents use to increase putting green speed (ball roll distance). At times, circumstances are such that require golf course superintendents to quickly increase green speed, which may be detrimental to turf quality. Little is known about the effects of high-frequency rolling (more than once daily) with a commonly-used greens roller. The objective of this study was to determine the effects of intense rolling frequencies on ball roll distance and putting green quality. Five rolling frequencies were evaluated: no rolling and rolled either one, two, four or eight times per day. At rolling frequencies greater than once per day, ball roll distance increased with increasing rolling frequency. In addition, turf rolled twice per day remained above minimum acceptable quality throughout the study, unlike plots rolled four and eight times per day. Turf quality and water infiltration decreased as rolling frequency increased. Temporary high-frequency rolling may provide a method for rapidly increasing putting green speed without a significant decline in putting green quality.

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Although it is known from previous research that specialized putting green rollers increase green speed (as measured by ball roll distance), it is unclear how high-frequency rolling affects green speed and turf quality. For many years, a standard recommendation for putting green rolling frequency has been no more than three times per week (Nikolai, 2004; Hartwiger et al., 2001; Hamilton et al., 1994), based on research on native soil greens and with older model, heavier rollers. However, it may be possible to roll putting greens with greater frequency without sacrificing turf quality when rolling on sand-based putting greens, especially when using the relatively lighter rollers that are currently commercially available. In a recently completed two-year study, daily rolling provided superior green speeds at a 0.156 inch mowing height compared to unrolled turf at an equivalent height and at a lower height of 0.125 inch (Richards et al., 2009). There may be occasions when a significant increase in putting green speed is needed in a relatively short period of time, such as prior to tournament play. Rolling more than once daily may help in such situations, but little is known about the effects of high-frequency rolling on putting green quality. The objective of this study was to determine the effects of high-frequency rolling on ball roll distance, visual quality, and water infiltration rate on a sand-based putting green.

Materials and Methods

Experimental area. This research was conducted at the University of Arkansas Agriculture Research and Extension Center in Fayetteville, Ark. on a 'Penn-G2' creeping bentgrass putting green that was constructed according to United States Golf Association specifications (USGA, 1993). Mowing, fertilization, growth regulator and pesticide applications, 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 the region. Plots were mowed 6 days per week at a height of 0.125 inch. Nitrogen, phosphorous, and potassium were applied with 0.5, 0.05, and 0.5 lb per 1000 ft^2 per month of active growth, respectively. Trinexapac-ethyl (TE) (PrimoMaxx 1 EC, Syngenta Group Comp., Wilmington, Del.) growth regulator was applied monthly throughout the growing season at the label rate. Plots were sand-topdressed lightly, twice monthly, with sand that matched that of the existing rootzone and brushed into the canopy following application. Irrigation was applied as needed to maintain optimum conditions.

Treatments. This experiment was conducted during a six week period from 15 May through 26 June in 2009. The study consisted of five rolling treatments: zero, one, two, four, and eight times per day. Treatments were applied six times per week and replicated three times in a total of 15 plots (5 by 24 ft each). Rolling treatments were applied using a Tru Turf greens roller (RS48-11C Golf Roll 'n' Spike, Tru-Turf Rollers, Ernest Junction, Queensland, Australia).

Evaluations. Green speed was evaluated weekly by measuring ball roll distance with a Pelzmeter (Pelz, 2002). On each plot, three golf balls were rolled in one direction, and then rolled back in the opposite direction. The six resultant ball roll distances were then averaged to determine a single ball roll distance for each plot. Each plot was also evaluated weekly for turf quality on a visual scale from 1 to 9, with 1 being poor, 6 being minimum acceptable quality, and 9 being exceptional. Water infiltration measurements were conducted at the conclusion of the study to estimate the compaction of the surface layer of the plots. Infiltration was measured using a double-ring infiltrometer with an inside diameter of 6 inches (Turf-Tec Double-Ring Infiltrometer, Turf-Tec International, Tallahassee, Fla.) and a mariotte siphon (Gregory et al., 2005).

Results and Discussion

Ball roll distance. As rolling frequency increased, ball roll distance also significantly increased (Fig. 1). Three days after initial treatments were applied, plots rolled four and eight times per day produced significantly faster green speeds than plots rolled zero and one time per day. Eleven days after initial treatments were applied, all plots that were rolled were significantly faster than plots that were not rolled. At 36 days after initial treatment application, all plots rolled eight times per day had the fastest green speeds; however, these speeds were not achieved until visual quality was unacceptable. With the exception of 36 days after initial treatments, rolling two times per day produced comparable ball roll distances to rolling four and eight times per day. Increases in green speed could have occurred more as a result of the thinning of the turf that occurred towards the end of the study on plots rolled eight times per day than a smoother putting surface. Thinner turf would offer less resistance to the ball than a healthy stand of turf. Therefore, a rolling frequency of two times per day maximized the benefit in ball roll distance.

According to this study, high-frequency rolling is a reliable cultural practice to increase putting green speeds in a short amount of time. Rolling four and eight times per day produced the fastest greens in the shortest amount of time. However, at eleven days after initial treatment, plots that were rolled two times per day were producing similar green speeds compared to plots rolled four and eight times per day. According to this study, in as little as three days, golf course superintendents can significantly improve their putting green speeds by implementing a high-frequency rolling program when preparing for events that require faster putting greens.

Visual quality. Plots rolled zero and one time per day did not differ in turfgrass quality on any evaluation date (Fig. 2). However, when averaged over all evaluation dates, plots rolled zero and one time per day had better visual quality than all other treatments, and turf quality decreased with increasing rolling frequency for plots rolled two, four, and eight times per day. All treatments remained above acceptable quality until 11 days after initial treatments were applied. At that point, plots rolled eight times per day had unacceptable quality. At 30 days after initial treatments, plots rolled four times per day declined to below acceptable quality. All other rolling treatments remained above acceptable quality throughout the study. Plots rolled once per day did not experience a decline in quality. Based on these results, golf course superintendents who are willing to sacrifice some turfgrass quality for improved green speed can roll as often as twice per day and see improvements in green speed compared to just once per day, and produce turf quality that remains above acceptable.

Water infiltration. There was a significant decrease in water infiltration as rolling frequency increased. Plots that were not rolled had a mean water infiltration rate of 22 inch/h compared to 8 inch/h for plots rolled eight times per day (Fig. 3). Though there were significant decreases in water infiltration rates as rolling frequency increased, infiltration rates for plots rolled eight times per day remained acceptable, and above USGA recommended saturated hydraulic conductivity rates (>6 inch/h) for a putting green constructed according to USGA specifications (USGA, 1993) and would likely drain adequately during heavy rain events.

These results indicate that a high-frequency rolling program can be used to significantly increase putting green speed in a short period of time. In addition, high-frequency rolling can be done for several days without producing unacceptable quality or infiltration rates that are detrimentally low. Therefore, golf course superintendents can implement higher-frequency rolling programs (2 times per day) for up to five weeks to maximize increases in green speed without decreasing turf quality or water infiltration below acceptable levels. This may be an important management practice when rapid increases in green speed are desired, such as prior to tournament play.

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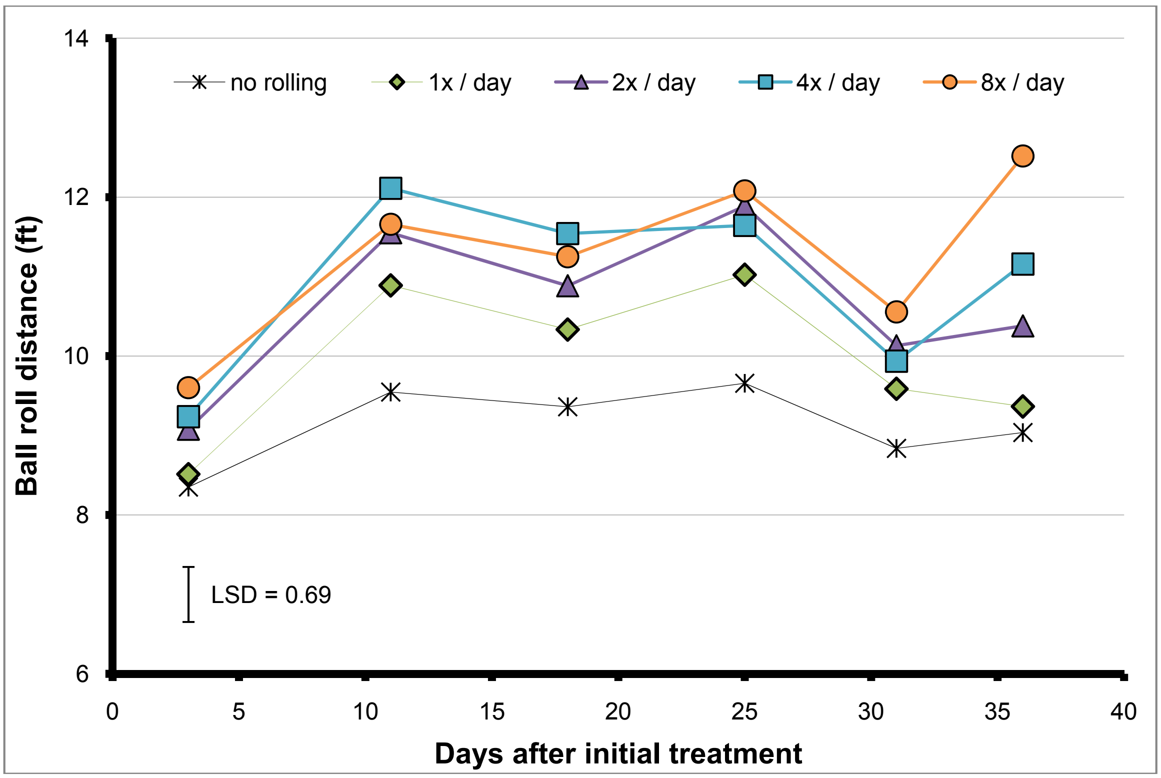

Fig. 1. Ball roll distance as affected by rolling frequency. Error bar represents Fisher's LSD (α = 0.05).

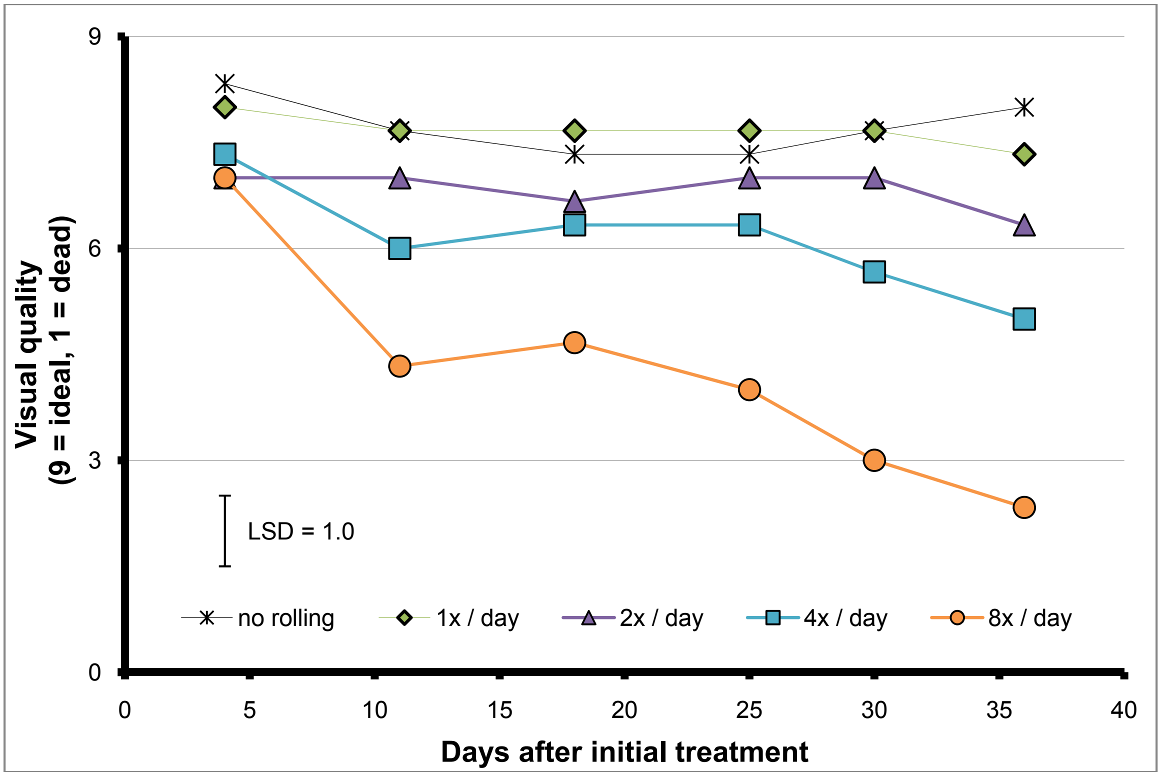

Fig. 2. Visual turf quality as affected by rolling frequency. Error bar represents Fisher's LSD ($\alpha = 0.05$).

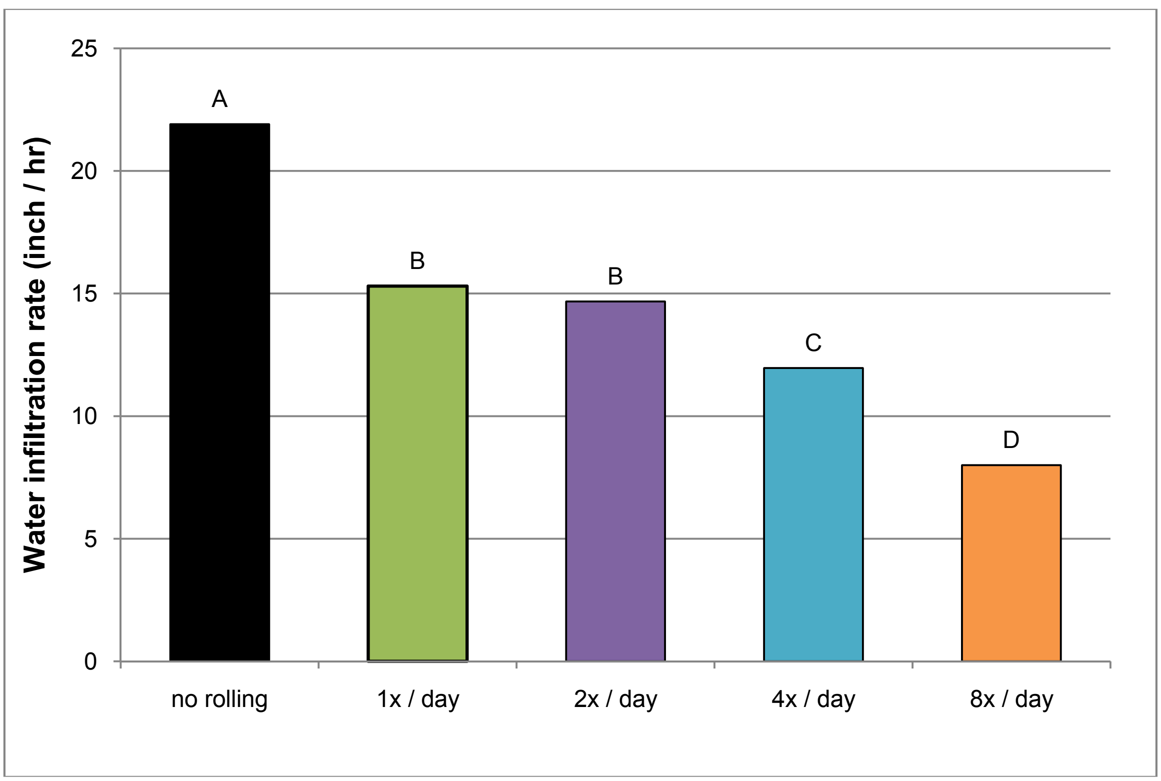

Fig. 3. Water infiltration rate as affected by rolling treatment. Measurements were taken six weeks after initial rolling treatments. Bars sharing a letter are not significantly different ($\alpha = 0.05$).

Ammonia Volatilization Following Foliar Application of Various Liquid and Granular-soluble Nitrogen Sources to Putting Green Turf

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

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Photo by Josh Landreth

Partial view of the experimental area after foliar N treatments were spray-applied and ammonia volatilization chambers were installed within each plot.

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 (NH_3) volatilization from a creeping bentgrass putting green following the application of various foliar N sources commonly used by local golf course superintendents. Regardless of label rate indicated on each liquid or soluble foliar fertilizer source, each product was mixed with deionized water and applied at a common rate of 0.25 lb N/1000ft^2. Applications were made once per year in late August/early September of 2007 and 2008 to a 'Penn G-2' creeping bentgrass putting green. Ammonia volatilization over a 24 h period was measured via boric acid trapping. Percentages of N applied and lost via NH_3 volatilization, when averaged across years, were less than one percent for each source used in this study. Attempts were made to utilize environmental conditions that would exacerbate NH_3 volatilization potential. Therefore, the results from our field trial suggest that, regardless of fertilizer source or chemical form, foliar N application (typical N rates) to putting green turf can be made without concern for substantial N loss via volatilization.

Abbreviations: N, nitrogen; NH_3, ammonia; 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 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 comparably less research attention. Some investigations into NH_3 volatilization from turfgrass stands have been reported, as shown in Turner and Hummel (1992); however, no such studies are known to be specific to N loss from the putting green turfgrass canopy following the application of different foliar-applied N sources. Characteristics inherent to foliar fertilization, such as liquid/soluble 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 or rootzone phenomena. Therefore, ammonia volatilization should be the most important N-loss mechanism associated with typical N foliar fertilizer 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 foliar applications of various products obtained from local golf course superintendents who use them for putting green nutrition.

Materials and Methods

This field research study was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. An experimental area of 'Penn G2' creeping bentgrass (*Agrostis stolonifera*) 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 treatment and application date.

Nine different N sources were collected from golf course superintendents in Arkansas who had previously indicated use of these selected products as foliar treatments on their golf course putting greens. These fertilizer products, along with a control (deionized water), made up our foliar treatments for 2007 and 2008 application dates (Table 1). Applications were made on 29 August 2007 (88 °F max air temperature) and repeated the next year on 7 September 2008 (85 °F max air temperature) to 2 ft by 4 ft plots with 6 inch borders. Foliar N application timing was selected during late August or early September when air temperatures would be expected to increase ammonia volatilization potential. Admittedly, air temperatures were higher at other times during each year, but timing and scheduling application events to coincide with the warmest days proved difficult. Foliar N was applied in 58 gallons/acre 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. For a 24 h period after treatment, plots received no irrigation or rainfall.

Regardless of the label rate indicated on the various liquid or soluble foliar fertilizer sources, products were mixed to achieve a common rate of 0.25 lb N/1000 ft^2 for each N source treatment. This application rate was selected because it was considered to be a foliar N rate on the higher end of what would commonly be used by golf course superintendents. Based on enzyme kinetics, an 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.

Estimates of ammonia 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

Due to a lack of homogeneity between the 2007 and 2008 data, statistical analysis was performed separately for each year. Percentages of N applied and lost via NH_3 volatilization were significantly ($P \leq 0.05$) affected by foliar N source in 2007, but this factor was not statistically significant in 2008. Numerical values of N lost via NH3 volatilization after application of the various fertilizer sources were very small and ranged from 0.0% to 1.4% (Table 1). Therefore, even though there were some statistical differences among the foliar N sources based on computational analysis of 2007 data, it is questionable whether these differences are meaningful and even worth noting for further discussion.

Overall, our data suggest that NH_3 volatilization from foliar N application may not be a significant N loss mechanism (Table 1). 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, along with pre-selecting dates of application to correspond with higher ambient temperatures, the largest N loss observed within any single acid trap sample among our treatments was only 1.4% of the N applied.

Comparing our results to NH_3 volatilization loss previously reported using foliar applications of urea (Wesely et al., 1987), we observed much lower numbers with our methodology and experimental parameters. The lower N rates used in this study, which are typical of putting green foliar fertilizer applications, could be the reason for this discrepancy. Wesely et al. (1987) applied foliar rates of 0.35 lb N/1000 ft^2 and 0.7 lb N/1000 ft^2 to higher cut Kentucky bluegrass and reported volatile losses in the range of 35%. 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 a very receptive environment for foliar absorption of N compounds. Rapid foliar uptake of N, which has been previously reported in our other foliar fertilizer studies (Stiegler et al., 2009b; Stiegler et al., 2009c), also has the capacity to limit NH_3 volatilization as a result of N transformations taking 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), this study along with another two-year investigation using only urea (Stiegler et al., 2009a) do not support these statements. Since this study isolated late summer month applications in both years, when air temperature maximums were close to 90 °F and these are conditions known to exacerbate

NH_3 volatilization, data obtained were believed to be a worst-case scenario to gauge the extent of volatilization potential. Therefore, the results from our field trials suggest that foliar applications (using common N rates ≤0.25 lb N/1000 ft^2) to putting green turf, regardless of N source or chemical form, can be made to actively growing plant tissue throughout the season without concern for substantial N loss via volatilization.

It should be noted, however, that a post-experiment analytical check of our field apparatus, using $^{15}NH_3$ alkali liberation from $^{15}(NH_4)_2SO_4$ solutions of known N mass, revealed that the NH_3 trapping efficiency of boric acid traps housed within our chambers was less than quantitative (data not shown). Interestingly, the creeping bentgrass tissue enclosed within the volatilization chambers was as comparable in sink strength for NH_3 gas as the boric acid traps. In other words, due to the potential for turfgrass leaf tissue to directly absorb some of the NH_3 floating off the plant canopy through stomata, adjusting our data by increasing two to three-fold may be warranted. Due to the very low initial percentages of applied N lost via volatilization (Table 1), even after such manipulation, we are confident that our studies still allude to a minimized potential for volatile loss following application of various foliar-applied N forms to creeping bentgrass putting greens.

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Table 1. Percentage of N applied and lost via ammonia volatilization, during the initial 24 hours after fertilization, as affected by foliar N source during 2007 and 2008 experimental dates.

Foliar N source	29 August 2007	7 September 2008
	---%---	
Urea (46-0-0)	1.41	0.18
Anderson's (28-5-18)	1.10	0.08
PBI Gordon Ferromec (15-0-0)	1.05	0.00
Ammonium sulfate (21-0-0)	0.99	0.00
Coron (10-0-11)	0.96	0.19
Floratine Carbon Power (24-0-0)	0.92	0.35
Plantex (12-0-44)	0.89	0.00
Emerald Isle Seaquential (7-0-1)	0.86	0.39
Control (DI H_2O)	0.86	0.00
Earthworks Calvantage (6-0-0)	0.75	0.43
$LSD_{0.05}$[z]	0.16	NS

[z] Least significant difference at 0.05 probability level can be used to compare means within an experimental date; ns = not significant.

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

Golf Ball Lie Differs Among Bermudagrass and Zoysiagrass Cultivars – Year 2

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

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

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Photo by Jon Trappe

Golf ball lie varies by cultivar.

Summary. Bermudagrass and zoysiagrass are two of the most commonly used turfgrass species on golf course fairways and tees in the southern U.S. However, there are few reports comparing commonly used cultivars of bermudagrass to commonly used cultivars of zoysiagrass. Because golf ball lie is an important characteristic of playability and management of bermudagrass and zoysiagrass fairways, research was conducted to compare ball lie among five cultivars of bermudagrass and seven cultivars of zoysiagrass. Ball lie was similar for all cultivars immediately following mowing. The cultivars Tifsport, Tifway, and Patriot bermudagrass, and Diamond and Meyer zoysiagrass had the best ball lie after four days of growth, while Palisades zoysiagrass had the poorest ball lie after four days of growth. These results will assist golf course managers in selecting cultivars of bermudagrass and zoysiagrass for golf course fairways or tees that have an improved golf ball lie.

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

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Bermudagrass (*Cynodon* spp.) and zoysiagrass (*Zoysia* spp.) are the predominant turfgrass species used on golf course fairways and tees in Arkansas. Little is known about the ball lie characteristics of bermudagrass and zoysiagrass cultivars. The position at which a golf ball comes to rest in a turf canopy greatly influences how a golfer will attempt their next shot. A golf ball that rests on top of the canopy provides golfers increased control over golf shots (Lowe, 2008). Beard and the United States Golf Association (2002) cited turfgrass species, cultivar, and shoot density as determining factors for ball lie. Others have also stated zoysiagrass provides an enhanced golf ball lie for players to make their shot (Hurley, 1976; Bevard et al., 2005).

Researchers at the University of Arkansas recently developed a method to measure golf ball lie using digital image analysis (Richardson et al., 2010). This method was evaluated on the 2002 bermudagrass and 2002 zoysiagrass National Turfgrass Evaluation Program trials. Little differences among cultivars of bermudagrass and zoysiagrass were reported for plots mown at 0.5 inch, but some differences in golf ball lie were observed for plots mown at 1.0 inch (Richardson et al., 2010). Other work has evaluated the specific management practices that affect ball lie in bermudagrass (Hanna, 2008; McCalla et al., 2008), but none have attempted to quantify differences in ball lie among bermudagrass and zoysiagrass cultivars.

Because golf ball lie is an important characteristic to playability and management of bermudagrass and zoysiagrass fairways, research was conducted to quantify the golf ball lie of bermudagrass and zoysiagrass cultivars. The objective of this research was to quantify the percent of ball exposed (ball lie) for bermudagrass and zoysiagrass 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 inch 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 three dates immediately after mowing and on plots that were not mown for four days. Three golf balls were randomly rolled onto each plot and the amount of ball exposed above the turf canopy was measured using a device developed at the University of Arkansas (Richardson et al., 2010). Each golf ball was considered a subsample and the three subsamples were collected for each plot on each sampling date.

Results and Discussion

Mown turf. Differences existed among cultivars and species of bermudagrass and zoysiagrass for ball lie (percent of ball exposed) in unmown and dormant conditions (Table 1). There were no differences among cultivars and species for ball lie when measured immediately following mowing and ball lie was >90% for all cultivars in mown turf. Richardson et al. (2010) also found greater differences in golf ball lie among bermudagrass and zoysiagrass in taller (1.0 inch) mown turf than turf maintained at fairway height (0.5 inch).

After four days of growth. The cultivars Patriot, Tifsport and Tifway bermudagrass had the best ball lie in June, July, and August when measured four days after the last mowing (Table 1). Palisades zoysiagrass had the poorest ball lie in June, July, and August 2009 after four days of growth. When differences existed between species, bermudagrass had a better ball lie. Cultivar rankings were similar when measured in June, July, and August or when the turf was dormant. Richardson et al., (2010) evaluated golf ball lie within species in different studies on cultivars of bermudagrass and zoysiagrass. Although Richardson et al. (2010) reported no differences in ball lie of Patriot, Princess 77, Riviera, Tifsport, and Tifway bermudagrass at a mowing height of 0.5 inch, there were differences among these same cultivars at a mowing height of 1.0 inch. Patriot, Tifsport, and Tifway had a better ball lie than Princess 77, though all cultivars had similar ball lie to Riviera (Richardson et al., 2010).

Dormant turf. Patriot and Riviera bermudagrass were the only two cultivars with ball lie on untrafficked dormant turf that was higher than Palisades zoysiagrass (Table 1). However, all cultivars had ≥92% ball lie on dormant turf. For discussion purposes, cultivars with ball lies greater than or equal to 90% are considered to have a good ball lie. Although differences existed among cultivars on dormant turf, ball lie above 92% indicated that all of the cultivars and species tested provide a good ball lie in dormant conditions.

More research is needed to correlate the percent of ball exposed to the difficulty of a golf shot. Based upon these results, turfgrass managers looking to increase the window between fairway mowings while maximizing golf ball lie should not plant Palisades zoysiagrass. Additionally, golf ball lie can be maximized in less frequently mowed conditions using the bermudagrass cultivars Tifsport, Tifway, and Patriot, or Diamond and Meyer zoysiagrass. These results will assist golf course managers in selecting cultivars of bermudagrass and zoysiagrass for golf course fairways or tees that contain a good golf ball lie. Selecting a cultivar with a good golf ball lie will not only help to improve playing conditions, but may also reduce labor and fuel costs associated with maintaining a golf course fairway or sports field, since mowing frequency can be reduced.

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Table 1. Ball lie (percent ball exposed) of bermudagrass and zoysiagrass cultivars in both mown and unmown conditions across four dates in 2009.

		4 Jun[z]	13 Jul	31 Aug	4 Jun	13 Jul	31 Aug	17 Mar
Cultivar	Species	Mown			4 days after mowing			Dormant
		%						
Cavalier	ZM[x]	93.4	90.5	91.6	84.9 bcd[y]	81.8 ab	82.0 c	92.8 d
Diamond	ZM	93.5	94.2	94.0	87.0 abc	76.7 b	86.7 abc	93.1 bcd
El Toro	ZJ	94.3	91.9	94.1	83.4 bcd	72.4 b	81.7 c	92.9 cd
Meyer	ZJ	91.9	91.2	91.5	81.9 cd	87.1 a	84.2 abc	92.8 d
Palisades	ZJ	92.6	94.3	93.0	80.0 d	58.6 c	69.8 d	92.0 d
Patriot	CDT	93.3	90.5	94.7	85.4 abcd	79.0 ab	88.5 abc	95.6 a
Princess 77	CD	94.4	94.1	93.1	89.5 ab	73.6 b	83.3 bc	93.9 abcd
Riviera	CD	92.5	93.0	94.7	81.9 cd	81.2 a	85.9 abc	95.0 abc
Tifsport	CDT	93.5	93.8	93.6	92.2 a	78.0 a	92.2 a	93.9 abcd
Tifway	CDT	93.6	93.5	93.5	90.2 ab	77.2 ab	91.4 ab	95.1 ab
Zenith	ZJ	92.3	93.4	93.0	72.0 e	77.6 ab	81.9 c	92.9 cd
Zorro	ZM	93.5	94.3	94.3	80.0 d	72.2 b	82.5 c	93.4 bcd
mean		93.2	92.9	93.4	84.0	76.3	84.2	93.6
Species								
C. dactylon	CD	93.4	93.5	93.9	85.7 ab	77.4	84.6 b	94.4 a
C. dactylon x. *C. transvaalensis*	CDT	93.5	92.6	93.9	89.3 a	78.1	90.7 a	94.9 a
Z. japonica	ZJ	92.5	92.7	92.9	83.9 b	73.9	79.4 c	92.6 b
Z. matrella	ZM	93.4	93.4	93.3	79.3 c	76.9	83.7 b	93.1 b

[z] Ball lie expressed as percent ball exposed.
[x] ZJ = *Zoysia japonica*; ZM = *Zoysia matrella*; CD = *Cynodon dactylon*; CDT = *Cynodon dactylon* × *C. transvaalensis*.
[y] Values in a column followed by the same letter are not significantly different from another (LSD, α = 0.05). On dates where letters do not follow means, all treatments were similar.

Clipping Yield and Scalping Tendency of Bermudagrass and Zoysiagrass Cultivars – Year 2

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

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

Trappe, J., A. Patton, D. Karcher, and M. Richardson. 2010. Clipping yield and scalping tendency of bermudagrass and zoysiagrass cultivars–year 2. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:91-94.

Photo by David Stone

Meyer zoysiagrass fairway mown after several days of growth.

Summary. Bermudagrass and zoysiagrass are two of the most commonly used turfgrass species on golf course fairways and tees in the southern U.S. However, there are few reports comparing commonly used cultivars of bermudagrass to commonly used cultivars of zoysiagrass. Because clipping yield and scalping tendency are important management characteristics of fairways and tees, research was performed on these characteristics among commonly used bermudagrass and zoysiagrass cultivars. Clipping yield and scalping tendency were evaluated on five cultivars of bermudagrass and seven cultivars of zoysiagrass. The cultivars producing the lowest amount of clippings were Diamond and Meyer zoysiagrass, while Tifsport and Tifway bermudagrass, and El Toro, Zenith, Zorro, and Palisades zoysiagrass had the highest amount of clippings. Patriot and Tifsport bermudagrass had the highest scalping tendency. These results will assist golf course managers in selecting cultivars of bermudagrass and zoysiagrass for golf course fairways or tees that produce few clippings and scalp infrequently.

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

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Bermudagrass (*Cynodon* spp.) and zoysiagrass (*Zoysia* spp.) are the predominant turfgrass species used on golf course fairways and tees in Arkansas. Species or cultivars that require less maintenance, such as reduced mowing frequency, are becoming more desirable to turfgrass managers. Research documenting differences in clipping yield among cultivars and species would allow superintendents the ability to choose a cultivar that could provide a reduced frequency for mowing and possibly reduce of the need for plant growth regulators (PGRs). However, more research is needed comparing mowing characteristics for commonly used cultivars of bermudagrass and zoysiagrass.

Scalping has been defined as "the removal of an excessive quantity of green shoots from a turf at any one mowing that result in a stubby, brown appearance due to the exposed stems, stolons, and dead lower leaves" (Beard and Beard, 2005). While Beard and Beard (2005) cite the aesthetic damage scalping causes to a turfgrass sward, it can also affect plant health (Oswalt et al., 1953; Reynolds and Smith, 1962; Biran and Bushkin-Harav, 1981). Another negative aspect of scalping is that it can thin turf and potentially affect the playability of the turfgrass area. A particular cultivar or species that is more prone to scalping will reduce the playability, aesthetics, and overall health of a turf sward. In addition to excessive thatch accumulation, other potential causes of scalping may include mower adjustment errors, infrequent mowing, or an uneven soil surface. The objectives of this research were to determine/evaluate the clipping yield and scalping tendency for bermudagrass and zoysiagrass 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. Plots were maintained under golf course fairway 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. 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 dried for four days in a dryer at 60 °C for dry weight determination.

Scalping was performed during the time of clipping collection and on the same experimental plots. Scalping, 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

Differences in clipping yield existed among cultivars and species of bermudagrass and zoysiagrass (Table 1). Cultivars with the highest clipping yields on 4 June and 31 August were El Toro, Palisades, Zenith and Zorro zoysiagrass and those cultivars with the lowest clipping yields were Patriot, Princess 77, Tifsport, and Tifway bermudagrass. On 13 July, Tifway and Tifsport bermudagrass produced the highest clipping yields, whereas Meyer zoysiagrass had the lowest clipping yield. *Zoysia* spp. produced more clippings than *C. dactylon* × *C. transvaalensis* (hybrid bermudagrass) in early summer (4 June), but *Z. matrella* produced similar clipping yields to *C. dactylon* (common bermudagrass). In late summer (31 August), *Zoysia* spp. yielded more clippings than *Cynodon* spp., while *Cynodon* spp. yielded greater clippings in the middle of summer (13 July). *Cynodon dactylon* and *C. dactylon* × *C. transvaalensis* had similar clipping yields throughout 2009.

Based upon 2009 results, the cultivars consistently producing the lowest clipping yields were Diamond and Meyer zoysiagrass. Conversely, the cultivars producing the highest clipping yields, Tifsport and Tifway bermudagrass and Palisades, El Toro, Zenith, and Zorro zoysiagrass, should be avoided if reduced mowing frequency is desired.

Although there were differences in clipping yield among cultivars of bermudagrass and zoysiagrass, this evaluation does not provide estimates for mowing frequency or leaf extension rate. In particular, these results do not provide turf managers with specific mowing requirements or growth rates that might affect management or playability characteristics.

Differences existed among bermudagrass and zoysiagrass cultivars for scalping on one of the three collection dates (Table 2). Differences in scalping among cultivars existed on 31 August but not on 6 June or 13 July. Patriot and Tifsport bermudagrass were more prone to scalping than other cultivars. *Cynodon dactylon* × *C. transvaalensis* consistently had more scalping than all other species, but this was heavily influenced by Patriot and Tifsport.

Zoysiagrasses in general are less likely to scalp because of their canopy structure and increased chlorophyll content in lower leaves compared to bermudagrass (Biran and Bushkin-Harav, 1981). Field and greenhouse observations suggest that zoysiagrasses produce more leaves lower in the canopy than bermudagrasses, making the actively growing part of the plant less exposed to scalping. This theory is supported by the work of Biran and Bushkin-Harav (1981) and may explain why bermudagrass cultivars such as Patriot and Tifway are more prone to scalping.

The range for scalping tendency for all cultivars across all dates was from 0 to 13%. While there were statistical differences between cultivars and species, it is unclear how much of an increase in scalping tendency will affect playability, overall plant health, or what percentage scalping is considered tolerable by most golf course superintendents. Future research should be performed to identify the effect of scalping on playability and overall plant health in warm-season turf. Based on these results, turfgrass managers concerned with scalping tendency of their playing surface should avoid planting Patriot and Tifsport bermudagrass, increase mowing frequency in late summer, or perhaps apply trinexapac-ethyl to reduce scalping (Fagerness et al., 2001).

Conclusions

The cultivars with the lowest clipping yield were Diamond and Meyer zoysiagrass. Patriot and Tifsport bermudagrass had the highest scalping tendency across multiple evaluation dates. These results will assist golf course managers in selecting cultivars of bermudagrass and zoysiagrass that have low clipping yields and scalping tendencies for golf course fairways or tees. Selecting a cultivar with low clipping yield and scalping tendency will not only help to improve playing conditions, but will also help to reduce PGR use, equipment wear, and labor and fuel costs associated with maintaining a golf course fairway or sports field.

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Table 1. Clipping yield dry weight means across three dates in 2009 for various bermudagrass and zoysiagrass cultivars in Fayetteville, Ark.

Cultivar	Species	4 Jun	13 Jul	31 Aug
		---------------g $m^{-2}d^{-1}$[z]	----------------	
Cavalier	ZM[y]	8.7 cd[x]	18.6 cd	10.9 a
Diamond	ZM	7.2 de	14.1 de	6.3 d
El Toro	ZJ	12.6 a	18.4 cd	10.3 ab
Meyer	ZJ	8.6 cd	8.7 f	8.5 bc
Palisades	ZJ	11.2 ab	19.5 c	11.2 a
Patriot	CDCT	5.8 ef	20.8 cd	6.1 d
Princess 77	CD	3.9 f	21.3 bc	6.5 d
Riviera	CD	10.1 bc	18.5 cd	5.3 d
Tifsport	CDCT	5.6 ef	25.2 ab	6.6 cd
Tifway	CDCT	5.4 ef	28.0 a	4.8 d
Zenith	ZJ	10.6 abc	13.6 e	9.5 ab
Zorro	ZM	10.5 abc	19.4 c	10.6 a

[z] Clipping yield of cultivars expressed as weight per unit area.

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

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

Table 2. Scalping tendency for five bermudagrass and seven zoysiagrass cultivars in Fayetteville, Ark. in 2009.

Cultivar	Species	4 Jun	13 Jul	31 Aug
		----------------%[z]	-----------------	
Cavalier	ZM[y]	2.0[x]	0.3	0.0 b
Diamond	ZM	2.8	0.7	0.0 b
El Toro	ZJ	2.7	0.0	0.0 b
Meyer	ZJ	11.0	0.2	0.0 b
Palisades	ZJ	1.8	1.3	0.0 b
Patriot	CDCT	1.8	0.0	13.3 a
Princess 77	CD	6.2	0.1	1.2 b
Riviera	CD	5.8	0.0	0.1 b
Tifsport	CDCT	0.1	0.7	12.0 a
Tifway	CDCT	6.4	0.8	0.3 b
Zenith	ZJ	1.6	0.2	0.0 b
Zorro	ZM	3.8	0.5	0.0 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*; CDCT = *Cynodon dactylon* × *C. transvaalensis*.

[x] Values in a column followed by the same letter are not significantly different (LSD, α = 0.05). On dates where letters do not follow means, all treatments were similar.

Establishment Rate of Commercially Available and Experimental St. Augustinegrass Cultivars

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Additional index words: coverage, stolon growth rate, Arkansas

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Photo by Aaron Patton

St. Augustinegrass cultivars establish at different rates.

Summary. Saint Augustinegrass is currently used in central and southern Arkansas. It is mainly used for shaded lawns, as it is among the most shade tolerant warm-season turfgrass. Many new cultivars are being developed and are being considered for use in Arkansas but prior to their adoption more data is needed on their growth and establishment rates. This experiment sought to determine the stolon growth rate and establishment rate of several commercially available cultivars and genotypes of St. Augustinegrass. Twenty commercially available cultivars and ten experimental genotypes were first grown as plugs in the greenhouse and then planted in research plots in Fayetteville, Ark. Plant materials were provided by University of Florida, Texas A&M University, Mississippi State University, North Carolina State University, and Double Springs Grass Farm in Searcy, Ark. Many of the new cultivars tested in this study have desirable attributes such as improved winter hardiness, enhanced turf color, and faster establishment rates, which may make them desirable for future use among Arkansas turf producers. On 13 September, 'Floratam', 'Texas Common', 'Sapphire', 'Floraverde', and WS had the most overall coverage. Results from this study are intended to help residents of Arkansas make informed decisions when selecting turfgrass cultivars.

Abbreviations: DIA, digital image analysis; SGR, stolon growth rate

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Saint Augustinegrass (*Stenotaphrum secundatum*) is a common lawn turf in Florida and Texas that has wide leaf blades (0.2 to 0.4 inch) and spreads by stolons. Saint Augustinegrass can make a quality lawn grass, but is undesirable for sports turf and golf due to its inability to tolerate low mowing heights and its poor traffic resistance and recovery. The favored climate for this turf species is warm, subtropical, and tropical climate regions and it is well-adapted to irrigated areas. Currently, St. Augustinegrass is grown in central and southern Arkansas primarily in lawns that are shaded and not suited for bermudagrass. Several cultivars are known to be more winter hardy, disease resistant and chinch bug resistant than others (Busey, 2003). The objective of this study was to evaluate St. Augustinegrasses in Fayetteville, Ark. to better understand their establishment rate and stolon growth rate as part of a larger study to identify winter hardy cultivars that might be well-suited for use in Arkansas.

Materials and Methods

Twenty commercially available cultivars and ten experimental cultivars were established on 30 June 2009. The 3 by 3 inch plugs were grown in the greenhouse from plant material provided by University of Florida, Texas A&M University, Mississippi State University, North Carolina State University, and Double Springs Grass Farm in Searcy, Ark. Raleigh St. Augustinegrass was obtained both from the University of Florida and North Carolina State University and will be referred to as either Raleigh (NC) or Raleigh (FL) throughout the paper. The experimental plots were 4 ft by 4 ft arranged in a randomized complete block design with four replications. One plug was planted in the center of each plot. Plots were irrigated as needed to prevent wilting and were fertilized with 1 lb N/1000 ft^2. The plots were not mown so as not to disturb stolon growth, and weeds were manually removed during establishment. Coverage was determined using digital images of each plot taken by a digital camera mounted on a monopod to ensure a consistent height from the lens to the soil surface. Digital image analysis (DIA) was used to determine plot cover (Richardson et al., 2001). Images were taken of a calibration disk with a known area and data were converted from selected green pixels to coverage. Stolon growth rate (SGR) was measured using a 6-inch digital caliper. Stolon growth rate was measured over a 4 day interval by marking the growing tip of three stolons in each plot with toothpicks on day 0 (20 August, 2009) and measuring stolon elongation with a caliper 4 days later (24 August, 2009). Stolon growth rate (mm/day) was then calculated.

Results and Discussion

There were differences in the stolon growth rate (SGR) of the St. Augustinegrass cultivars. Floratam, Sapphire, WS, Floralawn, and Texas Common had the highest SGR when measured in August 2009, whereas Sunclipse, Delmar, 106G3, GF, 106T3, SV27, Amerishade, Raleigh (FL), 904AT2 and Jade had the lowest SGR (Table 1).

In addition to differences in SGR, the establishment of the St. Augustinegrass also varied throughout the summer (Table 1). Those cultivars with the highest coverage on 23 July included Floratam, 106G3, and Delmar. On 12 and 26 August, Sapphire, Raleigh (NC), Floralawn, Floraverde, and Deltashade had the highest overall coverage, and on 13 September, Floratam, Texas Common, Sapphire, Floraverde, and WS had the highest overall coverage.

Cultivars with the lowest coverage included 106T3, Jade, Captiva, Raleigh (FL), MSA2-3-9, Majestic, Seville, WS, GF, TAES5714, Deltashade, Sapphire, Palmetto, Mercedes, Sunclipse, Bitterblue, Amerishade, 904AT2, Raleigh (NC), FX-10, and SV27 on 23 July. On 12 August, Seville, Bitter Blue, Sunclipse, DALSA0406, FX-10, Floratine, 106G3, 904AT2, 106T3, Jade, Amerishade, and SV27 had the lowest overall coverage. On 26 August, Raleigh (FL), Seville, Palmetto, Majestic, Captiva, Delmar, Sunclipse, DALSA0406, FX-10, Floratine, 106G3, 106T3, Jade, SV27, 904AT2, and Amerishade had the least overall coverage. On 13 September, Jade, DALSA0406, 106T3, SV27, Sunclipse, Raleigh, 106G3, Deltashade, Amerishade, and 904AT2 had the lowest overall coverage. Many of the cultivars with low coverage could be considered dwarf types due to their short internodes, smaller leaves, and a denser canopy (Moseley et al., 2010). Although slow establishment and low SGR may not seem like a desirable characteristic among turf producers (sod farmers), low SGR also translates to less frequent edging around landscape beds, which may be a desirable characteristic among homeowners. This data on growth and establishment rates will provide turf producers with needed information on selecting cultivars for future use.

Raleigh St. Augustinegrass is a cultivar known for its excellent cold tolerance (Philley et al., 1996). Raleigh was collected from a home lawn in Raleigh, N.C., developed by Dr. W.B. Gilbert at North Carolina State University, and released in the early 1980s (Milla-Lewis et al., 2009). The Raleigh St. Augustinegrass used in this study was obtained both from the University of Florida and North Carolina State University. Although both should be genetically identical, recent research has indicated that not all plant material sold as Raleigh St. Augustinegrass is genetically similar (Milla-Lewis et al., 2009). In our study, these two collections of Raleigh St. Augustinegrass did not appear to have similar stolon growth or establishment rate, which is additional evidence that not all Raleigh St. Augustinegrass has the same genetic make-up as the original Raleigh St. Augustinegrass released by North Carolina State University.

Raleigh St. Augustinegrass is available at four sod farms in Arkansas (Patton et al., 2008). It is unclear whether the Raleigh St. Augustinegrass being sold in Arkansas is genetically similar to that released by North Carolina State University, but it is very likely considering that it has performed well during cold winters in Little Rock. Palmetto, Majestic and Texas Common St. Augustinegrass are also grown in Arkansas (Patton et al., 2008). Many of the new cultivars tested in this study have desirable attributes such as enhanced winter hardiness, dark green color, and fast establishment rates, which may make them desirable for future use among Arkansas turf producers. Results from this study are intended to help residents of Arkansas make informed decisions when selecting turfgrass cultivars. Planting well-adapted cultivars will improve turfgrass quality, and reduce reestablishment cost from winterkill and ultimately increase sustainability. The winter survival of these cultivars will be assessed in spring 2010.

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Table 1. Stolon growth rate and coverage of St. Augustinegrass cultivars planted 30 June 2009 in Fayetteville, Ark.

		Coverage			
Cultivar	Stolon growth rate	23 July	12 August	26 August	13 September
	mm/d	cm²			
106G3	5.9 ijk[x]	292 ab	552 i-m	1074 ghi	2369 ghi
106T3	5.3 ijk	235 b-e	430 j-m	860 hi	2952 e-i
904AT2	4.9 k	176 cde	447 j-m	824 hi	1495 i
Amerishade [z]	5.1 jk	180 cde	388 lm	617 i	1784 hi
Bitterblue [z]	8.5 e-h	190 cde	695 d-m	1767 d-h	3343 d-h
Captiva [z]	7.5 ghi	232 b-e	761 c-l	1510 d-i	3740 c-g
Classic [z]	9.0 d-g	261 bcd	798 c-k	1800 d-h	4679 b-e
DALSA 0406	8.7 d-h	244 bcd	612 f-m	1272 e-i	2986 e-i
Delmar [z]	6.7 h-k	266 abc	857 c-i	1502 d-i	4631 b-e
Deltashade [z]	8.5 e-h	210 b-e	1054 a-e	2443 a-d	2359 ghi
FX-10	8.8 d-g	170 de	597 g-m	1270 e-i	3835 b-g
Floralawn [z]	10.8 a-d	247 bcd	1135 abc	3159 ab	3888 b-g
Floratam [z]	12.4 a	357 a	797 c-k	2181 b-f	6633 a
Floratine [z]	7.1 g-j	260 bcd	595 h-m	1213 f-i	3892 b-g
Floraverde [z]	8.2 fgh	246 bcd	1087 a-d	2446 a-d	5055 a-d
GF	5.6 ijk	220 b-e	866 c-i	1807 d-h	3275 e-h
Jade [z]	4.9 k	235 b-e	427 klm	847 hi	3026 e-i
MSA 2-3-98	9.1 d-g	227 b-e	821 c-j	1805 d-h	4198 b-f
Majestic [z y]	8.2 fgh	225 b-e	754 c-l	1536 d-i	4010 b-g
Mercedes [z]	10.1 b-f	198 cde	801 c-k	1802 d-h	3793 c-g
Palmetto [z y]	9.1 d-g	206 b-e	803 c-k	1569 d-i	4260 b-f
Raleigh [z y] (NC)	9.6 c-f	172 ed	1278 ab	2951 abc	2369 ghi
Raleigh [z y] (FL)	5.1 jk	232 b-e	821 c-j	1640 d-i	3949 b-g
SV27	5.3 ijk	146 e	360 m	842 hi	2875 f-i
Sapphire [z]	11.8 ab	206 b-e	1411 a	3360 a	5186 abc
Seville [z]	8.1 fgh	221 b-e	716 d-m	1627 d-i	3412 d-h
Sunclipse [z]	6.7 h-k	196 cde	676 e-m	1307 e-i	2844 f-i
TAES 5714	9.0 d-g	216 b-e	958 b-h	1816 d-h	3557 c-g
Texas Common [z y]	10.5 a-e	256 bcd	988 b-g	2095 c-g	5528 ab
WS	11.3 abc	221 b-e	996 b-f	2246 b-e	5052 a-d
Average	8.1	225	783	1706	3699

[z] Commercially available in 2009.
[y] Commercially available in Arkansas in 2009.
[x] Within column, values followed by the same letter are similar (α=0.05).

Seedling Emergence of Tall Fescue and Kentucky Bluegrass as Affected by Two Seed Coating Techniques

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Additional index words: polymer, starch-based coating, turfgrass, Zeba, Penkoted, emergence

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Photo by Mike Richardson

Tall fescue seeds coated with various thicknesses of Zeba® polymer.

Summary. Seed coating has been effectively used in the agricultural and horticultural industries for over 100 years. Recently, several turfgrass seed companies have been applying seed coating technologies to commercial seed lines, but there have been limited studies that have demonstrated a positive benefit of seed coating to turfgrass seed. The objective of this study was to determine the effects of two commercially-available seed coating technologies on tall fescue and Kentucky bluegrass in three soil types. Coated seeds were obtained from a retail outlet. Non-coated seed samples were developed by removing the coating from the seed just prior to planting. Neither coating technology had an effect on tall fescue germination time or total germination percentage in any soil type. Seed coating did have a positive effect on the germination time of Kentucky bluegrass in a sandy loam soil, but did not improve germination time or percentage emergence in the other soil types. These results support earlier findings that seed coating has minimal effects on establishment of turfgrass species.

Abbreviations: DAP, days after planting

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Seed coating technologies have been utilized in the agricultural and horticultural industries for several decades. Seed coatings have been used to deter insects and fungi, incorporate beneficial microbes, enhance seed handling characteristics, and improve germination and seedling establishment. Although these technologies have been successful with specific crops such as vegetables and legumes, their success with forage or turfgrass seeds has been modest (Dowling, 1978; Hathcock et al., 1984a; Hathcock et al., 1984b).

Over the past 5 years, turfgrass seed companies have begun to coat many lawn grass seeds with seed coatings that are described as having a beneficial effect on germination and establishment. Earlier studies of seed coatings on grass seeds have shown minimal positive effects (Bruneau et al., 1989; Dowling, 1978; Hathcock et al., 1984a), especially when using starch-based polymers (Berdahl and Barker, 1980). Based on these earlier reports that indicated minimal effects of polymers or other seed coatings on turfgrass seed germination and establishment, it was hypothesized that current seed coating technologies are providing minimal benefits to turfgrass seed. The objective of this study was to determine the effect of two seed coating technologies on establishment of two turfgrass species in three soil types.

Materials and Methods

Two commercially-available, coated seed sources were used for these studies, including Smart Seed (Pennington Seed Co., Madison, Ga.) and Turf Builder Grass Seed with Water Smart (Scotts Co., Marysville, Ohio). Tall fescue (*Festuca arundinaceae*) and Kentucky bluegrass (*Poa pratensis*) samples of both seed sources were purchased at a retail outlet. Smart Seed contains a proprietary liquid coating material (Penkoted®, Pennington Seed Co., Madison Ga.) containing a fungicide and a growth stimulant. Turf Builder seeds were coated with a starch-based polymer technology (Zeba seed coating®, Zeba Inc., Beaverton, Ore.) that is designed to absorb and retain water around the seed.

For each seed lot, a non-coated seed treatment was developed by washing the coated seed under a stream of warm (40 °C/104 °F) water for approximately 5 minutes, which effectively removed all the seed coating from the seeds (Photo 1). The coated and non-coated seeds were planted immediately after washing into the test soils. It was also observed that the Zeba® coating was highly variable on both the tall fescue and Kentucky bluegrass seed lots (Photo 1). As such, a third treatment was developed for the Turf Builder seed lots (Zeba® coated) and included a heavily-coated seed lot and a partially-coated seed lot. Heavily-coated seeds only comprise 3%-5% of the product in the bag but exhibit the greatest water absorbing capacity (K.W. Hignight, unpublished results). Sufficient seeds to conduct all experiments were separated by hand into heavily-coated and partially-coated seed treatments. A seed weight was determined for each seed treatment and was used to verify the difference in coating thickness of the partially- and heavily-coated, Turf Builder seed lots (Table 1). Although the inert material (primarily seed coating) in retail packages of Turf Builder is typically around 50%, the seed wt. results suggest that Zeba® seed coating can increase seed weight by as much as 5-fold when heavily-coated (Table 1).

All seed coating treatments for both turfgrass species were evaluated for emergence in three soil types including the following: 1) a Captina silt loam, with an average pH of 6.2), 2) a commercial sandy loam soil mix (The Bark Place, Albany Ore.) with an average pH of 6.5, and 3) a Woodburn silt loam with an average pH of 6.0). Emergence experiments for the Captina silt loam soil were conducted in greenhouse facilities at the University of Arkansas, while emergence tests for the commercial sandy loam and Woodburn silt loam treatments were conducted in greenhouse facilities at NexGen Turf Research in Albany, Ore. All soils were steam-sterilized (200 °F for 8 h) prior to use to assure that no weed seed contaminants or pathogens were present. Identical seed lots were used for all soil treatments, but non-coated treatments were developed at the two locations just prior to conducting emergence studies, as previously described.

For each soil type and seed treatment, 25 seeds were planted in a greenhouse flat (12 × 12 in.) filled with 2.0 in. of the test soil. A planting device was used to make small impressions (⅛ - ¼ inch deep) in the soil on a 5 x 5 grid and seeds were individually placed in the impression and lightly covered with similar soil. Each 25-seed flat was considered an experimental unit of that soil × seed treatment. Each soil × seed treatment was replicated 4 times and arranged along the greenhouse bench in a randomized complete block design. A mist irrigation system was used to maintain soil moisture that was ideal for germination and emergence throughout the experiment. For each experimental unit, the following data were collected: days after planting (DAP) when first emergence was observed and percentage of seeds emerged at the end of a 28-day observation period. The effects of seed coating were determined using analysis of variance procedures of the randomized complete block design. Coating effects were analyzed separately for each soil type and turfgrass species.

Results and Discussion

Coating had a significant effect on days to first emergence and percentage of emergence for Kentucky bluegrass in all three soils, but the response was not consistent between the three soils (Table 2). In the Captina silt loam soil, seed coating had a significant effect on date of first germination, but the only treatment mean that was significantly different from the other treatments was a delayed germination in the partially-coated Turf Builder seed (Table 2). In the sandy loam soil, both the Zeba®-coated and Penkoted® Kentucky bluegrass seeds had faster germination than their respective, non-coated controls (Table 2). Since this soil had the highest sand content and the least water- and nutrient-holding capacity, it appears that seed coating might have more of an impact in these soil types than in heavier soils where nutrients and water would be more readily available. Although the coatings decreased the germination time of Kentucky bluegrass in the sandy loam soil, the overall emergence was not affected by either the Penkoted® or Zeba® coating. In the Woodburn silt loam soil, coating had a significant effect on Kentucky bluegrass emergence percentage, but there were no significant differences when comparing the Penkoted® or Zeba® coating to their uncoated control (Table 2).

Neither of the coating technologies had an effect on tall fescue emergence date or percentage emergence in any of the soils (Table 2). Earlier investigations of seed coatings on tall fescue also demonstrated either minimal effects (Dowling, 1978; Hathcock et al., 1984a) or variable responses to fertilizer coatings (Hathcock et al., 1984b).

Overall, the results of these studies support earlier trials (Berdahl and Barker, 1980; Bruneau et al., 1989; Dowling, 1978; Hathcock et al., 1984a; Hathcock et al., 1984b) and suggest that seed coatings have a minimal effect on speed of emergence or overall emergence of turfgrass seeds and in some situations have a negative effect. In the present trial, larger seeds such as tall fescue were less affected by coatings than smaller-seed species such as Kentucky bluegrass (Table 2). Since Kentucky bluegrass has historically been described as having slow germination and poor seedling vigor, one would expect a greater effect of seed coatings, although the effects were inconsistent across soil types and seed types (Table 2). In addition, it appears that seed coatings only had a positive effect on germination and emergence in sandy soils, suggesting they may only be beneficial in conditions where water and nutrients are limiting.

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Table 1. Weight of 1000 seeds from each of the seed coating treatments and turfgrass species. Three separate tests, each containing 4 replicate, 25-seed samples, were conducted and then converted to 1000-seed wt. for analysis.

Species	Treatment	Weight / 1000 seeds	
		g	
Kentucky bluegrass	Smart Seed - Penkoted®	0.38	C[z]
	Smart Seed - No coating	0.39	C
	Turfbuilder - Heavy Zeba® coating	1.82	A
	Turfbuilder - Partial Zeba® coating	0.70	B
	Turfbuilder - No coating	0.38	C
Tall fescue	Smart Seed – Penkoted®	2.46	C
	Smart Seed - No coating	2.24	D
	Turfbuilder - Heavy Zeba® coating	7.50	A
	Turfbuilder - Partial Zeba® coating	3.72	B
	Turfbuilder - No coating	2.36	CD

[z] means within a turfgrass species not followed by a similar letter are significantly different, as determined by a least significant difference (P = 0.05).

Table 2. Average days after planting (DAP) for first emergence and avg. percentage emergence for 5 different seed coating treatments and two turfgrass species in three soil types.

		Captina silt loam		Processed sandy loam		Woodburn silt loam	
Species	Treatment	First emerg.	Avg. emerg.	First emerg.	Avg. emerg.	First emerg.	Avg. emerg.
		DAP	%	DAP	%	DAP	%
Kentucky bluegrass	Smart Seed – Penkoted®	10.8	41.0	12.5	76.0	9.0	76.0
	Smart Seed - No coating	11.9	55.0	14.0	81.2	8.3	80.0
	Turfbuilder - Heavy Zeba® coating	13.2	58.0	13.0	90.0	9.0	75.0
	Turfbuilder - Partial Zeba® coating	16.6	70.0	12.2	83.0	8.3	68.0
	Turfbuilder - No coating	11.5	49.0	14.0	83.0	8.3	78.0
	LSD (0.05)[z]	3.5	ns	1.5	8.5	ns	10.8
Tall fescue	Smart Seed – Penkoted®	6.7	74.0	8.3	93.0	12.0	92.0
	Smart Seed - No coating	7.0	44.0	8.0	95.0	12.8	94.0
	Turfbuilder - Heavy Zeba® coating	6.8	75.0	8.8	95.0	13.0	88.0
	Turfbuilder - Partial Zeba® coating	6.3	58.0	8.5	94.0	12.0	89.0
	Turfbuilder - No coating	7.2	52.3	7.8	89.0	12.5	94.0
	LSD (0.05)	ns	ns	ns	ns	ns	ns

[z] Least significant difference (P = 0.05) can be used to compare means within a soil type and turfgrass species; ns – not significant.

Poultry Compost as an Amendment for Establishing Creeping Bentgrass in a Sand-Based Rootzone

Josh Summerford[1] and Doug Karcher[1]

Additional index words: dark green color index, turf coverage, digital image analysis, *Agrostis stolonifera*

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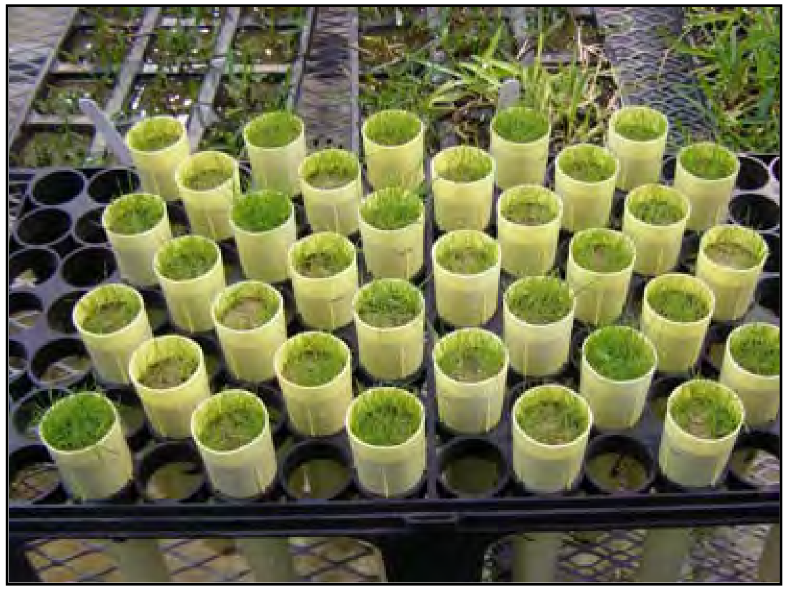

Creeping bentgrass establishment in sand rootzones amended with various ratios of poultry compost or reed sedge peat.

Summary. Establishing creeping bentgrass on sand-based putting green rootzones is a challenge due to the poor water and nutrient retention of the rootzone. Identifying locally available rootzone amendments to improve rootzone physical properties and enhance establishment would be beneficial. The objective of this study was to compare locally available poultry compost to peat and an unamended sand when establishing creeping bentgrass in sand-based rootzone. The compost treatment resulted in increased turf coverage and darker green turf color during establishment compared to the peat and unamended sand. Locally available compost shows promise as a sand-based rootzone amendment to enhance turf establishment.

Abbreviations: DAS, days after seeding; DGCI, dark green color index

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Putting green construction is one of the most crucial aspects of golf course construction as putting greens are the most vital area of a golf course and have the biggest impact on its success. For decades, the most accepted methods of putting green construction have called for the use of high sand content rootzones. Sand is the best material available for rootzone construction due to physical characteristics that enable it to resist compaction, maintain good aeration, and drain quickly. Although sand has many positive traits that make it a good rootzone material for putting greens, it does have deficiencies such as poor water and nutrient retention.

To compensate for these deficiencies, sand is commonly amended with materials to improve the physical and nutritional properties of the rootzone. The goal of rootzone amendments is to improve the relationship between the plant and the rootzone, thus improving growing conditions and minimizing management problems (Waddington, 1992). The most commonly used amendment is peat, an organic material with high water-holding capacity and some nutritional value. Peat fulfills the objectives of rootzone amendments by increasing water and nutrient-holding capacity, as well as reducing bulk density to improve the plant–rootzone interaction. In past research, peat amended rootzones have been shown to improve germination and establishment compared to 100% sand based rootzones, which is likely due to the increased water and nutrient retention provided by the addition of peat (Bigelow et al., 2001).

Another organic amendment that has shown promise in sand-based rootzones is compost (Carey and Gunn, 1998). Carey and Gunn (1998) showed that an 80:20 (v/v) blend of sand to compost significantly improved germination and establishment rates of bentgrass compared to the same ratio of sand and peat. This study also showed significantly faster growth rate of shoots and roots as well as significantly higher water-holding capacity on the sand-compost blend compared to the sand-peat blend. The increased growth rates are likely attributed to the nutrient content of the compost, with more nutrients being readily available compared to the peat. An advantage of compost over peat is that it is more locally available throughout many regions of the world, including Arkansas. In addition, studies are consistently demonstrating that compost can enhance disease suppression in many soils.

This study compared two ratios (90:10 and 80:20 (v/v)) of locally available poultry compost and peat-amended sand rootzones as well as a non-amended sand rootzone for creeping bentgrass establishment and turf color. The objective of this research was to determine which amendment and ratio provides the fastest establishment and darkest turf color.

Materials and Methods

This experiment was conducted from 30 October through 7 December 2009 in a greenhouse on the University of Arkansas, Fayetteville campus. All rootzone blends were made using sand meeting USGA greens construction guidelines (USGA 2004). Compost was supplied by Soil-Smart Professional Organics (Ag Natural, LLC, Colcord, Okla.) and had an N-P-K analysis of 1-3-1. Two rootzone blends were made for both compost and peat. The ratios were 90:10 and 80:20 (v/v) and were blended in bulk then added to cone-tainers. The cone-tainers measured 1.5 inch in diameter and 8.25 inch long and were filled to 0.5 inch from the rim. Each rootzone blend was replicated six times. Creeping bentgrass (*Agrostis stolonifera* cv. Providence) was seeded into each cone-tainer at a rate of 1 lb/1000 ft^2. Each cone-tainer was also fertilized with an organic fertilizer (6-2-0) at a rate of 1 lb N/1000 ft^2, then topdressed with 2 g sand to ensure good seed to soil contact. Following seeding, irrigation was applied 3 times daily until germination, once daily for the week following germination, and 4 times weekly for the remainder of the trial. Digital images were taken twice weekly to evaluate for percent green turf cover and dark green color. Dark green color was measured by a dark green color index (DGCI) value resulting from digital image analysis (Karcher and Richardson, 2003). Plots were maintained at a 0.5 inch height of cut with a mowing frequency of 3 times per week. In early December, the turf appeared chlorotic and the growth rate had slowed, so urea fertilizer was applied on 2 December at a rate of 0.5 lb N/1000 ft^2 to encourage complete establishment.

Results and Discussion

Throughout the duration of this trial, rootzone sand amended with peat at either ratio never produced significantly different percent green turf cover or dark green color compared to the 100% sand rootzone. This is likely due to water not being a limiting factor in this study, and therefore the abundance of irrigation compensated for the lower water holding capacity of the 100% sand rootzone.

Green turfgrass coverage. The rootzones amended with compost did however demonstrate improved green turf coverage and dark green color values (Figs. 1 and 2). From the second evaluation date, at 13 days after seeding (DAS), through 45 DAS the 80:20 compost blend produced higher turfgrass coverage than both peat blends as well as the 100% sand rootzone. By 25 DAS the 80:20 compost blend produced greater green turfgrass coverage than all other blends and the 100% sand rootzone and continued to do so until 41 DAS. From 31 DAS to 45 DAS, the 90:10 blend of compost and sand had greater green turfgrass coverage than both peat blends and the 100% sand rootzone.

Dark green color. From the first evaluation date at 11 DAS through 41 DAS, the 80:20 sand to compost blend had higher DGCI values than either peat blend as well as the 100% sand rootzone. At 11 DAS and 31 DAS, the 80:20 sand-compost blend had higher DGCI values than the 90:10 sand-compost blend. The 90:10 sand to compost blend had significantly higher DGCI values than the 100% sand rootzone on the first evaluation date, but was not different than the sand and peat blends and the 100% sand rootzone for the next six evaluation dates. At 38 DAS, the 90:10 sand-compost blends had higher DGCI values compared to both sand-peat blends. By 45 DAS, there were no differences in DGCI (data not shown).

Conclusions

Based on the data from this research, the 80:20 ratio of compost to sand provided significantly faster establishment rates compared to either ratio of peat and the non-amended rootzone. The 90:10 ratio of compost to sand provided better establishment than the peat and non-amended rootzones by the final three evaluation dates; however, establishment was still significantly lower than the 80:20 compost to sand blend. Since water was applied judiciously in this trial, the enhanced establishment with the compost treatments was likely a nutrient effect, although this was not evaluated in this experiment. Future work should evaluate the water-holding capacity of compost versus peat. These results suggest that locally available compost may be a viable option for amending sand-based putting green rootzones to enhance creeping bentgrass establishment.

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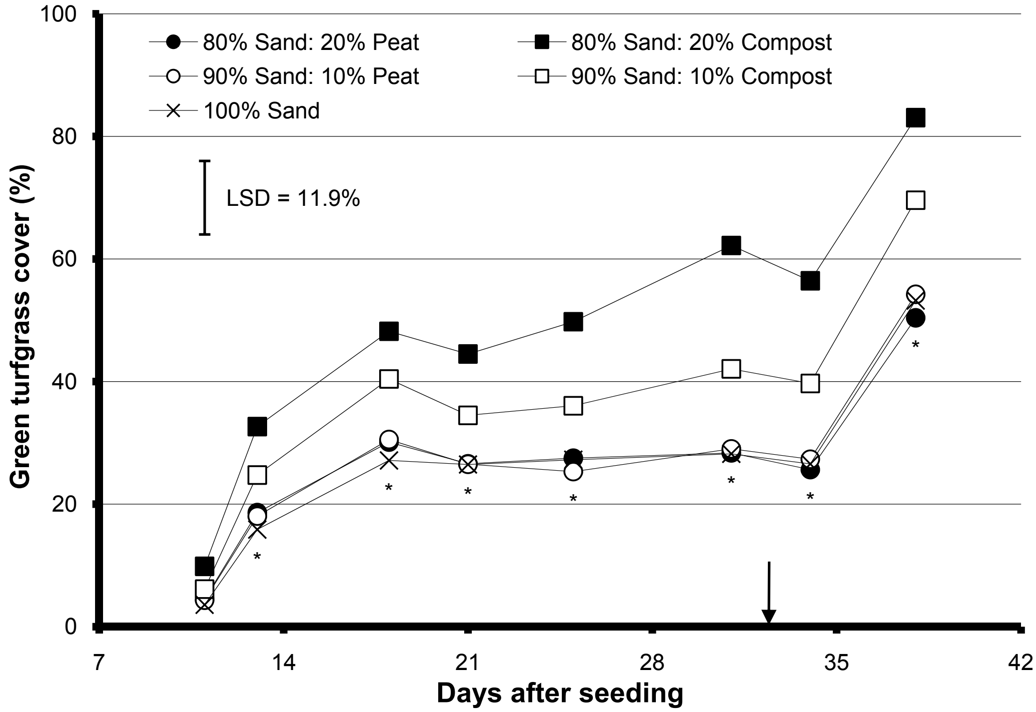

Fig. 1. Percent green turfgrass coverage as affected by rootzone blend. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing rootzone blends within dates. Significant treatment differences were present on evaluation dates denoted with a "*". Arrow indicates date of nitrogen fertilizer (urea) application.

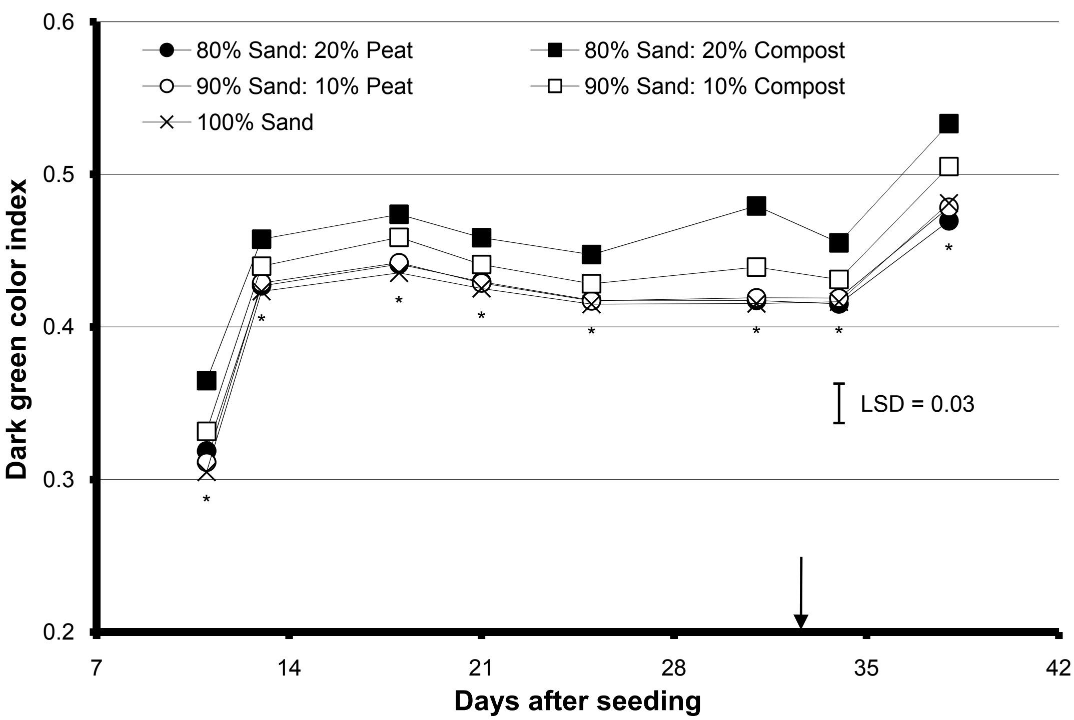

Fig. 2. Dark green color index values as affected by rootzone blend. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing rootzone blends within dates. Significant treatment differences were present on evaluation dates denoted with a "*". Arrow indicates date of nitrogen fertilizer (urea) application.

Tall Fescue Establishment Under Varying Levels of Phosphorous

Josh Summerford[1] and Doug Karcher[1]

Additional index words: turf coverage, digital image analysis, *Festuca arundinacea*

Summerford, J. and D. Karcher. 2010. Tall fescue establishment under varying levels of phosphorous. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:108-111.

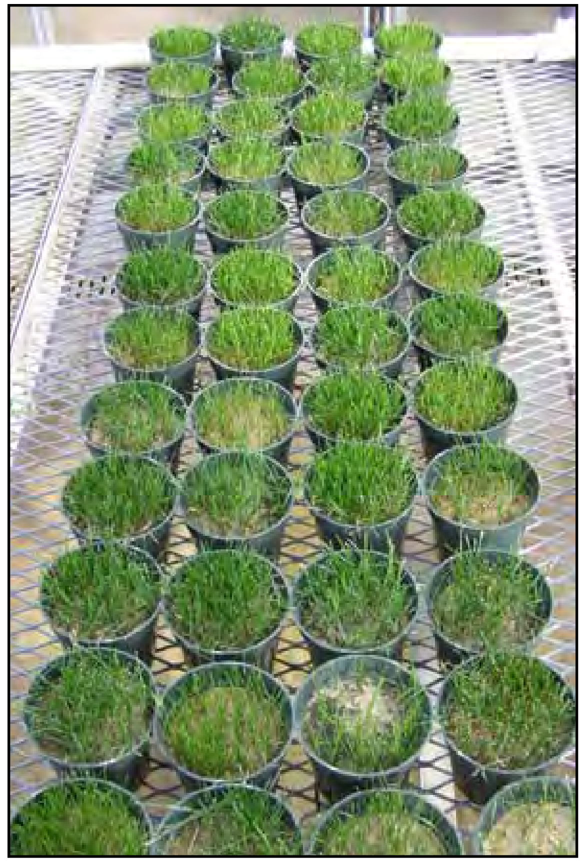

Photo by Josh Summerford

Establishment of tall fescue in rootzones varying in soil test phosphorous and either with or without phosphorous fertilization.

Summary. Many regions have placed restrictions on phosphorous (P) fertilizer application, requiring a soil test showing that P is necessary before applications may be made to turfgrasses. Traditionally, P application is recommended when establishing turfgrass. However, P fertilization at establishment and critical soil-test P levels for turfgrasses are not well understood. The objective of this trial was to determine the effects of P fertilizer application on the establishment of tall fescue turf on rootzones with varying soil-test P levels. In soils containing greater than 7 ppm P, P fertilization during seeding had no effect on establishment rate. Therefore, P application to turfgrasses may only be necessary on soils with extremely low soil-test P values.

Abbreviations: P, phosphorous

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Phosphorous is an essential nutrient for turf establishment and growth and is therefore commonly included in starter fertilizer blends. Starter fertilizer blends containing P are often used when establishing turfgrass on soils that may already contain sufficient P for establishment, resulting in excess P on the soil surface. Excessive P fertilization has been linked to deterioration of water quality due to runoff from non-point sources. As a result, many areas have placed restrictions on the use of P, requiring a soil test showing that P is necessary before application. Phosphorous fertilization recommendations for turf are often based on soil-test P levels for agronomic crops and therefore may be higher than necessary for turfgrass, resulting in over-application, potential runoff, and infiltration into water sources. Therefore, the objective of this experiment was to determine the effect of P fertilizer and soil-test P on the establishment of tall fescue.

Materials and Methods

This experiment was conducted from 30 October through 7 December 2009 in a greenhouse on the University of Arkansas, Fayetteville campus. All rootzone blends were made using sand that met United States Golf Association greens construction guidelines, and oven-dried native silt-loam soil with soil-test P values of 4.1ppm, and 11.4 ppm, respectively. Rootzone blends were as follows: 100% sand, 80:20, 60:40, 40:60 20:80 sand to soil respectively, and 100% soil. The soil-test P values for the soil blends are shown in Table 1. Soil-test P was determined by Mehlich-3 extraction at the University of Arkansas Agriculture Diagnostics Laboratory in Fayetteville, Ark. Each rootzone blend was replicated eight times. A turf-type tall fescue blend (*Festuca arundinacea*) was seeded into each pot at a rate of 8 lb/1000 ft^2. Each pot was also fertilized with urea at a rate of 1 lb N/1000 ft^2, then topdressed with 5 g sand to ensure good seed to soil contact. Half of the pots for each rootzone blend (4) received 1 lb P_2O_5/1000 ft^2 as triple super phosphate. Following seeding, irrigation was applied 3 times daily until germination, once daily for the week following germination, and 4 times weekly for the remainder of the trial. Digital images were taken twice weekly to evaluate percent green turf cover. The turf was maintained at a 2-inch height of cut with a mowing frequency of 3 times per week. In early December, the turf appeared chlorotic and the growth rate had slowed, so urea fertilizer was applied on 2 and 9 December at a rate of 0.5 lb N/1000 ft^2 to encourage complete establishment.

Results and Discussion

The effect of P fertilizer on turf coverage depended on the soil blend as well as the evaluation date. On average, the lower rates of sand produced greater green turfgrass coverage compared to the higher rates of sand (Fig. 1). For the first two evaluation dates, there were no significant differences between sand ratio with or without added P. By the third evaluation date, the 40% sand blend had significantly higher turf coverage than the higher two sand rates of 80% and 100% as well as the 0% sand rate. By the fourth evaluation date, the 0% sand rate produced similar cover compared to the 20%, 40%, and 60% sand rates. On the fifth evaluation date, the three lowest sand rates were producing higher turfgrass coverage than the two highest sand rates and the 40% sand rate had greater coverage than the 60% sand rate. This trend continued through the sixth evaluation date. On the seventh, eighth, and ninth evaluation dates, the three lowest sand rates outperformed the three highest sand rates. On the tenth evaluation date, the 0% sand rate had the highest coverage and was significantly higher than the 80 and 100% sand rates. On the final evaluation date, the 0% sand rate had significantly higher coverage than the 100% sand rate.

There was a three-way interaction of soil blend, P fertilization, and evaluation date for turf coverage. The interaction of soil blend by P fertilization was not present until the later evaluation dates and became more pronounced toward the end of the trial. The presence of this interaction on the final evaluation date is shown in Fig. 2. When the soil contained no more than 60% sand (at least 7 ppm P), additional P fertilization at seeding had no effect on turf coverage. There was significantly more coverage on pots receiving additional P at seeding when the soil contained 80% or 100% sand (5.6 and 4.1 ppm P, respectively). At 80% sand, P fertilization increased coverage from 44% to over 80%. At 100% sand, P fertilization increased coverage from 46% to 72%.

The data from this trial suggests that at soil-test P values less than 7.0 ppm, additional P is necessary to optimize establishment. This value is considerably lower than the critical soil-test level (25 ppm) which would trigger a P fertilization recommendation. This indicates that turfgrasses may have a much lower soil-test P requirement than what is traditionally recommended by soil testing laboratories. The lower P requirement of turfgrasses may also be attributed to the dense fibrous root system of turf compared to other field crops, for which the critical P levels were established, allowing turfgrasses to better utilize soil P reserves.

Table 1. Soil and sand blends, and the corresponding P content as determined by Mehlich-3 analysis, that were used in this experiment.

Sand	Soil	P
--------% -------		ppm
0	100	11.4
20	80	9.9
40	60	8.5
60	40	7.0
80	20	5.6
100	0	4.1

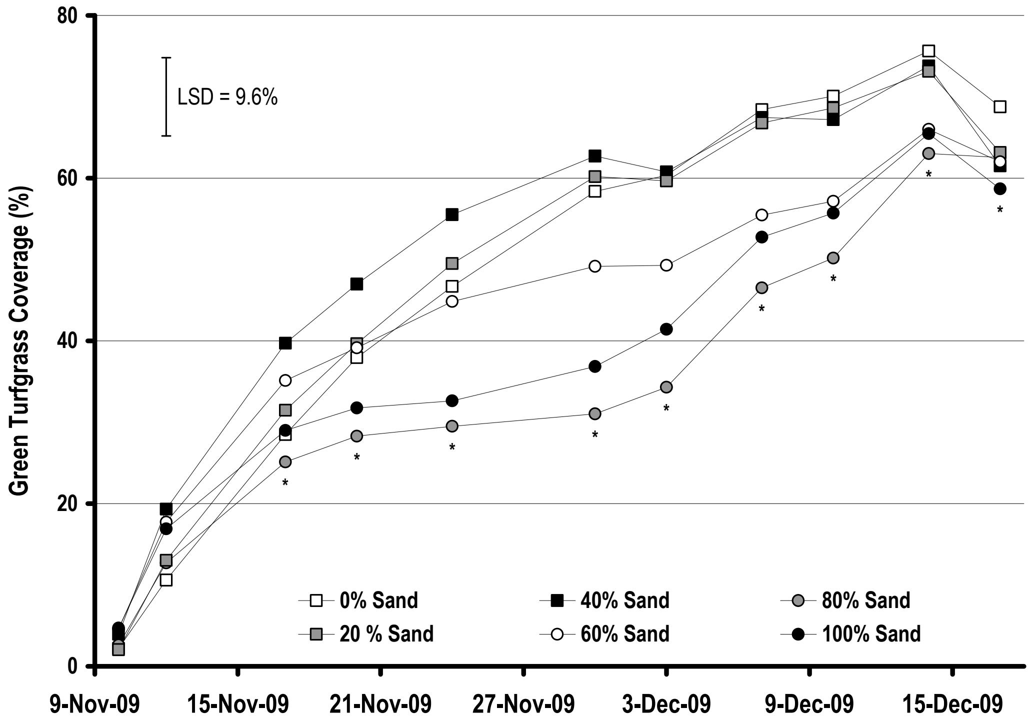

Fig. 1. Percent green turfgrass coverage as affected by rootzone blend. Error bar represents Fisher's least significant difference value (α = 0.05) for comparing rootzone blends within dates. Significant treatment differences were present on evaluation dates denoted with a "*".

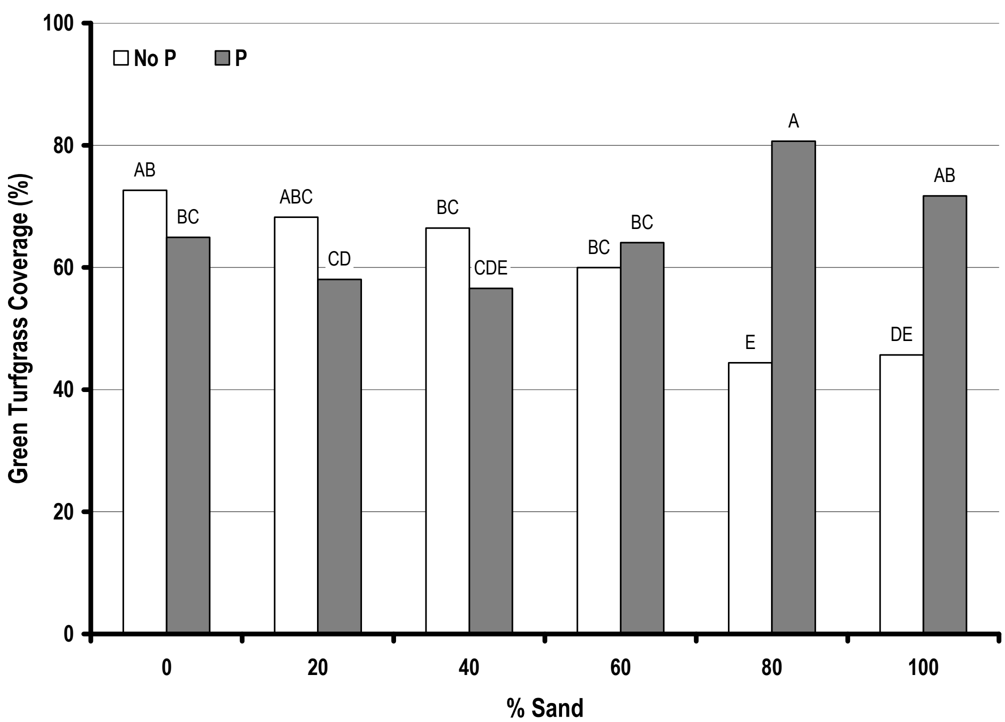

Fig. 2. Percent green turfgrass coverage as affected by rootzone blend. Bars not sharing a letter are significantly different according to Fisher's least significant difference test (α = 0.05).

Drought Tolerance of 15 Bermudagrass Cultivars

Mike Richardson[1], Doug Karcher[1], and John McCalla[1]

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

Richardson, M., D. Karcher, and J. McCalla. 2010. Drought tolerance of 15 bermudagrass cultivars. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:112-115.

Photo by Mike Richardson

Bermudagrass plots during a drought trial in 2009.

Summary. Newer cultivars of seeded bermudagrass may have improved drought tolerance over standard cultivars. The objective of this research was to compare the drought tolerance of cultivars and experimental lines of bermudagrass under lawn maintenance conditions. Cultivars were established in the spring of 2008 and dried down during the summer of 2009 in a fixed-roof 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. Compared to earlier studies on cool-season grasses, which often show drought stress symptoms in 2-3 weeks, it took over 40 days without water before bermudagrass cultivars began losing significant green coverage. Although there were significant differences between cultivars, the range between the best and worst cultivars was approximately 12 days, suggesting that there is less variability in drought tolerance among bermudagrass as compared to earlier studies on cool-season species.

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A desirable trait in lawn grasses is that they stay green during short periods of drought, as this can save significantly on irrigation needs. Bermudagrass is the most widely-used lawn grass in Arkansas and is adapted across the entire state. Although bermudagrass is generally considered to have good drought tolerance, there have been minimal studies that have attempted to document differences in drought tolerance between bermudagrass cultivars. Over the last five years, our research program has developed techniques that allow us to screen grasses for drought tolerance and we have demonstrated a wide variation in drought tolerance among cultivars of tall fescue (Karcher et al., 2008) and Kentucky and hybrid bluegrass species (Richardson et al., 2008; Richardson et al., 2009). The following research was initiated to compare the relative drought tolerance of 15 bermudagrass cultivars and experimental entries.

Materials and Methods

This research was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville, Ark. Fifteen cultivars and experimental entries of bermudagrass (Table 1) were either seeded (1.0 lb/1000 ft^2) or sprigged (sprigs planted on 12-inch centers) into three replicate plots in the spring of 2008 on a native soil experimental area that was constructed under a fixed-roof 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 2009, 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 the rain-out shelter prevented any rainfall from reaching the plots. 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 $Days_{75}$, $Days_{50}$, and $Days_{25}$ values for each cultivar, which are the estimated number of days after irrigation was withheld until green turf coverage decreased to 75%, 50%, or 25%. A complete description of digital image analysis and statistical methods are presented elsewhere (Karcher et al., 2008).

Results and Discussion

The number of days after irrigation was withheld until green turf coverage dropped to 75% ranged from 45 d for SWI-1122 to 58 d for SWI-1113. This range of 13 d is considerably smaller than what has been observed in similar tests on cool-season grasses, suggesting that the range of drought tolerance may be smaller in existing bermudagrass germplasm compared to cool-season grasses such as tall fescue or bluegrass. However it should still be noted that the first signs of drought stress in the weakest bermudagrass cultivars were not observed until 45 days after irrigation was withheld, and the overall drought tolerance of bermudagrass as a species is much greater than cool-season grasses.

The trends in drought tolerance among cultivars were similar at all evaluation levels, with the exception of SWI-113, which performed better at the 25% green coverage evaluation, while dropping in performance at 75% green coverage (Fig. 1). However, there were minimal statistical differences between any cultivars at the 25% green coverage evaluation. One interesting observation was that Tifway, a vegetatively-propagated standard cultivar, was one of the best entries tested in this trial and was in the top statistical group at each evaluation period. It would be desirable in future studies to examine a broader range of seeded and vegetative cultivars to determine if there are true differences between hybrid and seeded cultivars.

Conclusions

These results demonstrate that there are differences in drought tolerance among bermudagrass cultivars, although the range in differences was less than observed with cool-season grasses. These studies will be repeated in the 2010 growing season for confirmation.

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and D. Rush. 2008. Drought tolerance of tall fescue varieties selected for high root:shoot ratios. Crop Sci. 48:771-777.
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Richardson, M. D., D.E. Karcher, K. Hignight, and D. Rush. 2009. Drought tolerance of Kentucky bluegrass and hybrid bluegrass cultivars. Online. Applied Turfgrass Science doi:10.1094/ATS-2009-0112-01-RS.

Table 1. Bermudagrass entries tested in drought tolerance trial.

Entry	Propagation method
Tifway	Vegetative
SWI-1083	Seeded
SWI-1070	Seeded
SWI-1113	Seeded
NuMex-Sahara	Seeded
Princess-77	Seeded
PST-R62530	Seeded
PST-R6ON	Seeded
SWI-1081	Seeded
PST-R6LA	Seeded
PST-R6FLT	Seeded
PST-R6EY	Seeded
Transcontinental	Seeded
SWI-1117	Seeded
SWI-1122	Seeded

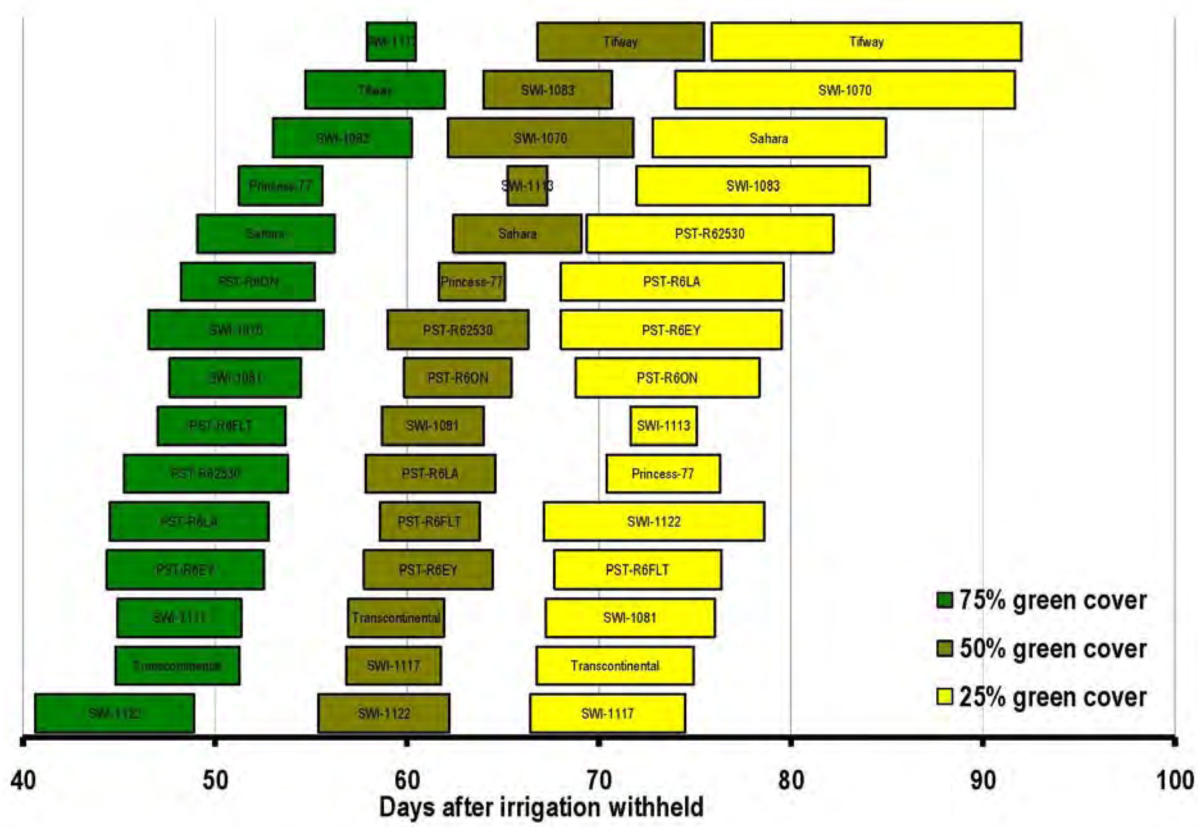

Fig. 1. Drought tolerance of 15 bermudagrass entries, as measured by days without water required to reach 75%, 50%, or 25% green cover.

Drought Tolerance of Kentucky and Hybrid Bluegrass Cultivars

Mike Richardson[1], Doug Karcher[1], and John McCalla[1]

Additional index words: digital image analysis, lawn, irrigation, rain-out shelter, green turf coverage

Richardson, M., D. Karcher, and J. McCalla. 2010. Drought tolerance of Kentucky and hybrid bluegrass cultivars. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:116-118.

Photo by Mike Richardson

Fixed-roof rainout shelter used to impose drought stress on bluegrass plots.

Summary. Newer cultivars of 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 was to compare the drought tolerance of 24 cultivars or experimental lines of these species when maintained as a lawn. Cultivars were established in fall, 2007 and dried down during the summer of 2008 and 2009 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. Data are reported from the 2009 dry-down study. The amount of time after irrigation was withheld until green turf coverage dropped to 50% varied by approximately two weeks among cultivars. In general, cultivars that have performed well (Mallard) or poorly (Solar Green) in previous trials performed similarly in the present study, suggesting that the methodology is consistent. Several Kentucky bluegrass and two hybrid bluegrass cultivars had the best drought tolerance in the present trial.

Abbreviations: KBG, Kentucky bluegrass; HBG, hybrid bluegrass

[1] University of Arkansas, Department of Horticulture, Fayetteville, Ark. 72701

A desirable trait of cool-season lawn grasses, such as Kentucky bluegrass (*Poa pratensis*), is that they stay relatively green throughout most of 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 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 demonstrated that there is variation in drought tolerance among cultivars of Kentucky and hybrid bluegrass species (Richardson et al., 2008; Richardson et al., 2009). Identifying cultivars of Kentucky bluegrass and hybrid bluegrass with excellent drought tolerance may expand the use of cool-season turfgrasses for lawns in Arkansas and throughout the transition zone. Research was initiated recently to compare the relative drought tolerance of 24 Kentucky bluegrass and hybrid bluegrass cultivars. The following is a summary of the drought tolerance data from that study.

Materials and Methods

This research was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville. Twenty cultivars of Kentucky bluegrass and four cultivars of hybrid bluegrass (Table 1) were seeded into three replicate plots in the fall of 2007 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 12 June 2009, 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. The rain-out shelter has a fixed-roof that prevents any rainfall from reaching the plots. 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 are presented elsewhere (Karcher et al., 2008).

Results and Discussion

The number of days after irrigation was withheld until green turf coverage dropped to 50% ranged from 15.8 d for Solar Green hybrid bluegrass to 28 d for A00891 Kentucky bluegrass (Table 1). This range of 12 d is smaller than we observed in earlier trials (Richardson et al., 2008; Richardson et al., 2009), but may reflect a difference in temperature between trials conducted at this site and earlier trials conducted in western Oregon. However, it is significant to note that cultivars such as Mallard, which have performed very well in previous trials, continued to perform near the top of the present trial (Table 1). In addition, Solar Green was a cultivar with poor drought tolerance in previous trials and also performed poorly in the current trial.

There were four hybrid bluegrass cultivars in this trial and their drought tolerance ranged from very good (Reveille and A04TB-275) to very poor (A03TB-676 and Solar Green). This is similar to results from earlier trials (Abraham et al., 2004; Richardson et al., 2009) and continues to support the premise that hybrid bluegrasses are not inherently more drought tolerant than Kentucky bluegrass and must be tested to verify those claims.

Conclusions

These results continue to demonstrate that there are significant differences in drought tolerance among cool-season grasses used in Arkansas lawns and that numerous Kentucky and hybrid bluegrasses could be valuable in limited water sites. 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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Richardson, M. D., D.E. Karcher, K. Hignight, and D. Rush. 2009. Drought tolerance of Kentucky bluegrass and hybrid bluegrass cultivars. Online. Applied Turfgrass Science doi:10.1094/ATS-2009-0112-01-RS.

Table 1. Drought tolerance of 24 Kentucky bluegrass and hybrid bluegrass entries, as measured by days without water required to reach 50% green cover.

Selection	Species[z]	Days50[y]	(SE)[x]
A00-891	KBG	28.1	0.20
Reveille	HBG	27.9	0.59
Limousine	KBG	27.7	1.40
Mallard	KBG	27.5	1.57
AKB449	KBG	26.4	0.47
A04TB-275	HBG	25.5	1.44
Eagleton	KBG	25.3	0.43
Bluestone	KBG	25.0	1.02
KH3010	KBG	25.0	0.38
AKB262	KBG	24.6	0.91
Brooklawn	KBG	24.5	1.90
AKB186	KBG	24.4	0.69
KH9739	KBG	24.2	1.14
Blue Ridge	KBG	24.0	0.81
Diva	KBG	23.8	0.96
Midnight	KBG	23.6	0.71
A98-948	KBG	21.1	1.18
Bedazzled	KBG	21.0	0.95
AKB254	KBG	20.2	1.02
KH2290	KBG	20.2	1.22
A03TB-676	HBG	19.5	1.14
Monte Carlo	KBG	19.0	0.97
Hunnington	KBG	16.7	0.23
Solar Green	HBG	15.8	0.88

[z]KBG – Kentucky bluegrass, HBG – hybrid bluegrass.
[y]Days50 – number of days after water was withheld for a cultivar to reach 50% green cover.
[x]SE – standard error of the Days50 value.

Divot Recovery Among Bermudagrass and Zoysiagrass Cultivars – Year 2

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

Additional index words: fairway, tee, golf course, digital image analysis, *Zoysia japonica*, *Zoysia matrella*, *Cynodon dactylon*, *C. dactylon x C. transvaalensis*

Trappe, J., A. Patton, D. Karcher, and M. Richardson. 2010. Divot recovery among bermudagrass and zoysiagrass cultivars–year 2. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:119-122.

Photo by Jon Trappe

Divot recovery is a key factor in the performance of turf on golf courses.

Summary. Divots created by a golf stroke are a regular occurrence on golf course fairways and tees. Divot recovery is an important factor that should be considered when selecting a species or cultivar for use on golf course tees or fairways. There are few reports comparing divot recovery of bermudagrass and zoysiagrass cultivars. Therefore, the objectives of this experiment were to quantify the divot recovery for various bermudagrass and zoysiagrass cultivars in a field experiment. Divot recovery was evaluated on three collection dates in 2009 on five cultivars of bermudagrass and seven cultivars of zoysiagrass. Princess 77 and Riviera bermudagrass were typically the cultivars with the fastest time to 50% recovery, whereas Meyer and Zenith zoysiagrass were typically the slowest. Additionally, Tifway bermudagrass had similar divot recovery to El Toro zoysiagrass. These results demonstrate that differences and similarities exist among bermudagrass and zoysiagrass cultivars for divot recovery and will allow golf course superintendents to better select cultivars and species that will improve playing conditions while decreasing inputs.

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A swing by a golfer while attempting to strike a golf ball commonly displaces an area of turf and soil that is referred to as a divot. It has been estimated that approximately 0.5 acres of turf are removed by divoting from a bermudagrass golf course fairway each year (Patton et al., 2010). The amount, size, and length of time divots exist on a tee or fairway can be dependent on species and cultivar (Beard, 1973). The rate of recovery of a turfgrass from divoting is an important factor that should be considered when selecting a species or cultivar for use on golf course tees or fairways, especially for facilities that have a high volume of play.

Karcher et al. (2005a, 2005b) examined the divot recovery of numerous bermudagrass (*Cynodon* spp.) and zoysiagrass (*Zoysia* spp.) cultivars in separate field studies. Although these species were in separate experimental areas, their data suggest that the recuperative capacity of these two species may not be as different as previously thought and reported in popular texts (Beard, 1973; Turgeon, 1996). For example, in 2004, Karcher et al. (2005a) reported that Riviera bermudagrass required 4.6 days to reach 50% recovery, while Karcher et al. (2005b) reported that Palisades zoysiagrass required 4.2 days to reach 50% recovery.

Therefore, the objectives of this experiment were to quantify and directly compare the divot recovery for various bermudagrass and zoysiagrass cultivars in a single field experiment.

Materials and Methods

Five cultivars of bermudagrass and seven cultivars of zoysiagrass were established in the summer of 2007. Plots were maintained under golf course fairway conditions, with a mowing height of 0.5 inch 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. Plots were divoted on 21 May and 29 June in 2009. 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

Differences among cultivars in time to reach 50% recovery occurred for each of the three divoting periods. When divoted 21 May 2009, the cultivars having the fastest time to 50% recovery were Princess 77, Riviera, Tifsport, and Tifway bermudagrass, as well as Palisades, Cavalier, and Zorro zoysiagrass (Fig. 1). The cultivars having the slowest time to 50% recovery and slower than Princess 77 and Riviera were Zenith, Diamond, El Toro, and Meyer zoysiagrass and Patriot bermudagrass.

The cultivars with the fastest time to 50% recovery from injury for plots divoted 29 June 2009 were Princess 77, Patriot, and Riviera bermudagrass (Fig. 2). The cultivars Tifway and Tifsport bermudagrass had slower divot recovery than Princess 77, Patriot, and Riviera bermudagrass, but faster than Meyer, Zenith, Diamond, and Cavalier zoysiagrass.

In summary, the cultivars generally with the fastest time to 50% recovery were Princess 77 and Riviera bermudagrass. The cultivars generally with the slowest time to 50% recovery were Meyer and Zenith zoysiagrass. Additionally, Tifway bermudagrass and El Toro zoysiagrass were similar in divot recovery. *Cynodon dactylon* consistently had the fastest recovery, while other species tended to have similar recovery rates across all cultivars. These results demonstrate that differences and similarities exist among bermudagrass and zoysiagrass cultivars for divot recovery. These results also suggest that differences in divot recovery between bermudagrass and zoysiagrass may be less than previously expected. Golf course superintendents should select a species or cultivar having a fast divot recovery for use on fairways or tees anticipating heavy amounts of divoting, especially driving range and par 3 tees.

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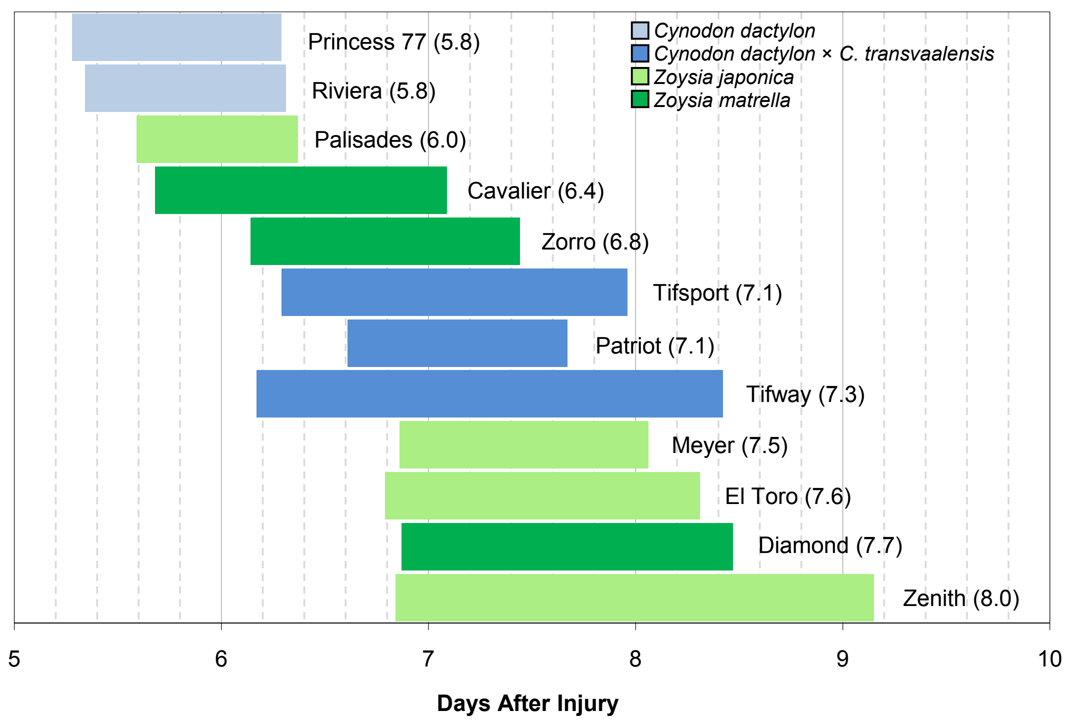

Fig. 1. Confidence intervals (95%) for mean number of days to 50% recovery from divoting on 21 May 2009. Cultivars are not significantly different (α = 0.05) if their confidence interval bars overlap. Cultivar name and number of days to 50% recovery (in parentheses) are located to the right of their corresponding bar.

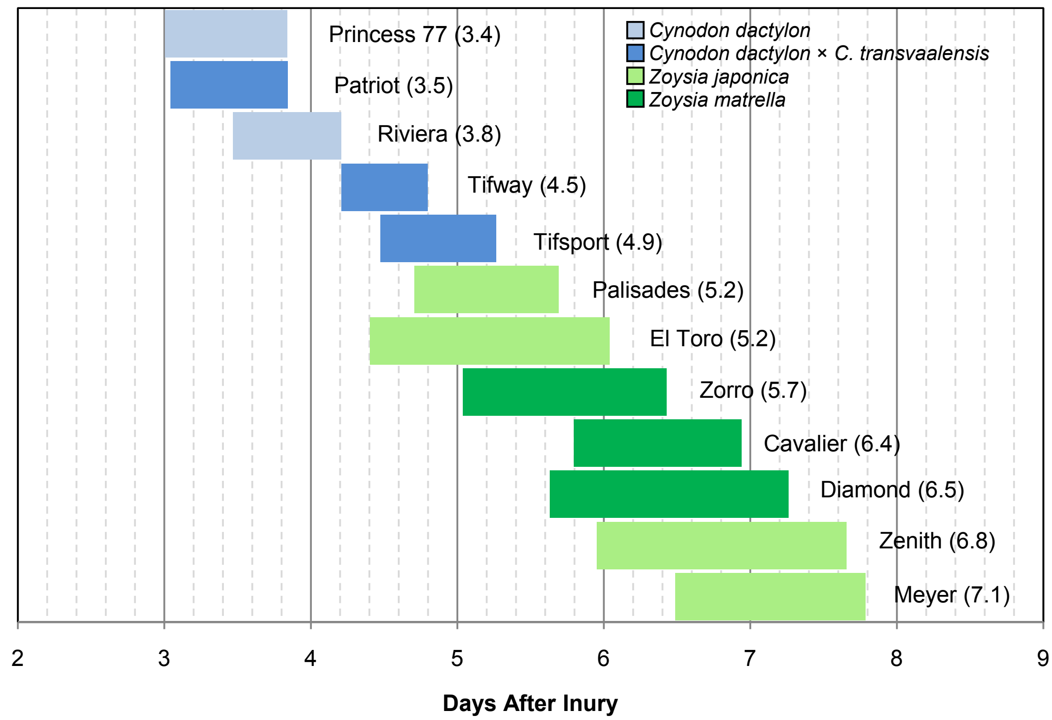

Fig. 2. Confidence intervals (95%) for mean number of days to 50% recovery from divoting on 29 June 2009. Cultivars are not significantly different (α = 0.05) if their confidence interval bars overlap. Cultivar name and number of days to 50% recovery (in parentheses) are located to the right of their corresponding bar.

Divot Resistance of Bermudagrass and Zoysiagrass Cultivars

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

Additional index words: *Cynodon dactylon*, *C. dactylon x C. transvaalensis*, fairway, shear strength, tee, *Zoysia japonica*, *Zoysia matrella*

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Photo by Jon Trappe

The ability of a turf to resist divoting can reduce maintenance inputs.

Summary. Divots created by a golf stroke are a regular occurrence on golf course fairways and tees. Divot resistance describes how often a divot is made as well as the size of the divot and is an important factor that should be considered when selecting a species or cultivar for use on golf course fairways or tees. There are no reports comparing the divot resistance of bermudagrass and zoysiagrass cultivars. Therefore, the objective of this experiment was to quantify the divot resistance for various bermudagrass and zoysiagrass cultivars in a field experiment. In the summer of 2009, divot resistance was evaluated on two collection dates on five cultivars of bermudagrass and seven cultivars of zoysiagrass. Cavalier, Diamond, and Zorro zoysiagrass had the highest divot resistance; while those with the lowest divot resistance were Patriot, Princess 77, and Riviera bermudagrass. These results demonstrate that differences exist among bermudagrass and zoysiagrass cultivars for divot resistance, and will allow golf course superintendents to better select cultivars and species that will improve playing conditions while decreasing inputs.

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

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Divots created by a golf stroke are a natural occurrence on golf course fairways or tees. It has been estimated that approximately 0.5 acres of turf are removed by divoting from a bermudagrass golf course fairway each year (Patton et al., 2010). The amount, size, and length of time divots exist on a tee or fairway can be dependent on species and cultivar (Beard, 1973). Divot resistance is an important factor that should be considered when selecting a species or cultivar for use on golf course tees or fairways. Divot resistance describes the resistance of a particular turfgrass to injury such as divoting. It can determine how often a golf stroke will result in a divot as well as the size of the divot made.

Resistance to injury is a characteristic of turf that has typically only been evaluated on sports turf. Research performed by Chivers and Aldous (2003) evaluated the shear strength of a turf stand using the Turf Shear Tester. Although this apparatus was evaluated to determine if an objective measurement device could be used to compare the safety and establishment of athletic fields, it has potential for comparing the shear strength (divot resistance) of turf.

Therefore, the primary objective of this experiment was to quantify the divot resistance for various bermudagrass and zoysiagrass cultivars in a field experiment, while a secondary objective was to compare evaluation methods of divot resistance.

Materials and Methods

Five cultivars of bermudagrass (*Cynodon* spp.) and seven cultivars of zoysiagrass (*Zoysia* spp.) were established in the summer of 2007 (Table 2). 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/1000 ft^2 for bermudagrass and 0.5 lb N/1000 ft^2 for zoysiagrass during the growing season.

Divot resistance was determined using two methods: 1) naturally divoted turf and 2) the Turf Shear Tester (Dr. Baden Clegg Pty. Ltd. Jolimont, Western Australia). Plots were divoted with both methods on 17 July and 1 September in 2009. Two golfers containing single digit handicaps each hit three golf balls on each plot using a pitching wedge. Each divot was numbered and assigned to one of the two golfers. The resulting effect of the club striking the turf was then rated for divot severity for each golf shot (Table 1).

To calculate the volume of each divot, the divot was filled with sand until the sand was level with the soil surrounding the divot. The sand used to fill the divots was sieved using a 1.5 mm sieve to remove small gravel and oven dried prior to use. Bulk density was calculated for the sand as 1.53 g/cm^3. The amount of sand needed to fill the divot was calculated by subtracting the weight of container plus sand before filling the divot and weight of container and sand after filling. The volume of each divot was determined using the calculated bulk density of the sand and the weight of sand needed to fill each divot.

Additionally, a Turf Shear Tester was used to determine lateral shear strength of each of the species and cultivars (Chivers and Aldous, 2003). The wedge of the tester was set to a 1.2-inch depth below canopy height, which approximated a 0.67-inch deep divot. A total of six measurements (subsamples) were collected on each plot using the Clegg Shear Tester.

Results and Discussion

Differences existed among cultivars for divot resistance using both a pitching wedge and the Turf Shear Tester (Table 2). The cultivars having the most severe injury from divoting across the two dates of the study were Patriot, Princess 77, Riviera, and Tifsport bermudagrass, as well as Meyer, Palisades, and Zenith zoysiagrass. Zorro zoysiagrass had the lowest mean divot severity and was less than Palisades zoysiagrass, Princess 77, Riviera, and Tifsport bermudagrass. The cultivar with the largest volume divots was Riviera bermudagrass (Table 2). The cultivars with the smallest volume divots were Cavalier, Diamond, El Toro, Meyer, Zenith, and Zorro zoysiagrass.

Differences existed in the amount of force required to make a divot for cultivars and species using the Turf Shear Tester (Table 2). The cultivars requiring the highest amount of force to remove a divot (most divot resistance) were Cavalier, Diamond, Palisades, and Zorro zoysiagrass, as well as Tifsport, and Tifway bermudagrass (Table 2). The cultivars requiring the lowest amount of force to make a divot (least divot resistance) were Patriot, Riviera, and Princess 77 bermudagrass, as well as El Toro, Meyer, and Zenith zoysiagrass.

There is little published work comparing the divot resistance of bermudagrass or zoysiagrass cultivars. Beard (1973) suggested that wear tolerance is similar to a turfgrass' ability to withstand injury. Wear tolerance has been evaluated extensively in selecting turfgrass species and cultivars with higher resistance to foot and vehicle stresses (Youngner, 1961; Shearman and Beard, 1975; Trenholm et al., 2000). Youngner (1961) simulated wear (scuffing) on different turfgrass species and reported that 'Meyer' *Z. japonica* and a *Z. matrella* cultivar tolerated more simulated wear than two different common bermudagrass cultivars. Although no statistical analysis was reported in Youngner (1961), for discussion purposes, some similarities to the reports of this research could be stated. *Zoysia matrella* has been reported as having a high shoot density (Riffell et al., 1995), which has been reported as an important factor in a turfgrass' ability to withstand injury (Serensits, 2008). This may explain why *Z. matrella* was found to have a higher divot resistance in this study.

Conclusion

Across the three evaluation methods for divot resistance, the cultivars having the highest divot resistance were Cavalier, Diamond, and Zorro zoysiagrass. The cultivars having the lowest divot resistance were Patriot, Princess 77, and Riviera bermudagrass. These results demonstrate that differences exist among bermudagrass and zoysiagrass cultivars' divot resistance. Golf course superintendents should select a species or cultivar having a high divot resistance for use on fairways or tees anticipating heavy amounts of divoting, especially Par 3 or driving range tees.

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Table 1. Visual rating scale used to describe divot severity of various bermudagrass and zoysiagrass cultivars in Fayetteville, Ark.

Divot severity
1 = none to very small divot or turf surface disruption
2 = small divot or turf surface disruption
3 = moderate divot size or turf surface disruption
4 = large divot or turf surface disruption
5 = very large divot or turf surface disruption

Table 2. Divot severity, divot volume, and force required to make a divot with the Turf Shear Tester on various bermudagrass and zoysiagrass cultivars in Fayetteville, Ark.

Cultivar	Species	Severity[z]	Volume[x]	Shear strength[y]
		(1-5)	cm^3	N/m
Cavalier	ZM[v]	2.3 bcd	19 e	72 ab
Diamond	ZM	2.1 cd	21 de	73 a
El Toro	ZJ	2.3 bcd	27 b-e	61 cde
Meyer	ZJ	2.4 a-d	22 cde	59 de
Palisades	ZJ	2.8 ab	35 b	68 abc
Patriot	CDCT	2.5 a-d	31 bc	57 e
Princess	CD	2.8 ab	33 b	59 de
Riviera	CD	3.0 a	45 a	64 b-e
Tifsport	CDCT	2.7 abc	31 bc	67 a-d
Tifway	CDCT	2.3 bcd	30 bcd	67 a-d
Zenith	ZJ	2.5 a-d	25 b-e	58 e
Zorro	ZM	2.0 d	18 e	70 ab

[z] Visual rating of divot severity (1-5). See Table 1.
[x] Average volume of sand (cm^3) required to fill divot.
[y] Force ($N\ m^{-1}$) required to make a divot using the Turf Shear Tester.
[v] ZJ = *Zoysia japonica*; ZM = *Zoysia matrella*; CD = *Cynodon dactylon*; CDCT = *Cynodon dactylon* × *C. transvaalensis*.

Shade and Traffic Tolerance of Bermudagrass and Zoysiagrass – Year 2 Results

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

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Photo by Jon Trappe

Traffic application to bermudagrass and zoysiagrass.

Summary. Bermudagrass and zoysiagrass are two of the most commonly used turfgrass species on golf course fairways and tees in the southern U.S. Shade from trees is common on golf courses and limits turfgrass growth. Additionally, turfgrasses are often subjected to traffic, which damages turf. The objectives of this study were to evaluate the effects of shade and traffic on bermudagrass and zoysiagrass cultivars. Five cultivars of bermudagrass and seven cultivars of zoysiagrass were maintained under typical golf course fairway conditions. Plots were grown in either full sun or were shaded with a 50% light reducing fabric. The cultivars containing the highest coverage after two years of growth in continuous shade were Cavalier, Diamond, Meyer, Palisades and Zorro zoysiagrass, as well as Princess 77, and Riviera bermudagrass. The cultivars having the lowest coverage in shade were Patriot and Tifsport bermudagrass and Zenith zoysiagrass. Princess 77 and Riviera bermudagrass, as well as Cavalier, Meyer, and Zorro zoysiagrass had the highest coverage when trafficked regardless of shade treatment. Selecting cultivars well-adapted to shade and tolerant of trafficking will help golf course and sports field managers improve playing conditions while reducing maintenance inputs and costs.

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

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Trees that produce shade are common on golf courses due to their importance in course design. Shade limits turfgrass growth, and results in reduced root mass, root number, carbohydrate reserves, rhizomes and stolons, and overall turfgrass quality (Qian and Engelke, 1997). Shade is especially detrimental to bermudagrass (*Cynodon* spp.) growth (Baldwin et al., 2008). Responses of turfgrasses to shade vary by species (Bunnell et al., 2005) and by cultivars within species (Baldwin et al., 2008; Qian and Engleke, 1997).

Traffic is a term used to describe the combined effects of wear and soil compaction (Trenholm et al., 2000). Regular traffic that occurs on sports fields, golf courses, and residential areas can be detrimental to bermudagrass and zoysiagrass (*Zoysia* spp.) growth. Previous research has investigated which species have superior wear and traffic tolerance. Youngner (1961) evaluated different wear types on various turfgrass species. It was reported that 'Meyer' zoysiagrass and a *Z. matrella* cultivar tolerated more simulated wear than two common bermudagrass cultivars, though no statistical analysis was reported. Although Meyer zoysiagrass was used in the study, no other cultivars used in the study are commercially available today. Trappe et al. (2009) investigated traffic tolerance of newer bermudagrass cultivars but did not investigate their traffic tolerance in the same trial with commonly used zoysiagrass cultivars. The objectives of this research were to evaluate the traffic tolerance and performance of bermudagrass and zoysiagrass cultivars in two different light environments.

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 inch 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. For each replication, there was one shaded and one non-shaded plot. A shade fabric reducing light by 50% was placed over the plots continuously beginning April 2008. Shade tolerance was evaluated using digital image analysis to determine percent green turf cover as affected by shade when compared to full sun (Richardson et al, 2001). Images of turf were taken monthly, and two sampling dates were used to distinguish shade tolerance among cultivars and species.

Traffic was applied weekly for five consecutive weeks using the Cady traffic simulator (Henderson et al., 2005) beginning on 1 August. Two passes in the forward direction were made to half of each plot in both full sun and shaded plots. Four passes simulate two football games within the hash marks (Henderson et al., 2005). After four weeks of traffic had occurred, two weeks of additional traffic were applied to the full sun plots only in each year, because coverage in shaded plots receiving traffic was less than 20%. 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), and a total of four evaluation dates were used to distinguish traffic tolerance among cultivars and species.

Results and Discussion

Non-trafficked plots. Of the two sampling dates used to distinguish differences in non-trafficked coverage in shaded or full sun, an interaction between shade treatment and cultivar existed for both sampling dates (16 July and 29 September 2009) (Table 1). On 16 July 2009, Patriot bermudagrass had equal coverage to other cultivars in the full sun but less coverage in the shade while the coverage of other cultivars was not significantly reduced in shade. Additionally, a shade treatment by cultivar interaction existed on 29 September 2009. The cultivars Diamond and Zenith zoysiagrass, and Tifsport and Tifway bermudagrass each had similar coverage to other cultivars in the full sun but had less coverage in the shade, while the coverage of other cultivars was not reduced in shade. Patriot bermudagrass had less coverage than all other cultivars in full sun on 29 September 2009, and like others contributing to the interaction, had reduced coverage in the shade treatment compared to the coverage of other cultivars in shade. It is unclear why Patriot bermudagrass has reduced coverage in full sun plots when compared to other cultivars.

When comparing these findings for shade tolerance within species to previous work, some similarities and differences exist. These findings are similar to Baldwin et al. (2008), in that Princess 77 and Riviera had greater shade tolerance than Patriot, Tifsport, and Tifway when grown in 64% shade.

Few differences occurred among zoysiagrass cultivars for shade tolerance across all dates of the study, excluding Zenith zoysiagrass, which had decreased coverage in shaded plots. The lack of separation among zoysiagrass cultivars in this study may be from using lower shade intensity than previous researchers (Riffell et al. 1995; Qian and Engelke, 1997). However, Sladek et al. (2009) reported differences in shade tolerance using a similar shade intensity to this experiment, though their work was performed in a controlled environment. Additionally, although Diamond zoysiagrass was found to have excellent shade tolerance in two studies (Qian and Engelke, 1997; Sladek et al. 2009) in Texas, its coverage was less than Meyer and Palisades in the shade on the last evaluation date of 29 September 2009. It was not clear what caused this reduction on the last evaluation date (Table 1). Greater separation of shade tolerance among cultivars and species may have been observed if greater shade intensity were used in this experiment, or if shade had been simulated beyond the two years of this study.

Trafficked plots. Shade treatment by cultivar interactions existed for both 1-2 and 3-4 weeks of traffic timings in trafficked plots (Table 2). This shade treatment by cultivar interaction indicates that some cultivars have relatively greater coverage when trafficked (traffic tolerance) at a particular light treatment while others perform similar in the shade and full sun. Under 1-2 weeks of traffic, Cavalier, El Toro, and Zenith zoysiagrass, as well as Patriot and Tifway bermudagrass had the highest coverage in full sun plots but had reduced coverage in shade. Meyer, Palisades, and Zorro zoysiagrass, as well as Princess 77 and Riviera bermudagrass had the highest coverage in both the full sun and shade. A shade by cultivar interaction also existed for 3-4 weeks of traffic in 2009. El Toro, Palisades, and Zorro zoysiagrass as well as Princess 77 and Riviera bermudagrass had the highest coverage in full sun conditions, but had reduced coverage in shade. Similarly, although Cavalier and Meyer zoysiagrass as well as Tifsport and Tifway bermudagrass only had reduced coverage in full sun compared to Riviera bermudagrass and Zorro zoysiagrass, these cultivars also had reduced coverage in shade. In addition to having the lowest coverage among shaded cultivars, Patriot bermudagrass also had reduced coverage in full sun conditions, indicating this cultivar's susceptibility to traffic stress.

Differences existed among cultivars across trafficked plots in full sun conditions when receiving additional traffic (two additional weeks) compared to shaded plots (Table 3). After six weeks of trafficking, all bermudagrass cultivars had similar coverage except Patriot bermudagrass on 29 September. The cultivars with the highest turfgrass coverage were Princess 77, Riviera, and Tifway bermudagrass as well as Cavalier, Meyer, and Zorro zoysiagrass. Additionally, Meyer zoysiagrass and Riviera and Tifway bermudagrass had higher coverage than El Toro, Palisades, and Zenith zoysiagrass as well as Tifsport bermudagrass. As a whole these results demonstrate that after 6 weeks of trafficking in full sun, bermudagrass and zoysiagrass traffic tolerance were similar. It is uncertain whether these similarities would still exist if traffic was increased in duration or intensity.

The overall traffic tolerance of zoysiagrass compared to bermudagrass was surprisingly similar despite the limited use of zoysiagrass cultivars on athletic fields. Though *Zoysia* spp. have been reported as having superior wear tolerance than *Cynodon* spp. (Youngner, 1961), little work has evaluated their traffic tolerance within or among other species. This lack of research may be due to decreased recovery rates from injury of zoysiagrass compared to bermudagrass reported in popular texts such as Beard (1973). Future research in zoysiagrass traffic tolerance should evaluate additional traffic durations and intensities of trafficking as well as the time to full recovery from injury.

Conclusion

This research provides cultivar recommendations for specific growing environments. For instance, if a golf course superintendent were selecting a species or cultivar for a lightly shaded tee or fairway, Cavalier, Diamond, El Toro, Meyer, Palisades, and Zorro zoysiagrass, as well as Princess 77 and Riviera bermudagrass would be appropriate cultivars for that location. Additionally, if turfgrass managers anticipating traffic in areas such as sports fields, parks, or golf turf, the cultivars Princess 77, Riviera, Tifsport and Tifway bermudagrass as well as El Toro, Palisades, and Zorro zoysiagrass would be appropriate cultivars for these situations. Lastly, for situations having both light shade and traffic stress, such as golf course fairways receiving cart traffic, or shaded park areas that receive heavy foot traffic, Princess 77 and Riviera bermudagrass, as well as Cavalier, El Toro, Meyer, Palisades, and Zorro zoysiagrass would be appropriate cultivars. The ultimate goal of these studies 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 costs.

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Table 1. Percent green coverage of various bermudagrass and zoysiagrass cultivars grown in 50% shade or full sun without traffic stress.

		16 July			29 September		
Cultivar	Species	Sun	Shade	Mean	Sun	Shade	Mean
		-----	-----	-----	%	-----	-----
Cavalier	ZM[z]	99.7 AB[y]	99.4 AB	99.6	88.6 A-E	88.6 A-E	88.6
Diamond	ZM	99.9 A	99.0 AB	99.5	90.5 A-D	83.3 EF	86.9
El Toro	ZJ	99.7 AB	99.0 AB	99.4	92.7 ABC	88.1 B-E	90.4
Meyer	ZJ	99.2 AB	98.7 AB	99.0	93.6 AB	91.1 A-D	92.4
Palisades	ZJ	99.8 AB	97.7 AB	98.8	89.8 A-E	91.0 A-D	90.4
Patriot	CDCT	99.8 AB	82.6 C	91.2	86.2 DEF	74.6 G	80.4
Princess 77	CD	99.8 AB	97.0 AB	98.4	93.1 ABC	89.4 A-E	91.3
Riviera	CD	99.7 AB	95.7 B	97.7	93.2 AB	88.6 A-E	90.9
Tifsport	CDCT	99.9 A	95.8 AB	97.9	93.7 AB	66.2 H	80.0
Tifway	CDCT	99.9 A	97.9 AB	98.9	94.6 A	67.0 H	80.8
Zenith	ZJ	99.7 AB	97.2 AB	98.5	93.0 ABC	81.3 F	87.2
Zorro	ZM	99.9 A	99.5 AB	99.7	88.9 A-E	86.8 C-F	87.9

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

[y] Within columns, means followed by the same letter are not significantly different according to Fisher's protected LSD ($\alpha = 0.05$).

Table 2. The effect of full sun and 50% shading on trafficked bermudagrass and zoysiagrass cultivar coverage in 2009. Traffic was applied weekly from 31 July until 31 August in 2009.

		1-2 weeks of traffic			3-4 weeks of traffic		
Cultivar	Species	Sun	Shade	Mean	Sun	Shade	Mean
		-----	-----	-----	%	-----	-----
Cavalier	ZM[z]	91 ABC[y]	88 BCD	90	69 BCD	32 IJ	50
El Toro	ZJ	97 A	81 DE	89	80 ABC	19 JK	50
Meyer	ZJ	92 ABC	94 ABC	93	72 BCD	53 EFG	62
Palisades	ZJ	97 A	91 ABC	94	78 ABC	39 GHI	57
Patriot	CDCT	89 A-D	54 G	71	49 FGH	12 K	31
Princess 77	CD	89 A-D	91 ABC	90	81 ABC	45 GHI	63
Riviera	CD	96 AB	89 A-D	93	84 AB	38 GHI	61
Tifsport	CDCT	88 CD	75 EF	81	70 BCD	35 HIJ	54
Tifway	CDCT	92 ABC	73 CD	82	66 CDE	22 JK	44
Zenith	ZJ	93 ABC	70 F	82	61 DEF	21 JK	41
Zorro	ZM	95 ABC	89 A-D	92	89 A	29 IJ	59

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

[y] Within columns, means followed by the same letter are not significantly different according to Fisher's protected LSD ($\alpha = 0.05$).

Table 3. Full sun trafficking (6 weeks) of bermudagrass and zoysiagrass cultivar coverage. Traffic was applied weekly from 31 July until 19 September in 2009.

Cultivar	Species	2009
		(%)
Cavalier	ZM[z]	81 ABC[y]
El Toro	ZJ	75 BC
Meyer	ZJ	89 A
Palisades	ZJ	73 C
Patriot	CDT	53 D
Princess 77	CD	84 AB
Riviera	CD	86 A
Tifsport	CDCT	76 BC
Tifway	CDCT	87 A
Zenith	ZJ	76 BC
Zorro	ZM	83 AB

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

[y] Values in a column followed by the same letter are not significantly different from one another ($\alpha = 0.05$).

Annual Bluegrass Control in Creeping Bentgrass Putting Greens

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Additional index words: *Poa annua*, *Agrostis stolonifera*, cumyluron, herbicide

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Photo by Casey Crittenden

Annual bluegrass control with cumyluron at Bella Vista, Ark.

Summary. Annual bluegrass is the most problematic weed in creeping bentgrass putting greens around the world. Three different studies were conducted over a three year period to evaluate the effectiveness of cumyluron as a postemergence control option for annual bluegrass and to evaluate any bentgrass injury caused from herbicide applications. Studies were conducted at Pinnacle Country Club in Rogers, Ark. and The Brittney Golf Course in Bella Vista, Ark. All treatments in all studies were broadcast applied using a CO_2-propelled sprayer. In the first two trials, results varied and, although annual bluegrass populations were reduced, treatments were not significantly different from the controls. In the third trial, cumyluron significantly reduced annual bluegrass populations compared to the control. The higher applications rates resulted in almost complete removal of the annual bluegrass from creeping bentgrass putting green turf.

Abbreviations: GPA, gallons per acre

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Annual bluegrass (*Poa annua*) is the most problematic winter weed in creeping bentgrass (*Agrostis stoloniferia*) putting greens (Beard, 1973). Its ability to grow and reproduce at a rapid rate and under varying conditions makes it very difficult to control. Annual bluegrass has the ability to grow and thrive in almost any condition whether it be compacted, dry, or under close mowing, as seen on golf putting greens (Beard et al., 1978; Lush, 1989; Sweeney and Danneberger, 1997). Annual bluegrass is often yellow-green in color and can lead to a mottled look when growing amongst a darker green grass such as creeping bentgrass (Lycan and Hart, 2006). Annual bluegrass is also undesirable because it is very coarse textured and can produce numerous seed heads which can affect playability of golf greens (Engel and Ilnicki, 1969; McCarty, 1999).

Annual bluegrass germinates during the fall and again during the spring when temperatures are in the mid-70s during the day and the mid-50s at night (McCarty, 1999). There are also two types of annual bluegrass found in putting greens, including an annual type and a type that behaves as a perennial. The annual type has the ability to produce as many as 2,200 seeds per plant during the growing season, and this contributes to the difficulty in controlling the weed since there are so many seeds in the soil. The perennial type produces less seed, but has more of a prostrate growth habit and can thrive under extremely low mowing heights (McCarty, 1999).

Control of annual bluegrass often includes a range of cultural and chemical approaches. In recent years, turf managers have been effectively using plant growth regulators such as paclobutrazol (Trimmit) to give bentgrass a competitive advantage over annual bluegrass (McCarty, 2005 and Murphy, 2005). However, these approaches are inconsistent and very rarely provide complete control of annual bluegrass. The objective of this research was to evaluate the effectiveness of cumyluron, a substituted urea herbicide under development by Helena Chemical Co, Colliver, Tenn. (Calhoun and Hathaway, 2009), for annual bluegrass control in creeping bentgrass putting greens.

Materials and Methods

All trials were conducted on creeping bentgrass putting greens in Northwest Arkansas. Each trial received treatments in both the fall and spring (Table 1). Prior to initiation of treatments, annual bluegrass populations were determined for each plot using a line intersect grid. Each grid was randomly thrown twice in each plot and intersects were counted and averaged to determine an existing population. All herbicide treatments were applied using a CO_2-propelled sprayer and a 5 ft. spray boom. Plot size was 5 ft by 10 ft. Plots were rated for percent injury at 3 days following herbicide application and percentage annual bluegrass was rated in each plot at several dates following treatment. All studies were arranged in a randomized complete block design.

The first trial was conducted on a practice green at Pinnacle Country Club in Rogers, Ark. Three different rates of cumyluron were sprayed in this trial, including 0.75, 1.5, and 2.25 oz a.i./1000 ft^2. All treatments were applied at a spray volume of 66 gpa (Table 1). For all treatments rates, a second set of treatments were combined with an adjuvant, HM0716 (Helena Chemical Co.), at a rate of 0.25% v/v. Finally all three treatment rates were also replicated in plots in which irrigation was applied immediately following herbicide application at a rate of 0.25 inch using a pre-measured volume of water and a watering can. Treatments were applied in fall 2007 and spring 2008.

The second trial was conducted at The Brittney Golf Course (Hole #7) in Bella Vista, Ark. The duration of this trial was from spring 2008 to spring 2009 and included three treatment application dates. This trial used the same rates of cumyluron as the trial at Pinnacle C.C. As in the previous study, existing bluegrass populations were determined using the line intersect grid prior to treatment application. Treatments were applied at a spray volume of 96 gpa with half the plots receiving irrigation immediately following herbicide applications. Irrigation was applied at a rate of 0.25 inch using a watering can and a predetermined volume of water.

The third trial was also conducted on the The Brittney Golf Course (Hole #6). Treatments were applied at a spray volume of 45 gpa. In this trial three different rates of two different formulations of cumyluron were applied in the fall of 2008 and the spring of 2009. Annual bluegrass populations were calculated in the same method as in the previous two trials. Phytotoxicity ratings were taken three days after treatment and bluegrass populations were determined three times following treatment applications.

Results and Discussion

There was no injury to the creeping bentgrass following any application of treatments in any of the three trials (data not shown). In the first trial at Pinnacle C.C., annual bluegrass populations slightly declined across the whole plot area in the first 6 months after treatments were initiated, but no differences between treatments were significant (Table 2). This trend continued until the spring of 2008 where on 29 May we observed a significant reduction in annual bluegrass from several treatments. The 1.50 oz + surfactant and all 2.25-oz treatments had significantly less annual bluegrass than the untreated control. Bluegrass populations continued to fall through the summer and there were no treatment effects observed on 15 August 2008, but this can be attributed to summer heat and normal bluegrass growth patterns. In the fall of 2008, the study was concluded at this site because the green was destroyed for renovation.

In the second trial there were no significant differences between any of the treatments and the untreated check on any of the rating dates (data not shown). Annual bluegrass populations were maintained at around 25% throughout the study. Again, there was no phytotoxicity observed with any of the treatments (data not shown).

The third trial provided the most significant treatment effects of all trials. This green was the most infested with annual bluegrass and had annual bluegrass populations between 60-75% prior to treatment applications (Table 3). At approximately 5 months after the first treatment application, there were significant decreases in all cumyluron-treated plots compared to the untreated check (Table 3, Fig. 1). The higher two rates of cumyluron decreased the annual bluegrass population from approximately 60% to less than 5% with a single application (Table 3). Following the second application date, the 1.5- and 2.25-oz treatments were significantly better than the 0.75-oz treatment in reducing annual bluegrass populations. Our results with this new herbicide are similar to those seen at Michigan State in 2007 (Calhoun, 2009) where they also observed better annual bluegrass control when the herbicide rates were increased.

Conclusions

Since the results varied between studies, it is premature to make firm recommendations regarding the effectiveness of cumyluron for annual bluegrass control. However, control of annual bluegrass using most postemergence herbicides has been unreliable at best (McCarty, 1999). Factors such as timing, temperature, tank mixes, and irrigation may play some role in the efficacy of cumyluron in the control of annual bluegrass. We did see in our third trial that population reductions were possible, which may have been an effect of the particular subspecies of annual bluegrass that was present on that green and/or herbicide rate or formulation (McCarty, 1999). Finally, one consistent observation in these trials was that no phytotoxicity was ever observed with these treatments, suggesting that cumyluron has a high degree of safety on creeping bentgrass.

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Table 1. Treatments for various cumyluron trials conducted over the past three growing seasons.

Treatment	Rate	Surfactant	Irrigation	Application dates			
	oz. a.i./1000 ft^2	0.25% v/v	0.25 inch	Fall 2007	Spring 2008	Fall 2008	Spring 2009
Pinnacle CC							
Untreated check				x	x		
HM9930	0.75			x	x		
HM9930	0.75	X		x	x		
HM9930	0.75		X	x	x		
HM9930	1.50			x	x		
HM9930	1.50	X		x	x		
HM9930	1.50		X	x	x		
HM9930	2.25			x	x		
HM9930	2.25	X		x	x		
HM9930	2.25		X	x	x		
Bella Vista #6							
Untreated check					x	x	x
HM9930	0.75				x	x	x
HM9930	0.75		X		x	x	x
HM9930	1.50				x	x	x
HM9930	1.50		X		x	x	x
HM9930	2.25				x	x	x
HM9930	2.25		X		x	x	x
Bella Vista #7							
Untreated check						x	x
HM9930	0.75					x	x
HM9930	1.50					x	x
HM9930	2.25					x	x
HM0814	0.75					x	x
HM0814	1.50					x	x
HM0814	2.25					x	x

Table 2. *Poa annua* incidence at Pinnacle Country Club, as affected by various cumyluron treatments.

Treatment	Rate	Surfactant	Irrigation	9/28/07	11/28/07	2/27/08	5/29/08	8/15/08
	oz a.i./1000 ft^2	0.25 % v/v	0.25"	------------------------ Poa annua (%) ------------------------				
Untreated check				27	15	18	28ab [z]	8
HM9930	0.75			38	25	20	32a	7
HM9930	0.75	X		32	24	12	16cde	8
HM9930	0.75		X	24	25	14	19bcd	4
HM9930	1.50			32	30	13	19bcd	11
HM9930	1.50	X		30	25	14	11de	5
HM9930	1.50		X	32	27	23	23abc	10
HM9930	2.25			26	18	13	13cde	8
HM9930	2.25	X		24	26	15	14cde	5
HM9930	2.25		X	17	27	7	8e	7
LSD (P=0.05)				ns [y]	ns	ns	10	ns

[z] means followed by different letters are significantly different at the 0.05 level of probability.
[y] ns – not significantly different.

Table 3. *Poa annua* incidence at Brittney Golf Course (Hole #6), as affected by various cumyluron treatments.

Treatment	Rate	9/25/09	2/6/09	4/2/09
	oz a.i./1000 ft^2		*Poa annua* (%)	
Untreated check		75	63 a [z]	81 a
HM9930	0.75	66	25 b	24 b
HM9930	1.50	64	3 b	6 c
HM9930	2.25	64	2 b	3 c
HM0814	0.75	63	16 b	19 b
HM0814	1.50	59	2 b	5 c
HM0814	2.25	61	1 b	4 c
LSD (P=0.05)		ns [y]	19	8

[z] means followed by different letters are significantly different at the 0.05 level of probability.
[y] ns – not significantly different.

Fig. 1. Image of untreated check plot on 27 March 2009 at Bella Vista, Ark. Notice reduction in *Poa annua* in both treated plots on each side of check.

Effect of Mesotrione on Overwintering and Spring Green-up of Seeded Bermudagrass

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Additional index words: *Cynodon dactylon*, postemergence, phytotoxicity, digital image analysis

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Photo by Mike Richardson

Bleaching injury on Riviera bermudagrass with mesotrione.

Summary. Seeded bermudagrass is most susceptible to weed infestations and winter injury during its first growing season. The objective of this trial was to evaluate the effects of mesotrione, applied in the fall to two seeded bermudagrass cultivars, on winter injury and spring green-up. The two seeded bermudagrass cultivars tested were Princess-77 and Riviera, which are considered cold-sensitive and cold-resistant, respectively. This trial was seeded in the late summer of 2008 and was concluded once the turf canopy reached 100% cover the following summer. There were 4 treatments in this trial, including 4 sequential applications of 0.125 lb a.i./acre, 2 sequential applications of 0.25 lb a.i./acre and 2 sequential applications of 0.5 lb a.i./acre. Turfgrass coverage ratings were documented using digital image analysis. Significant reductions in grass cover were observed on both cultivars in the fall for all herbicide treatments. Spring green up was slightly delayed due to herbicide treatment, especially with the cold-sensitive cultivar, Princess-77, when mesotrione was applied at the highest rate.

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The improved quality of seeded bermudagrass (*Cynodon dactylon*) cultivars has led to their widespread use over the last few years. Several factors have been shown to affect the successful establishment of these cultivars. It is also well known that several of these new seeded varieties have superior cold tolerance once established (Richardson et al., 2004). Riviera and Yukon have significantly better winter survival than several other varieties of seeded and vegetatively-propagated bermudagrass (Morris, 2002; Richardson, et al., 2004).

Seeded bermudagrass has also shown excellent tolerance to postemergence herbicides during establishment (McCalla et al., 2004; McElroy et al., 2005; Patton et al., 2007). Mesotrione (Tradename Tenacity™, Syngenta, Wilmington, Del.) 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, and mesotrione provides turf managers with another option to control these weeds.

Mature bermudagrass in typically injured by mesotrione (Boyd, 2008) as the plant tissue turns white (bleaching), then necrotic within three to five days (Fig. 3). This phytotoxicity would be unacceptable in most turfgrass situations, but may be less problematic in situations such as sod production, since the phytotoxicity is short-lived and the turf can recover from injury. However, there have been no studies to date to investigate the effects of mesotrione on bermudagrass injury going into the fall and how it may adversely effect green-up the following spring. The objective of this trial was to evaluate mesotrione for phytotoxicity in the fall and how it affects regrowth the following spring on Princess-77 and Riviera seeded bermudagrass.

Materials and Methods

This study was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville Ark. on newly established Princess-77 and Riviera seeded bermudagrass during the fall 2008 and the spring 2009. Both Princess-77 and Riviera seeded bermudagrass were planted in June 2008 at a rate of 1.0 lb pure live seed/1000 ft^2. Both plot areas were fertilized at a rate of 1.0 lb N/1000 ft^2 monthly from July-September. Herbicide treatments were applied using a CO_2-propelled single nozzle boom with 8001 VS nozzle at a volume of 40 gallons per acre and a spray shield was used to prevent drift between plots. Plots were 4 by 4 ft. There were four treatments in this trial, including 4 sequential applications of 0.125 lb a.i./acre, 2 sequential applications of 0.25 lb a.i./acre, 2 sequential applications of 0.5 lb a.i./acre, and an untreated control. A nonionic surfactant was included with each herbicide treatment at a rate of 0.25% v/v.

Turfgrass coverage ratings were collected using digital image analysis (Richardson et al., 2001). Photos were taken beginning the week following the first herbicide treatment (22 August 2008) and concluded once dormancy was reached in the fall. In the spring, photos were also taken beginning 18 March 2009 and were concluded 22 May 2009.

Results and Discussion

Mesotrione applications on newly established seeded bermudagrass caused typical injury (Fig. 3) on both cultivars and did significantly reduce the green coverage on several dates going into dormancy (Fig. 1). The levels of injury were similar to what were observed when applications were made during the summer at similar rates on established Tifway bermudagrass (McCalla et al., 2009). The week following the first application of the 0.125 lb a.i./acre application, there was a significant reduction in turfgrass coverage on Riviera when compared to the control (Fig. 1). Coverage was also significantly reduced on both cultivars following the second application of the 0.125 lb a.i./acre treatment (Fig. 1). All treatments were applied at the third application date and significantly reduced coverage at the 0.25 and the 0.5 lb a.i./acre treatments. Following the final herbicide application date, the two highest rates significantly reduced the coverage on both Princess-77 and Riviera. The 0.5 lb treatment had significantly less coverage than all other treatments on both cultivars (Fig. 1). It is important to note that the most severe injury occurred at the 0.5 lb a.i./acre treatment being applied twice, which exceeds the maximum recommended label rate for annual applications of mesotrione.

The following spring, initial greenup was observed in late March (Fig. 2). There were significant reductions in spring greenup on Riviera treated with mesotrione throughout the spring evaluation at the higher application rates, although most reductions were only 10-20% when compared to the controls. As the Riviera reached 80% turfgrass coverage, differences between treated and untreated plots were minor (Fig. 2). There were no differences in coverage between any treatments on the first two rating dates in the Princess-77 plots (Fig. 2). However, beginning on 11 May 2009, the 0.5 lb/acre rate significantly delayed green-up in Princess-77 compared to all other treatments and the untreated control.

Spring green up of Riviera was only slightly affected by mesotrione and it reached complete coverage before the Princess-77. The cold-sensitive cultivar, Princess-77, also seemed to be more severely affected by fall-applied mesotrione treatments, especially at higher rates. These results suggest that fall applications of mesotrione might cause more winter injury to cultivars that are typically more sensitive to cold temperatures. These trials are currently being repeated during the 2009-2010 winter season.

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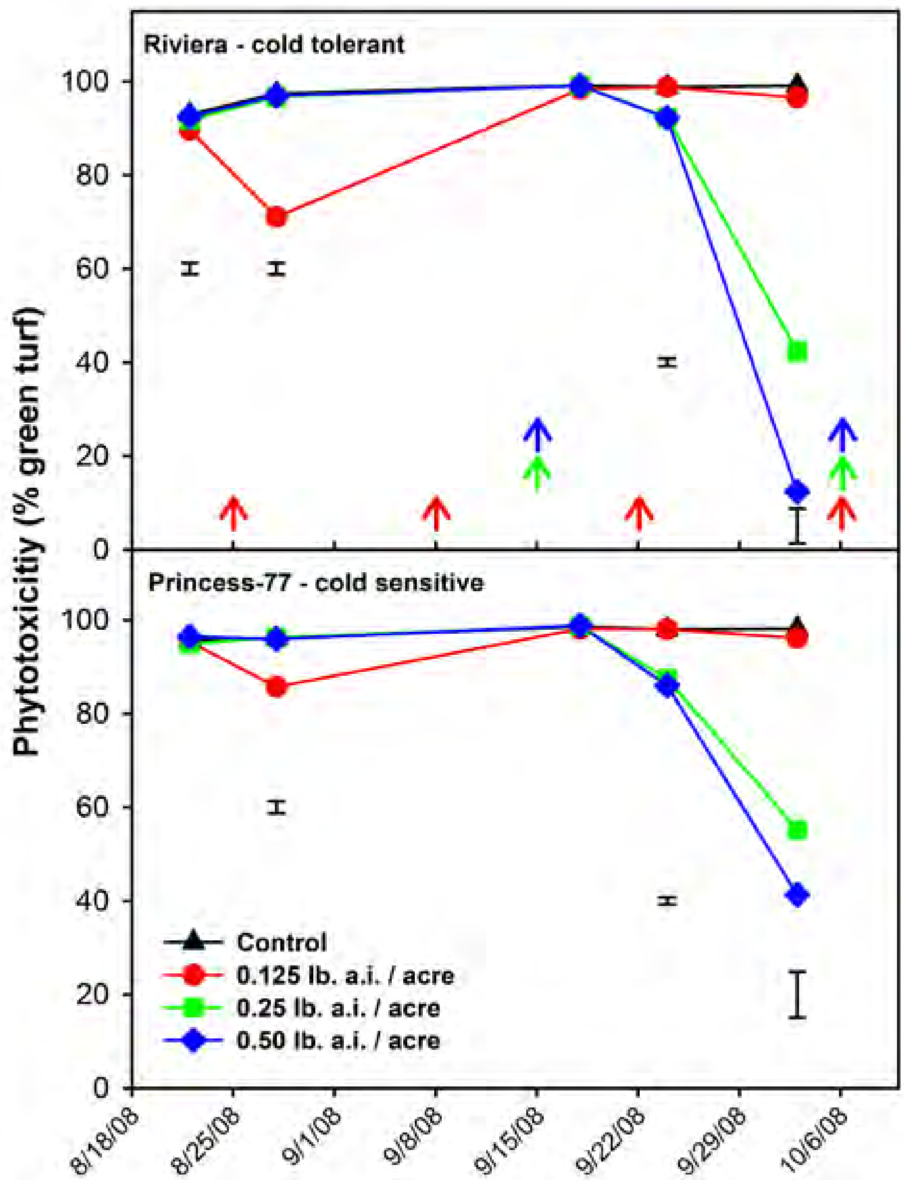

Fig. 1. Phytotoxicity, as measured by loss of green cover, for two bermudagrasses treated with various rates and timings of mesotrione. Arrows indicate application timings for the various treatments. Error bars can be used to separate treatments within cultivar at each observation date.

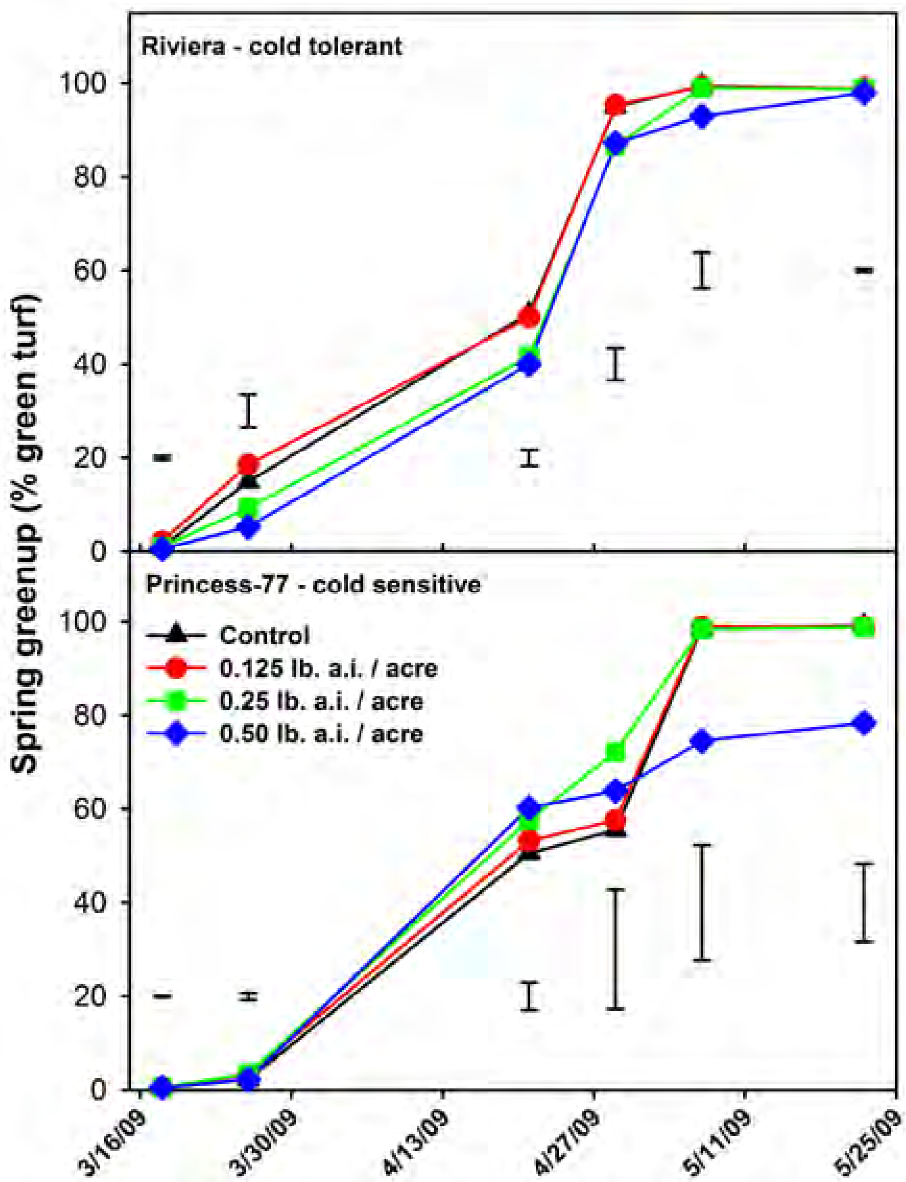

Fig. 2. Spring green-up of two bermudagrass cultivars treated with various rates and timings of mesotrione the previous fall. Error bars can be used to separate treatments within cultivar at each observation date.

Fig. 3. Phytotoxicity following mesotrione treatments on Riviera bermudagrass.

Effect of Mesotrione on Sod Quality of Tifway Bermudagrass

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Additional index words: *Cynodon dactylon*, Tenacity™

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Photo by Mike Richardson

Sod harvested for sod strength trials.

Summary. Commercial sod production has been in existence since the 1920s. Sod growers must have weed-free, high-quality sod to sell their product. Producing weed-free sod is a priority of sod producers; therefore, the evaluation of these new herbicides being introduced into the market is important because it reveals the proper rates for application and the effects of these applications. 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 2 June 2009 and five different rates of mesotrione were applied at different timings during the regrowth of the sod. Herbicide injury was evaluated seven days after each herbicide application and sod regrowth was monitored. Sod was harvested three weeks after final herbicide application (17 October 2008 and 2 October 2009) in the fall. An early-summer harvest (6 June 2009) was done on the same plots to see if there were any residual effects from the previous year's treatments. There were no significant effects of mesotrione on turfgrass coverage for any of the application dates for both the 2008 and 2009 growing seasons. The highest rate (0.5 lb ai/acre) 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 in 2008. In 2009, plots treated with the highest rate produced weaker sod but there were no statistical differences in percentage harvestable sod.

Abbreviations: WAIT, weeks after initial treatment

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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 (Tradename Tenacity™ , Syngenta, Wilmington, Del.) 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, and 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 desirable grass in different situations such as sod production.

Bermudagrass is typically injured by mesotrione (Boyd, 2008, Fig. 1). 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 effects sod regrowth of 'Tifway' bermudagrass.

Materials and Methods

This study was conducted at the University of Arkansas Agricultural Research and Extension Center in Fayetteville on a 'Tifway' bermudagrass 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. In 2009, sod was harvested completely (no ribbons) and regrowth was solely from rhizomes. Herbicide applications were initiated 14 days after sod harvest. Mesotrione was applied at five different rates, including an untreated control, across four different timings (Table 1). Herbicides were applied using a 5-ft boom sprayer with CO_2 as the propellant at a spray volume of 30 gpa. Herbicide plot size was 5 ft by 25 ft. The turf was maintained at a mowing height of 2.0 inch throughout the study, which is typical for sod production. 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 the fall 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 to 9 scale (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, 6 June 2009 and 2 October 2009, which corresponded to three weeks after the final herbicide application date and a summer harvest date for the fall treatments the previous year. 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. 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 during the 2008 trial. At seven days after the final treatment application, the high rate of mesotrione (0.50 lb ai/acre), caused significantly more injury than the 0.25 lb ai/acre 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 (data not shown). The experimental area had full turf coverage at eight weeks after the initial sod harvest. The early-summer harvest from the 2008 trial yielded no significant differences in strength and percent harvestable sod (data not shown), suggesting that mesotrione residual effects were minimal.

In the 2009 trial, there were no statistical differences for the first herbicide application but there was significant injury at the 3, 6 and 9 WAIT herbicide application dates (Table 2). At 3 WAIT, the 0.156 lb ai/acre rate had more injury than the control, while the 0.125 and 0.156 lb ai/ acre rates were not statistically different. After the 6 WAIT application, the 0.5 lb ai/acre rate produced significantly more injury than all other treatments. The 0.156 and 0.25 lb ai/acre treatments showed significantly higher injury than the control but were not statistically different from the 0.125 lb ai/acre treatment. At the 9 WAIT application date, the injury from the 0.25 and 0.5 lb ai/acre treatments were significantly higher than the control and the 0.5 lb rate also caused more injury than 0.156 and 0.125 lb treatments. Although herbicide injury was observed on these dates, the effects were not long-lasting and did not delay turfgrass coverage.

In the 2008 trial, the highest rate of mesotrione produced significantly less harvestable sod than all other treatments with the exception of the 0.156 lb ai/acre treatment, with only 58% being harvestable in 2008 (McCalla et al., 2009; Table 3). There were no statistical differences between any of the treatments in harvestable sod for the 2009 trial (Table 3). However, the highest rate (0.5 lb ai/acre) of mesotrione did have weaker sod strength than the 0.25 lb ai/acre treatment (Table 3). 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 did not affect sod strength when compared to the untreated check. But at the highest rate (0.50 lb ai/acre), which is higher than recommended by the label ("at or below the maximum label rate"), 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 label rates with minimal effects on sod quality and appearance.

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Table 1. Herbicide timings and rates used in the study. The initial mesotrione treatment was applied on 6 June 2008 and 6 June 2009.

Treatment	Rate	Timing
	lb ai / acre	
Untreated check		
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. Herbicide injury 7 days following application of mesotrione for 2009.

Treatment	Rate	Injury		
	lb ai / acre	3 WAIT[z]	6 WAIT	9 WAIT
		--------------1-9,9=death----------------		
Untreated check		1.0	1.0	1.0
Mesotrione	0.125	2.0	1.8	2.0
Mesotrione	0.156	2.8	2.2	2.5
Mesotrione	0.25	1.0	2.5	3.8
Mesotrione	0.5	1.0	4.2	4.5
LSD(P=.05)		0.7	0.6	1.0

[z]WAIT – weeks after initial treatment.

Table 3. Harvestable sod and sod strength, as measured as the peak force to break the sod. Sod was harvested on 10 Oct. 2008 and 2 Oct. 2009.

		Fall 2008		Fall 2009	
Treatment	Rate	Harvest	Strength	Harvest	Strength
	lb ai / acre	%	lb	%	lb
Untreated control		87.5	109.5	100	192
Mesotrione	0.125	97.5	106.4	100	178
Mesotrione	0.156	72.5	108.8	98	151
Mesotrione	0.25	85.0	121.2	100	172
Mesotrione	0.50	57.5	97.1	93	136
LSD(0.10)		22.5	18.4	ns	31

Fig. 1. Bleaching injury (right) caused by mesotrione applications to bermudagrass turf.

Controlling Dollar Spot on Creeping Bentgrass with Fungicides

Aaron Patton[1] and Jon Trappe[1]

Additional index words: *Agrostis stolonifera, Sclerotinia homoeocarpa,* disease

Patton, A. and J. Trappe. 2010. Controlling dollar spot on creeping bentgrass with fungicides. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:150-154.

Photo by Aaron Patton

Dollar spot is a common disease of creeping bentgrass. A tip of a key is shown for reference.

Summary. Dollar spot is one of the most problematic diseases of creeping bentgrass putting greens in Arkansas. The objective of this research was to evaluate a few commonly used fungicides for their ability to suppress dollar spot on a creeping bentgrass putting green. All treatments (Emerald, Trinity, Iprodione) provided excellent control of dollar spot on 20 August with the exception of Daconil Ultrex. All fungicides performed similarly on subsequent evaluation dates. No phytotoxicity was noted with any of the products from any of the three application timings.

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Dollar spot (*Sclerotinia homoeocarpa*) is one of the most problematic diseases of creeping bentgrass (*Agrostis stolonifera*) putting greens in Arkansas, and the U.S. Dollar spot can significantly be reduced on Arkansas golf courses by selecting the appropriate cultivar (Karcher et al., 2008). But fungicide applications are still needed for complete control. The objective of this research was to evaluate a few commonly used fungicides for their ability to suppress dollar spot on a creeping bentgrass putting green.

Materials and Methods

Research was conducted at the Arkansas Agricultural Research and Extension Center, Fayetteville. The plots were located on an eight-year old 'SR1020' creeping bentgrass putting green maintained at a height of 0.156 inch under typical golf course conditions and constructed on a sand-based rootzone according to United States Golf Association specifications. Grass clippings were collected when mown (6/wk) and the site was irrigated to prevent stress. Plots were spoon-fed nitrogen at a rate of 0.25 lb N/1000 ft^2 every two weeks until 21 July when nitrogen applications were stopped to help stimulate dollar spot activity. No other fungicides were applied to these plots although Acelepryn™ (chlorantraniliprole) and Advion® (indoxacarb) were applied to control caterpillar feeding and ant mounding, respectively. Plots were 5 ft by 5 ft with 1 foot borders. Disease was allowed to develop from natural inoculum as the site has had an occurrence of dollar spot in previous years. Approximately five active dollar spot infection centers were present in each plot prior to the study being initiated on 31 July. Treatments were initiated on 31 July and applied sequentially on 21 August and 3 September. Fungicide applications were made using a Tee-Jet XR8002VS flat fan nozzle. Fungicides were applied in 2 gal water-carrier per 1000 ft^2 at 30 psi using a CO_2-powered sprayer. Dollar spot was visually assessed by counting the number of active dollar spot infection centers per plot until more than 300 infection centers occurred in untreated plots. Percent dollar spot incidence was visually rated on 24 September on the last evaluation date.

Results and Discussion

All treatments provided excellent control of dollar spot on 20 August with the exception of Daconil Ultrex. Dollar spot control with Daconil Ultrex was less than expected early in the study likely because there was a three-week period between the initial and second sequential application which is beyond the application window recommended on the label. All fungicides performed similarly on subsequent evaluation dates (Figs. 1 and 2). No phytotoxicity was noted with any of the products from any of the three application timings. These results are consistent with previous reports on the efficacy of these fungicides for controlling dollar spot (Vincelli and Powell, 2009).

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Table 1. Dollar spot control with fungicides in Arkansas on 'SR1020' creeping bentgrass.

	Dollar spot				
	Number of infection centers/plot[z]				Incidence (%)[z]
Treatment and rate/1000 ft^2	11-Aug.	20-Aug.	1-Sep.	11-Sep.	24-Sep.
Emerald 70 WG 0.13 fl oz	0 b[y]	0 b	0 b	0 b	0 b
Emerald 70 WG 0.18 fl oz	0 b	0 b	0 b	0 b	0 b
Daconil Ultrex 3.25 oz	2 b	29 a	7 b	3 b	1 b
Iprodione Pro 2 SE 4 fl oz	0 b	1 b	0 b	0 b	2 b
Trinity 19.2 SC 2 fl oz	0 b	0 b	0 b	0 b	0 b
Untreated	25 a	47 a	53 a	261 a	23 a
Days after fungicide application	11	20	11	8	21

[z] Value represent means of 4 replications

[y] Means followed by the sample letter are not significantly different according to Fisher's protected LSD, alpha=0.05.

Emerald 70 WG 0.13 fl oz/1000 ft^2

Emerald 70 WG 0.18 fl oz/1000 ft^2

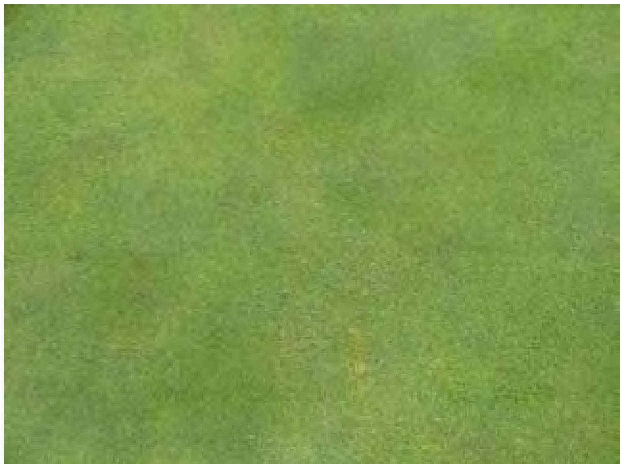
Iprodione Pro 2 SE 4 fl oz/1000 ft^2

Trinity 19.2 SC 2 fl oz/1000 ft^2

Daconil Ultrex 3.25 oz/1000 ft^2

Untreated

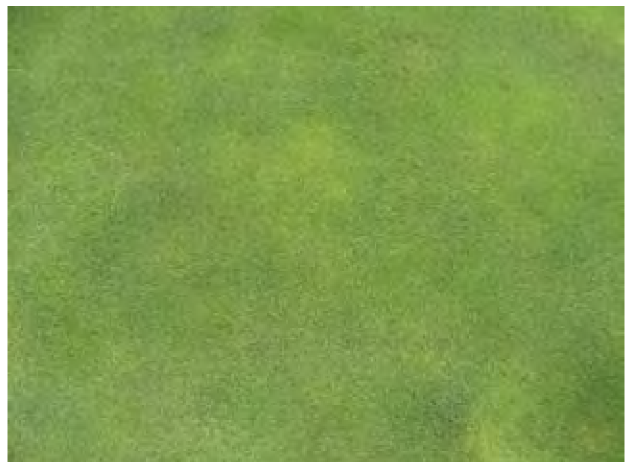
Fig. 1. Images showing dollar spot control taken of the second replication on 11 September 2009.



Emerald 70 WG 0.13 fl oz/1000 ft^2

Emerald 70 WG 0.18 fl oz/1000 ft^2

Iprodione Pro 2 SE 4 fl oz/1000 ft^2



Trinity 19.2 SC 2 fl oz/1000 ft^2

Daconil Ultrex 3.25 oz/1000 ft^2

Untreated

Fig. 2. Images showing dollar spot control taken of the second replication on 24 September 2009.

Response of Bermudagrass and Zoysiagrass Cultivars to Dismiss South and Solitare Herbicides

Mike Richardson[1] and John McCalla[1]

Additional index words:
sulfentrazone, imazethapyr, quinclorac, phytotoxicity

Richardson, M. and J. McCalla. 2010. Response of bermudagrass and zoysiagrass cultivars to Dismiss South and Solitare herbicides. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:155-159.

Injury from Dismiss South on a zoysiagrass cultivar.

Summary. New herbicide formulations that contain sulfentrazone have been recently introduced into the turfgrass industry and these may provide new options for controlling specific weed pests in warm-season grasses. The objective of the present study was to determine the tolerance of several bermudagrass and zoysiagrass cultivars to two herbicide formulations, Dismiss South and Solitare, containing sulfentrazone. Phytotoxicity was observed on all cultivars of bermudagrass and zoysiagrass, but zoysiagrass had higher injury levels than bermudagrass. In both species, injury was short-lived and was not evident at 4 weeks after treatment. In zoysiagrass, the *Zoysia matrella* cultivars tested were more sensitive to these two formulations than *Z. japonica* cultivars. Although some injury was observed with sulfentrazone formulations in bermudagrass and zoysiagrass, both species have enough tolerance to warrant their use in those situations where problematic weeds such as nutsedge or kyllinga are present.

Abbreviations: DAT, days after treatment

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There has been a continued decline in new herbicide chemistries in the turfgrass industry. As such, a recent trend in turfgrass weed control is the development of new formulations and combination products that can be used to cover a broad spectrum of weeds. Two new combination products being marketed by the FMC Corporation (Philadelphia, Pa.) are Dismiss® South and Solitare®. These combination products have suflentrazone as their primary active ingredient and then each has a secondary active ingredient, including imazethapyr in Dismiss® South and quinclorac in Solitare®.

Sulfentrazone is a postemergence herbicide that is classified as a protox inhibitor which acts on the chlorophyll synthesis pathway and ultimately disrupts membrane synthesis. In turfgrass systems, sulfentrazone has been primarily used to control sedges and some broadleaf weeds (Gardner, 2009). Early trials with sulfentrazone products indicated a relatively good tolerance of common bermudagrasses to this herbicide (Kopec and Gilbert, 2001); however, injury on improved bermudagrass cultivars has been reported (Bobby Walls, FMC, Inc., pers. comm.). The objective of the present study was to determine the tolerance of a large group of bermudagrass and zoysiagrass cultivars to two herbicide formulations that contained sulfentrazone.

Materials and Methods

These trials were conducted on the 2002 National Turfgrass Evaluation Program zoysiagrass and bermudagrass trials, which have been retained for such screening since the trials ended in 2007. The experimental areas were planted on 2 July 2002 at the University of Arkansas Agricultural Research and Extension Center in Fayetteville on a Captina silt-loam soil. The plot size for both the bermudagrass and zoysiagrass trials was 8 ft by 8 ft. and there were three replications of each cultivar. Other specifics regarding the establishment and maintenance of this trial have been described previously (Patton et al., 2008a; Patton et al., 2008b). Plots were maintained under simulated sports field conditions, with a mowing height of 0.75 inch, and monthly applications of 1.0 lb N/1000 ft^2 during the growing season.

Dismiss® South and Solitare® herbicides were band-applied (6 inch band) using a single flat-fan nozzle (TeeJet 110 015) and CO_2 as the propellant. Herbicide rates (lb. ai/acre) included 9.5 (0.29) , 12.4 (0.38), and 14.4 (0.45) fl. oz. Dismiss® South per acre, 20.8 (1.0) fl. oz. Solitare® per acre, and an untreated control. All herbicides were applied at 42 gpa on 2 July 2009. Phytotoxicity was rated at 4, 14, and 28 days after treatment (DAT) on a 1-9 scale, with 1 = no injury and 9 = dead turf. A rating of 5 would be equal to 50% herbicide injury.

Results and Discussion

Cultivar and herbicide both had a significant effect on phytotoxicity ratings in bermudagrass and zoysiagrass at 4 and 14 DAT, but there was no injury present on the 28 DAT observation date. In addition, there was a significant herbicide × cultivar interaction on zoysiagrass. As such, data are presented as this interaction.

In bermudagrass, there was no significant difference in phytotoxicity ratings between any of the Dismiss® South treatments at 4 DAT, but all Dismiss® South treatments had higher phytotoxicity ratings than Solitare® on that date (Table 1). At 14 DAT, the Solitare® treatment had slightly higher phytotoxicity than Dismiss® South treatments, which were not significantly different from the untreated control (Table 1). It should be noted that phytotoxicity was relatively minor with all treatments and on all observation dates and the level of injury would not be considered unacceptable in most turfgrass situations.

Cultivar also had a significant effect on phytoxicitiy ratings in bermudagrass, but was only significant at 4 DAT. Although there was a range of responses by various cultivars, the *C. transvaalensis* cultivar, Ashmore, was the most sensitive cultivar to these herbicides and had a significantly higher phytotoxicity rating than all other cultivars at 4 DAT (Table 2). However, by 14 DAT, there were no differences in any of the cultivars tested in this trial.

In zoysiagrass, more phytotoxicity was observed with these herbicides in comparison to bermudagrass, but was only present up to the 14 DAT observation date (Table 3). By 28 DAT, there was no herbicide or cultivar effect on phytotoxicity ratings (data not shown). The range of injury was similar for all cultivars tested, generally ranging from a low of 2.0 up to a high of 5.0. For all herbicides and observations, there was also a significant difference between the *Zoysia matrella* and *japonica* cultivars, with the *Z. matrella* cultivars having more injury than the *Z. japonica* cultivars (Table 3).

Within each herbicide, there was some slight variability between cultivars, but there were a few cultivars that consistently had higher injury from these herbicides, including the *Z. matrella* cultivars, Cavalier, DALZ 0105, and Zorro, and the *Z. japonica* cultivars, DALZ 9604 and Palisades (Table 3). The commercially-available, seeded cultivars in this trial, Zenith and Compadre, had relatively good tolerance of these herbicides compared to other cultivars (Table 3).

In summary, certain cultivars of both bermudagrass and zoysiagrass appear to be more sensitive to sulfentrazone formulations, but most of the injury observed was relatively short-lived and would not preclude the use of these products.

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Table 1. Phytotoxicity effects of Dismiss South and Solitare across 42 bermudagrass cultivars.

Herbicide	Rate	4 DAT[z]	14 DAT
	fl. oz. / acre	--------- phytotoxicity (1-9)[y] -------	
Dismiss South	9.5	2.1	1.0
Dismiss South	12.4	2.1	1.0
Dismiss South	14.4	2.0	1.1
Solitare	20.8	1.9	1.3
Untreated control		1.0	1.0
LSD (0.05)		*0.1*	*0.1*

[z] DAT – days after treatment.
[y] Phytotoxicity rated on a 1-9 scale with 1 = no injury and 9 = dead turf.

Table 2. Phytoxicity ratings of 42 bermudagrass cultivars, as affected by Dismiss South and Solitare.

Cultivar	4 DAT[z]	14 DAT
	------------- phytotoxicity (1-9)[y]	----------
Arizona Common	1.7	1.0
Ashmore	2.7	1.0
Aussie Green	1.9	1.1
B-14	1.7	1.1
Celebration	1.5	1.0
CIS-CD5	1.7	1.0
CIS-CD6	1.7	1.1
CIS-CD7	1.8	1.0
Contessa	1.9	1.0
FMC-6	1.4	1.0
GN-1	1.5	1.1
La Paloma	1.8	1.0
Midlawn	2.1	1.2
Mohawk	1.9	1.0
MS- Choice	1.3	1.1
NuMex Sahara	1.9	1.0
OKC 70-18	2.0	1.3
Panama	1.7	1.0
Patriot	1.8	1.1
Premier	2.2	1.3
Princess 77	1.9	1.1
PST-R68A	2.0	1.0
Riviera	2.1	1.0
Southern Star	1.7	1.0
Sovereign	1.9	1.0
SR 9554	1.5	1.3
Sundevil II	2.0	1.0
Sunstar	2.2	1.1
SW1-1001	1.7	1.0
SW1-1003	1.9	1.0
SW1-1004	1.7	1.1
SW1-1014	1.7	1.1
SW1-1046	1.5	1.0
Tifsport	2.0	1.3
Tift_1	2.1	1.0
Tift_2	2.0	1.3
Tift_3	1.4	1.0
Tift_4	1.5	1.0
Tifway	2.1	1.1
Transcontinental	1.8	1.1
Veracruz	1.7	1.1
Yukon	2.0	1.4
LSD (0.05)	*0.4*	*ns*

[z] DAT – days after treatment.
[y] Phytotoxicity rated on a 1-9 scale with 1 = no injury and 9 = dead turf.

Table 3. Phytotoxicity of several herbicide treatments on 24 zoysiagrass cultivars.

		Dismiss (9.5 fl oz / acre)		Dismiss (12.4 fl oz / acre)		Dismiss (14.4 fl oz / acre)		Solitare (20.8 fl oz / acre)	
Cultivar		4 DAT[z]	14 DAT	4 DAT	14 DAT	4 DAT	14 DAT	4 DAT	14 DAT
		------------------------------------- phytotoxicity (1-9)[y] -------------------------------------							
6186	*Z. japonica*	2.7	2.3	2.3	2.0	2.7	2.3	3.0	2.7
BMZ 230	*Z. japonica*	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Chinese Common	*Z. japonica*	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.0
Compadre	*Z. japonica*	2.7	2.7	2.7	2.3	2.7	2.3	2.3	2.0
Crowne	*Z. japonica*	2.7	3.0	2.0	2.3	2.0	2.3	2.3	2.3
DALZ 0102	*Z. japonica*	3.7	3.7	3.0	2.7	3.0	2.7	4.0	3.7
DALZ 9604	*Z. japonica*	4.3	4.0	4.0	3.7	4.0	3.7	4.0	3.7
El Toro	*Z. japonica*	2.7	2.7	2.0	2.0	2.0	2.0	2.0	2.0
GN-2	*Z. japonica*	3.7	3.7	2.7	3.0	3.3	3.7	3.7	3.0
Himeno	*Z. japonica*	2.7	2.3	2.0	2.0	2.3	2.3	3.0	2.7
J-37	*Z. japonica*	3.3	2.7	2.7	3.0	3.0	3.0	3.3	3.0
Meyer	*Z. japonica*	2.3	2.0	2.3	2.7	2.0	2.3	2.3	2.3
Palisades	*Z. japonica*	4.0	3.7	3.7	3.3	4.0	3.7	3.7	3.3
PST-R7MA	*Z. japonica*	2.7	2.3	2.7	2.7	2.0	2.3	3.0	2.7
PST-R7ZM	*Z. japonica*	3.0	3.0	2.3	2.0	2.7	2.3	3.0	2.3
PZA 32	*Z. japonica*	2.3	2.0	2.3	2.7	2.3	2.7	2.7	2.7
PZB 33	*Z. japonica*	3.0	3.0	2.0	2.0	2.3	2.3	2.7	2.7
Zenith	*Z. japonica*	2.3	1.7	2.3	2.0	2.3	2.0	2.7	2.0
Cavalier	*Z. matrella*	4.7	4.3	4.0	4.0	4.0	4.0	4.3	4.3
DALZ 0101	*Z. matrella*	4.0	3.7	2.7	3.0	3.0	3.0	4.0	3.7
DALZ 0105	*Z. matrella*	5.0	4.0	4.0	4.0	4.7	4.3	4.3	4.3
DALZ 104	*Z. matrella*	4.0	3.3	3.3	3.0	3.3	3.3	3.0	3.0
Emerald	*Z. matrella*	3.7	3.0	3.3	3.7	3.3	3.3	4.0	3.7
Zorro	*Z. matrella*	4.3	4.3	3.3	3.7	3.7	4.0	4.7	4.7
LSD (0.05)		*0.9*	*1.2*	*0.8*	*0.9*	*0.7*	*0.8*	*1.0*	*0.9*
	Z. japonica	2.9	2.7	2.5	2.5	2.6	2.6	2.9	2.6
	Z. matrella	4.2	3.7	3.3	3.5	3.6	3.6	4.0	3.9
	P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[z] DAT – days after treatment.
[y] Phytotoxicity rated on a 1-9 scale with 1 = no injury and 9 = dead turf.

Arkansas Turfgrass Acreage

Aaron Patton[1]

Additional index words: species, area, land, golf, sod, lawn

Patton, A. 2010. Arkansas turfgrass acreage. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:160-164.

Photo by Aaron Patton

Lawns comprise the largest facet of turf acreage in Arkansas.

Summary. Previous estimates of cultivated turf (518,427 acres) and home lawn area (308,271 acres) in Arkansas are published. The following article summarizes some information by others and estimates the acreage of turfgrass in Arkansas by use and species. The average lawn in Arkansas is 12,591 ft^2, but lawns represent <1% of Arkansas' total land mass. Seventy-two percent of Arkansas lawns are bermudagrass for a total of 221,351 acres of bermudagrass lawns. Zoysiagrass is the next most commonly used turf species for lawns, but only 12.5% or 38,426 acres are used on lawns in Arkansas. Tall fescue is the primary cool-season grass used in the state with 9.6% of the lawns or 29,649 acres across Arkansas. There are approximately 18,032 acres of turf on golf courses in Arkansas with the majority of that area planted in bermudagrass comprising 87% of the areas on Arkansas golf courses. Zoysiagrass comprises 8% of the turf on Arkansas golf courses. Currently, 8,276 acres of sod are produced in Arkansas on its 46 sod farms. At least 200,000 acres of turfgrass are planted on Arkansas roadsides. These values are approximate estimates (not absolute values) of turf areas in Arkansas and should be treated as such and used to guide future turfgrass research and aid in extension program planning.

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Numerous research studies and surveys have attempted to define the turfgrass acreage in the United States (Vinlove and Torla, 1995; Milesi et al., 2005; Lyman et al., 2007), but less is known about the turfgrass acreage within each state including Arkansas. Milesi et al. (2005) estimated that 518,427 acres of turf was cultivated in Arkansas. Vinlove and Torla (1995) estimated that 308,271 acres or 59.5% of cultivated turf was home lawn acreage. The following article summarizes some information by others and attempts to quantify and estimate the acreage of turfgrass in Arkansas by use and species.

Materials and Methods

Using previous estimates of turfgrass acreage in Arkansas (Vinlove and Torla, 1995; Milesi et al., 2005) and summary data on home lawn turfgrass species from soil samples submitted to the University of Arkansas, Soil Testing and Research Laboratory, Marianna, Ark. (Slaton, pers. comm., 2007), estimates were calculated on lawn acreage in Arkansas. Golf course acreage was estimated by the number of golf facilities in Arkansas (NGF, 2003) and average golf course acreage (GCSAA, 2007). A species breakdown is provided based upon and informal survey (M. Richardson, pers. comm.) in Arkansas and site visits to golf courses in Arkansas.

Results and Discussion

Lawns. The average lawn in Arkansas is 12,591 ft^2 (Vinlove and Torla, 1995), but lawns only represent 0.925% of Arkansas' total land mass. Based on calculations and previous estimates, 71.8% of Arkansas lawns are bermudagrass (*Cynodon* spp.) for a total of 221,351 acres of bermudagrass lawns (Table 1). Zoysiagrass (*Zoysia* spp.) is the next most commonly used turf species for lawns, with 12.5% or 38,426 acres of zoysiagrass used on lawns in Arkansas. Tall fescue (*Festuca arundinacea*) is the primary cool-season grass used in the state with 9.6% of the lawns or 29,649 acres across Arkansas. St. Augustinegrass (*Stenotaphrum secundatum*) is the fourth most commonly used turfgrass species comprising 3.7% of the lawns and a total of 11,295 acres across the state. Kentucky bluegrass (*Poa pratensis*), perennial ryegrass (*Lolium perenne*), and centipedegrass (*Eremochloa ophiuroides*) are also used, but each is present in <2.2% of the lawns and represent a combined total of 7,550 acres. New cultivars of Kentucky bluegrass that are more heat and drought resistant could increase its use in northern counties in Arkansas in the future. When summarized by turf species type (cool-season or warm-season), 90% of Arkansas' lawns are warm-season turf species (bermudagrass, zoysiagrass, St. Augustinegrass, and centipedegrass), while only 10% are cool-season turf species (Kentucky bluegrass, tall fescue, perennial ryegrass) (Table 2). Other species grown in Arkansas lawns, but not listed on the soil test sample submission form, include carpetgrass (*Axonopus fissifolius*) in southern Arkansas and fine fescues such as hard fescue (*Festuca brevipila*) or creeping red fescue (*Festuca rubra* ssp. *rubra*) in shady areas of northern Arkansas lawns. Since these estimates are based upon soil tests, acreage of some species such as centipedegrass could be underestimated as the soil testing is more likely to occur on turf species with higher maintenance requirements.

Golf Courses. There are approximately 18,032 acres of turf on golf courses in Arkansas (Table 3). The majority of that area is comprised of golf course roughs and fairways (Table 3) with bermudagrass comprising 15,595 acres or (86.5%) of the areas on Arkansas golf courses. Zoysiagrass is the next most commonly used turfgrass species comprising 7.5% or a total of 1,350 acres on Arkansas golf courses. Among Arkansas golf course putting greens, about 70% (386 acres) are creeping bentgrass and 30% (166 acres) are bermudagrass. Most creeping bentgrass putting greens contain some level of annual bluegrass (*Poa annua*) contamination, but it is difficult to estimate an average contamination based upon seasonal populations shifts between these two species. Most other species (carpetgrass, Kentucky bluegrass, perennial ryegrass, tall fescue) are used on less than 1.2% of the areas on Arkansas golf courses and their use varies by location.

Sod Farms. There are approximately 46 sod farms in Arkansas although that number fluctuates based on the economic climate (Census of Agriculture, 2007). Currently, 8,276 acres of sod are grown in Arkansas (Census of Agriculture, 2007) with the species grown including bermudagrass, zoysiagrass, St. Augustinegrass, centipedegrass, tall fescue, and Kentucky bluegrass (Patton et al., 2008). The species breakdown is similar to that grown on lawns (Table 1), with the exception of perennial ryegrass which is not typically grown as sod.

Other. Other areas of turf in Arkansas include roadsides, athletic fields, and parks, but these areas are difficult to estimate because there is little published research or surveys on their acreage. Most roadsides in Arkansas are planted as bermudagrass, although they are a mixture of grass and broadleaf species. According to the Arkansas State Highway and Transportation Department, at least 200,000 acres of turf-covered roadsides are mown each year in Arkansas (C. Flowers, pers. comm., 2010). Most athletic fields in Arkansas are bermudagrass although at least 6 acres of zoysiagrass athletic fields are in central Arkansas. Park areas likely have a similar species composition to lawns, but their acreage is unknown.

These values are approximate estimates (not absolute values) of turf areas in Arkansas and should be treated as such and used to guide future turfgrass research and aid in extension program planning.

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Table 1. Breakdown of acreage of various turfgrass species in Arkansas lawns based upon lawn estimates by Vinlove and Torla (1995) and data from Arkansas soil tests (Slaton, 2007).

Lawn species	Number of soil samples submitted in 2006 for each lawn species	Percentage of all lawns	Estimated acreage[z]	Percentage of the total land mass in Arkansas[y]
		---%---	---acres---	---%---
Bermudagrass	7,212	71.8	221,351	0.664
Centipedegrass	210	2.1	6,445	0.019
Kentucky bluegrass	14	0.1	430	0.001
Perennial ryegrass	22	0.2	675	0.002
St. Augustinegrass	368	3.7	11,295	0.033
Tall fescue	966	9.6	29,649	0.089
Zoysiagrass	1,252	12.5	38,426	0.115
Total	10,044	100.0	308,271	0.925

[z] Calculated based upon Vinlove and Torla's (1995) estimate of 308,271 acres of home lawns in Arkansas.
[y] Calculated based upon 33,323,643 acres of land mass in Arkansas (U.S. Census 2000).

Table 2. Breakdown of acreage of various turfgrass types (cool-season or warm-season) in Arkansas lawns based upon lawn estimates by Vinlove and Torla (1995) and data from Arkansas soil tests (Slaton, 2007).

Lawn species	Number of soil samples submitted in 2006 for each lawn species	Percentage of all lawns	Estimated acreage[z]	Percentage of the total land mass in Arkansas[y]
		---%---	---acres---	---%---
Warm-season	9,042	90.0	277,518	0.833
Cool-season	1,002	10.0	30,753	0.092
Total	10,044	100.0	308,271	0.925

[z] Calculated based upon Vinlove and Torla's (1995) estimate of 308,271 acres of home lawns in Arkansas.
[y] Calculated based upon 33,323,643 acres of land mass in Arkansas (U.S. Census 2000).

Table 3. Breakdown of acreage of various golf course components based upon average estimates (GCSAA, 2007) and the number of golf courses in Arkansas (NGF, 2003).

Golf course components	Average size on each golf course[z]	Total acreage in Arkansas[y]
	----------acres----------	
Rough	51	9,384
Fairways	30	5,520
Driving ranges/practice areas	7	1,288
Putting greens	3	552
Tee boxes	3	552
Clubhouse grounds	3	552
Turf nursery	1	184
Totals	98	18,032

[z] Average acreage on an 18-hole golf course.
[y] Calculated based upon 184 golf courses in Arkansas (NGF, 2003).

Table 4. Breakdown of acreage of various golf course components by turf species based upon site visits to golf courses and an informal survey by M. Richardson.

Golf course components	Bermudagrass	Zoysiagrass	Carpetgrass	Creeping bentgrass[z]	Kentucky bluegrass	Perennial ryegrass	Tall fescue	Total acreage in Arkansas[y]
	--acres--							
Rough	8,774	94	94	0	188	47	188	9,384
Fairways	4,416	1,021	55	0	0	28	0	5,520
Driving ranges/Practice areas	1,172	64	13	0	13	13	13	1,288
Putting greens	166	0	0	386	0	0	0	552
Tee boxes	442	102	6	0	0	3	0	552
Clubhouse grounds	497	50	6	0	0	0	0	552
Turf nursery	129	18	0	37	0	0	0	184
Totals	15,595	1,350	173	423	201	90	201	18,032
Percentage of total (%)	86.5	7.5	1.0	2.3	1.1	0.5	1.1	100

[z] A majority of creeping bentgrass putting greens in northern Arkansas are a mixture of creeping bentgrass and annual bluegrass.
[y] See Table 3.

Golf Club Selection and Golfer Influence Divot Size in Bermudagrass Fairways

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Additional index words: tee

Patton, A., J. Trappe, D. Karcher, and M. Richardson. 2010. Golf club selection and golfer influence divot size in bermudagrass fairways. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:165-168.

A golfer getting ready to hit a tee show on a heavily divoted par 3 tee box.

Summary. While a great deal of research has attempted to quantify divot recovery of various species and cultivars, very little research has attempted to quantify divot injury. The objective of this study was to quantify the divot size and type in a bermudagrass fairway as influenced by golf club selection. Divot severity and volume varied by club with lofted wedges creating the largest divots. Severity and volume varied by golfer, but there were no correlations between these measurements and golfer ability (handicap). Based on this average size of a divot, it is estimated that 0.5 acres of bermudagrass are removed from divots on fairways on a golf course receiving 32,000 rounds of golf per year.

Abbreviations: GW, gap wedge; LW, lob wedge; PW, pitching wedge; SW, sand wedge

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The result of a golfer's stroke in an attempt to strike a golf ball commonly displaces an area of turf and soil that is referred to as a divot. Divots created by a golf stroke are a natural occurrence on a golf course fairway or tee. The amount, size, and length of time divots exist on a tee or fairway can be dependent on species, cultivar, and management (Beard, 1973). Karcher et al. (2005) examined the divot recovery of numerous bermudagrass cultivars in a field study, and this report is useful for selecting cultivars with good divot recovery. Fry et al. (2008) published work comparing devices used to make divots. Although data on divot recovery and divoting devices are published, there is no information in the literature on the average size of a divot created by an actual golf swing.

The main objective of this study was to quantify the divot size, type, and severity (Table 1) in warm-season turf as influenced by golf club selection and golfer. Secondary objectives to the study were to 1) determine the frequency each golf club was used during a round of golf, 2) quantify the number of divots taken in an average round of golf, and 3) develop a method for rapid assessment of divot injury.

Materials and Methods

Survey. A survey was conducted among a group of golfers playing in a local superintendent fund-raiser. A divot survey was provided to each golfer (n = 84) prior to the start of the round and thirty-four surveys were returned. Golfers were asked to record which golf club they used for each shot and the total number of divots taken from the fairway or tee. It was assumed that divots were only taken with irons and not woods (although a wood can take a divot).

Field study. A field study was conducted at the University of Arkansas Agricultural Research and Extension Center at Fayetteville, Ark. Using eleven different irons (3, 4, 5, 6, 7, 8, 9, PW, GW, SW, and LW golf clubs), fifty-five shots were hit by eight golfers from 'Rivera' bermudagrass grown in a Captina silt loam and mown at 0.5 inch. Five shots were taken at a time with each club by each golfer. The order that the clubs were used was randomized for each golfer. To ascertain divot injury, divots were classified into three types and five severities (Table 1) depending on the level of damage from each club. After a visual rating was recorded, each divot was then filled with sand until the sand was level with the soil surrounding the divot. The sand used to fill the divots was dried prior to use. Bulk density was calculated for the sand as being 1.53 g cm^{-3}. The amount of sand needed to fill the divot was calculated by subtracting the weight of container plus sand before filling the divot and the weight of the container plus sand after filling. The volume of each divot was then determined using the bulk density of the sand and the weight of sand needed to fill each divot. Immediately after filling with sand, a 11 in. by 5 in. frame was centered around each divot and a digital image was taken (Karcher et al., 2005). Images were analyzed for percent green turf coverage using SigmaScan Pro, and the surface area of each divot was calculated.

Results and Discussion

Survey. The survey indicated that the average number of times each golf club was used during a round of golf varied by club and ranged from 0.7 times per round for a 3-iron to 2.5 times per round with a sand wedge (Fig. 1). A range of wedges (pitching wedge (PW), gap wedge (GW), sand wedge (SW), and lob wedge (LW)) are used by each golfer. Gap wedge, SW, and LW were all pooled together and termed SW in Fig. 1. The survey also indicated that a divot was taken (soil and grass removed) 67% of the time the golfer made a stroke for an average of 13 divots per round.

Field study. Results from the field study indicated that divot severity and divot volume varied by golfer and by golf club, with lofted, short irons (8, 9, PW, GW, SW, LW) taking larger divots than long irons (3, 4, 5 iron) (Fig. 2). Although divot volume and severity varied by golfer there was no correlation between golfer handicap (skill level) and divot volume or divot severity (data not shown). Visual severity ratings were closely related (r^2 = 0.75; P = 0.0057) with volume measurements indicating the usefulness of visual ratings for rapid assessment of divot injury (data not shown).

The average size of each divot (type = 3) using digital image analysis was calculated as 7.94 in^2 (51.2 cm^2) or 0.055 ft^2 which is approximately 2 in. by 4 in. Based on this average size of a divot and that the average golfer takes 13 divots per round, then it could be calculated that 22,926 ft^2 (0.53 acres) of bermudagrass are removed from divots on fairways on a golf course receiving 32,000 rounds of golf per year. Furthermore, the average size of a golf course fairway is 30 acres (Anonymous, 2007), which means that 1.8% of the turf from the average golf course with bermudagrass fairways is removed each year from golfer divoting. Although, the average golf course in the U.S. receives 32,000 rounds of golf/year (NGF, 2003), golf courses that receive more rounds of golf/year could expect more damage. Additionally, we estimated the size of divot on a native silt loam soil, but other soil types such as sandy loams or areas heavily topdressed with sand such as driving range tees may be more conducive to divot injury resulting in larger divots and more turf removed. Additionally, other turfgrass species such as creeping bentgrass used on fairways in locations north of Arkansas may be more susceptible to divot injury resulting in more damage annually.

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Table 1. Rating scale used to characterize divot type and severity.

Divot type	Divot severity
1= no turf removed	1 = none to very small divot or turf surface disruption
2= turf removed	2 = small divot or turf surface disruption
3= both turf and soil removed	3 = moderate divot size or turf surface disruption
	4 = large divot or turf surface disruption
	5 = very large divot or turf surface disruption

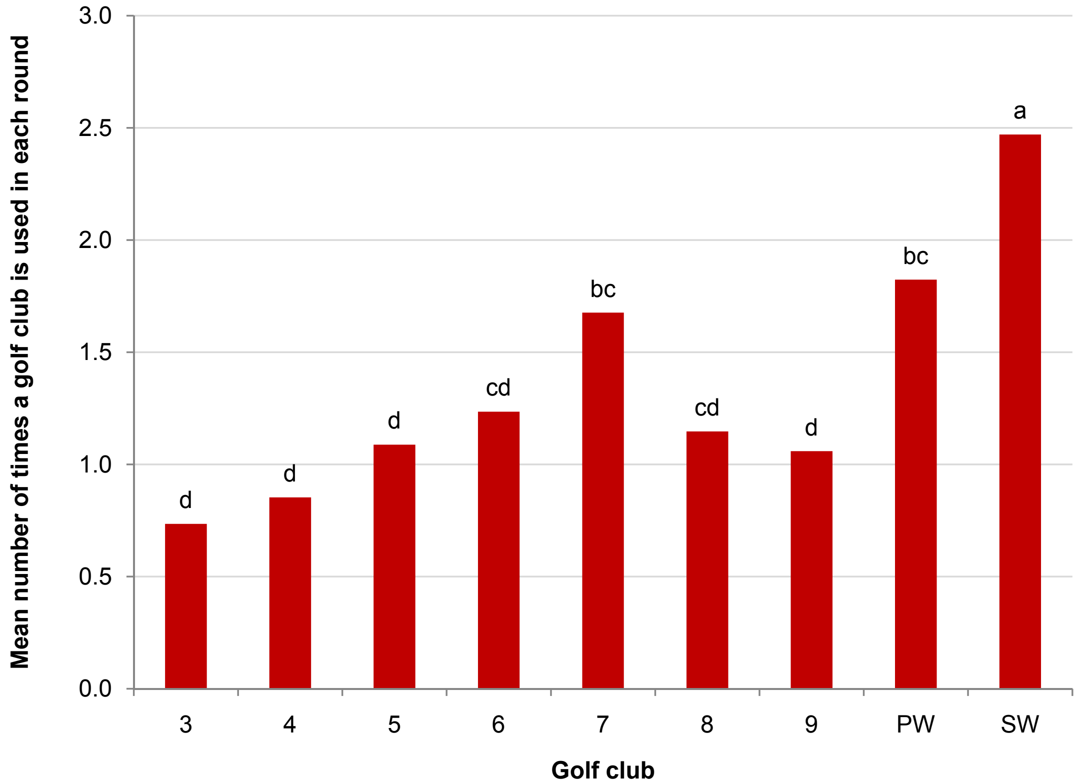

Fig. 1. The average number of times each golf club was used during a round of golf (n = 34). Means followed by the same letter are not significantly different according to Fisher's protected LSD, α = 0.05.

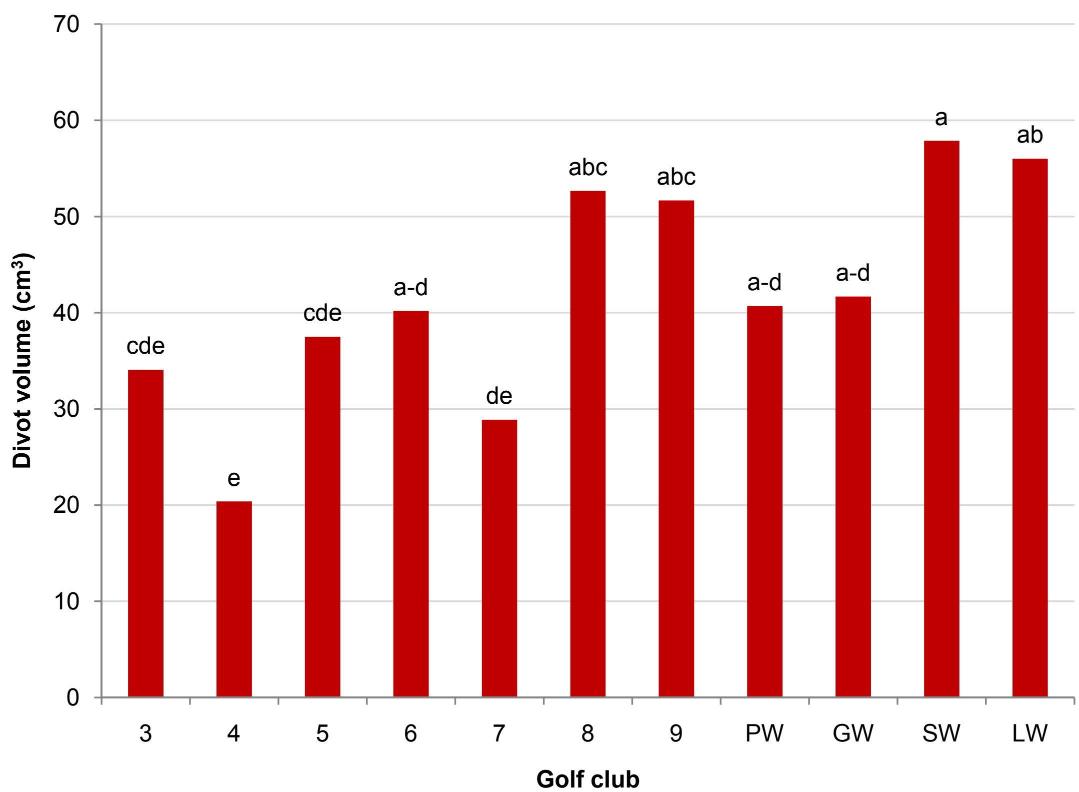

Fig. 2. Divot volume varied by golf club (n = 40, 8 golfers, five subsamples per club). Means followed by the same letter are not significantly different according to Fisher's protected LSD, α = 0.05.

2009 Weather Summary for Fayetteville, Arkansas

Mike Richardson[1] and Chris Stiegler[1]

Richardson, M., and C. Stiegler 2010. 2009 weather summary for Fayetteville, Arkansas. Arkansas Turfgrass Report 2009, Ark. Ag. Exp. Stn. Res. Ser. 579:169-170.

Photo by Mike Richardson

Weather station at the Agricultural Research and Extension Center

Summary. Summary data on air temperature 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 2009 Arkansas Turfgrass Report. 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 2009 was a higher than average rainfall, especially during the late summer and early fall months. Cooler than average temperatures were also observed during those months. The rainfall total for the year was 52 inches, which is approximately 6 inches above normal for Fayetteville.

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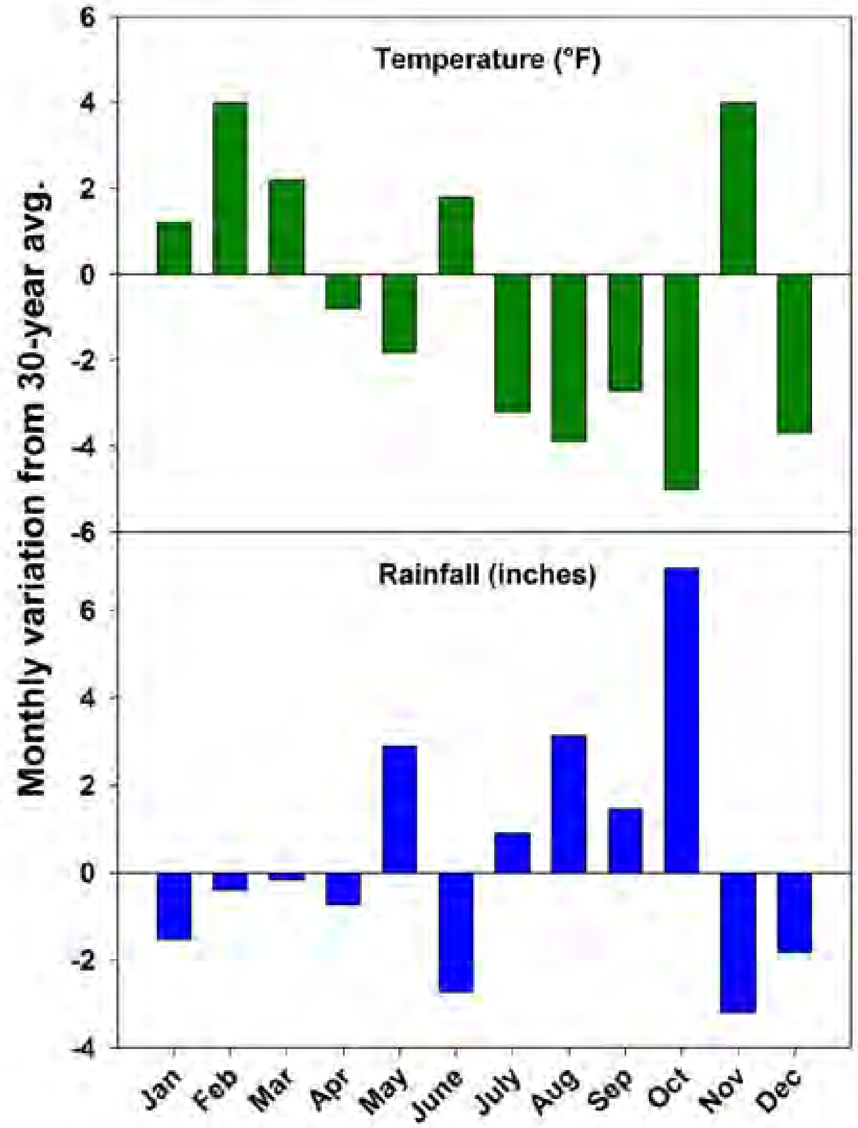

Fig. 1. Monthly temperature and rainfall data for 2009 at Fayetteville, Ark. Data are presented as a deviation from the 30-yr average for the site.

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