University of Connecticut

College of Agriculture & Natural Resources

2013 Annual Turfgrass Research Report

UCONN | COLLEGE OF AGRICULTURE AND NATURAL RESOURCES

PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

Cover photo: UConn Turfgrass Science support staff, graduate students, and researchers preparing and seeding the tall fescue National Turfgrass Evaluation Program (NTEP) trial (read about this exciting research beginning on page 54).

UCONN | COLLEGE OF AGRICULTURE AND NATURAL RESOURCES
PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

2013 Annual Turfgrass Research Report Summary

University of Connecticut
College of Agriculture and Natural Resources
Department of Plant Science and Landscape Architecture
Storrs, Connecticut

The University of Connecticut's Annual Turfgrass Research Report is published to provide timely dissemination of current research findings. The purpose of this report is to encourage the exchange of ideas and knowledge between university researchers and members of the turfgrass industry. Research summaries included within this report are designed to provide turfgrass managers, extension specialists, research scientists, and industry personnel with information about current topics related to managing turfgrass.

This report is divided into various sections and includes original research results in the fields of turf pest control (pathology, weed control, entomology), athletic field and golf turf maintenance, fertility and nutrient management, and cultivar improvement. Additionally, abstracts and citations of scientific publications and presentations published in 2013 by University of Connecticut turfgrass researchers are included. This information is presented in the hopes of providing current information on relevant research topics for use by members of the turfgrass industry.

Special thanks are given to those individuals, companies, and agencies that provided support to the University of Connecticut's Turfgrass Research, Extension, and Teaching Programs.

Dr. Karl Guillard, Editor

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2013 Financial Support

The University of Connecticut Turfgrass Research and Education Program appreciates the support of the turfgrass industry, state and federal agencies, private foundations, and university units and departments. Without your contributions, we would be unable to conduct many of the research projects included in this report. We extend our thanks to all of the individuals and companies who supported turfgrass research and education at the University of Connecticut.

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We regret that some individuals may have been inadvertently left off of this list. If you or your company has provided financial support for turfgrass research at the University of Connecticut and were not included on the above list, please contact us to ensure that you are included in future reports.

The University of Connecticut Turf Group

2013 In-Kind Support

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PREVENTIVE ANTHRACNOSE CONTROL ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2013

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INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. Recent research has demonstrated cultural practices that minimize abiotic stress can reduce anthracnose severity. However, the application of fungicides remains necessary to control the disease and maintain high quality putting surfaces. Previous studies have found that rotational programs or tank mixes often provide improved anthracnose control compared to individual products applied alone. This strategy is also important in minimizing resistance of the pathogen to certain classes of fungicides The objective of this study was to examine the efficacy of commonly used, and developmental fungicides applied alone or as tank mixtures, and fertilizer programs for anthracnose control on an annual bluegrass putting green turf.

MATERIALS & METHODS

A field study was conducted on an annual bluegrass (*Poa annua*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Minimal nitrogen was applied to the study area to encourage anthracnose development. A total of 1.5 lb N 1000-ft^{-2} was applied as water soluble sources from April through July. Overhead irrigation and hand-watering was applied as needed to prevent drought stress and move soluble fertilizer applications into the rootzone. A rotation of Curalan (1.0 oz.) and Emerald (0.18 oz.) was applied every 14 d beginning 19 May for dollar spot control; ProStar (1.5 oz) was also applied every 14 days from 16 June throughout the trial to prevent brown patch development. Subdue MAXX (1.0 fl.oz.) was applied preventively for Pythium blight on 3 July. Scimitar GC (0.23 fl.oz.) and Dylox 80 (3.75 oz.) were applied on 7 and 25 May for control of annual bluegrass weevil adults and larvae, respectively.

Treatments consisted of currently available and developmental fungicides applied individually, or as tank mixes. Foliar fertilizer programs with and without fungicides were also evaluated. Initial applications were made on 28 May prior to disease developing in the trial area. Subsequent applications were made at specified treatment intervals through 24 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose was determined visually as the percent area blighted by *C. cereale* from 5 July through 30 July. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum

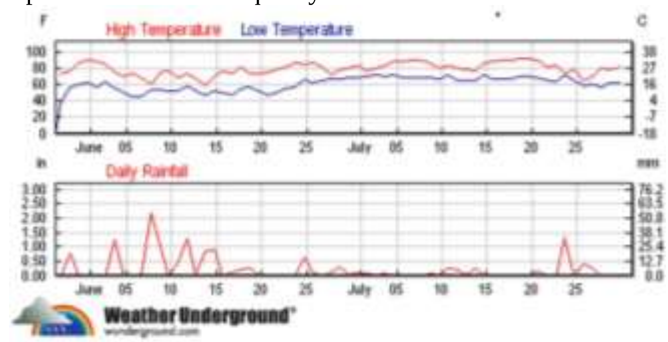

Fig. 1. High and low temperatures and daily rainfall in Storrs, CT during 28 May to 30 July 2013.

acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. All data were subjected to an analysis of variance and means were separated using the Student-Newman-Kewls test. Anthracnose severity data were arcsine transformed for ANOVA and mean separation tests, means were back-calculated for presentation.

RESULTS & DISCUSSION

Anthracnose Severity

Anthracnose symptoms were first observed uniformly throughout the trial on 5 July, developing from a natural infestation (Table 1). Disease pressure was high throughout July, with the epidemic increasing rapidly during high day/night temperatures (Fig. 1) and humidity. Untreated controls reached a maximum of 73% plot area blighted by 30 July (Table 1), 25 days after the epidemic began.

Most treatments provided acceptable disease control on 5 July. However, treatment differences became more apparent 7 days later (12 July) as anthracnose severity dramatically increased. Treatment differences were generally consistent throughout the remainder of the trial. Excellent anthracnose control (≤ 2% plot area blighted) was provided by tank mixes of Daconil Action + Appear + Briskway, QP Chlorothalonil 720SFT + Chipco Signature + Honor, Daconil Action + Appear + Primo MAXX, and QP Enclave (3.0 fl.oz.) + QP Fosetyl-Al + Foursome applied every 14 days (Table 1). QP Enclave (4.0 fl.oz.) + QP Fosetyl-Al + Foursome applied every 21 days also provided excellent control throughout most of the trial, although breakthrough began to occur (5% plot area blighted) on 30 July, 21 days after the last application. All of these treatments included combinations of chlorothalonil, phosphonates (i.e., fosetyl-Al or phosphite), and a green pigment. This combination has consistently provided effective anthracnose control in studies throughout the country. The addition of QP Fosetyl-Al and Appear (pigmented phosphite) significantly improved anthracnose control of turf treated with QP Enclave + Foursome and Daconil Action + Primo MAXX, respectively.

Xzemplar and UC13-5 are second generation succinate dehydrogenase inhibitor (SDHI) fungicides; Encartis is a pre-mix containing boscalid and chlorothonil. UC13-5 + Primo MAXX provided acceptable anthracnose control until 30 July and was significantly better than Xzemplar and Encartis. Encartis (3.0 fl.oz.) applied every 14-d reduced disease compared to untreated control, but was no different than Daconil WeatherStik (2.99 fl.oz.) applied at the same interval and equivalent amount of active ingredient. Xzemplar treated turf was no different than the untreated control in the current trial.

Briskway applied alone at the low label rate (0.3 fl.oz.) and Torque on a 21-d interval did not provide acceptable disease control in this trial. Reduced sensitivity of *C. cereale* to DMIs, and QoI resistance is suspected at this site based on poor performance by these classes of chemistry in recent trials. Low rates and extended intervals are unlikely to provide acceptable control at sites were resistant populations are established.

UC13-1 and UC13-2 were generally no different than the untreated control throughout the trial regardless of rate or interval. Among these treatments anthracnose was less severe, albeit unacceptable, in UC13-1 applied at 1.65 fl.oz. every 7-d, 4.356 fl.oz. every 21-d, or 6.6 fl.oz. every 28-d. No difference between UC13-1 and UC13-2 applied every 7-d was observed.

Plant Food Program 1 contained, a foliar 16-2-7 fertilizer plus micronutrients, Phosphite 30, 6 Iron, (nitrogen and iron source), Flo Thru (penetrant), Impulse (biostimulant containing salicylic acid), and Omega (experimental chitin based biostimulant); whereas Plant Food Program 2 incorporated the same program plus Daconil WeatherStik applied at 0.9 fl.oz. every 7-d. Each program provided approximately 0.1 lb N 1000 ft^{-2} every 7-d, until 9 July, when applications of 16-2-7 were arrested. Both programs provided excellent anthracnose control at the onset of disease (5 July). Plant Food Program 2 provided good anthracnose control (≤ 5% plot area blighted) through 12 July, and acceptable disease control through the remainder of the trial. Plant Food Program 1 provided acceptable control through 18 July, but became unacceptable by the last observation date.

Turf Quality and Phytotoxicity

Turf quality in the trial was predominantly influenced by anthracnose incidence and phytotoxicity. Most treatments provided good turf quality in June (Table 2), prior to significant anthracnose development. Highest quality turf during June was observed in Daconil Action + Appear + Briskway (0.5 fl.oz.), UC13-1 and UC13-2 applied on a 7-d interval, and QP Enclave tank mix treatments. Slight (≤ 2 on 0-5 scale), phytotoxicity (grayish blue turf color) was observed in plots treated with Torque and tank mixes containing Primo MAXX (9 DAIT) (Table 3). However, these symptoms subsided after the initial application period, and no subsequent phytotoxcity was observed in any treatments throughout the remainder of the trial.

CONCLUSION

Rotational programs and tank mixes/pre-mixes have repeatedly been found to provide the most effective anthracnose control in studies throughout the country. Tank mixes containing chlorothalonil, phosphonate (i.e., fosetyl-Al or phosphite) and a green pigment provided excellent anthracnose control in this trial, and support results from other studies. This combination also has very low risk of phytotoxcity even when applied repeatedly throughout summer months. QP Enclave is a pre-mix of tebuconazole, chlorothalonil, iprodione, and thiophanate-methyl, and provided excellent anthracnose control when combined with QP Fosetyl-Al. Still, alternative fungicides in different chemical classes with activity against anthracnose are needed to provide turf managers additional options for safe summer rotation programs for disease and resistance management. Data from this and previous studies suggest that the new SDHI fungicide UC13-5 may provide superintendents a new tool for managing anthracnose during summer months.

Table 1. Anthracnose severity influenced by various fungicides applied preventatively to annual bluegrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Int[x]	Anthracnose Severity 5 Jul	12 Jul	18 Jul	30 Jul
			--- % plot area blighted ---			
Daconil Action	3.5 fl oz	14-d	0.0[u] h[t]	0.0 o	0.4 l	0.5 h
+Appear	6.0 fl oz					
+Briskway	0.725 fl oz					
Daconil Action	3.5 fl oz	14-d	0.0 h	0.2 no	0.4 l	0.5 h
+Appear	6.0 fl oz					
+Briskway	0.5 fl oz					
QP Chlorothalonil 720 SFT	3.0 fl oz	14-d	0.0 h	0.2 o	0.2 l	0.9 h
+Chipco Signature	4.0 oz					
+Honor	1.1 oz					
Encartis	3.0 fl oz	14-d	0.7 e-h	28.7 hij	33.7 g	48.7 d
Encartis	4.0 fl oz	21-d	0.8 e-h	30.8 g-j	26.5 gh	63.8 bc
Daconil WeatherStik	2.99 fl oz	14-d	1.1 d-h	28.6 ij	33.4 gh	47.5 d
Torque	0.6 fl oz	21-d	0.1 gh	21.0 jk	24.1 ghi	33.7 e
Daconil Action	3.5 fl oz	14-d	0.0 h	11.0 l	10.8 jk	27.3 e
+Primo MAXX	0.125 fl oz					
Daconil Action	3.5 fl oz	14-d	0.0 h	0.2 o	0.1 l	1.0 h
+Appear	4.0 fl oz					
+Primo MAXX	0.125 fl oz					
UC13-5	0.5 oz	14-d	0.1 fgh	7.2 lm	11.9 ijk	16.0 f
+Primo MAXX	0.125 fl oz					
UC13-1	1.65 fl oz	7-d	0.1 fgh	42.1 d-g	51.1 f	61.4 bc
UC13-1	1.65fl oz	14-d	1.2 d-g	54.6 a-d	75.7 ab	69.3 b
UC13-1	3.3 fl oz	14-d	3.3 b-e	58.1 ab	74.7 abc	71.5 b
UC13-1	4.356 fl oz	21-d	0.6 e-h	36.7 f-i	53.8 ef	70.2 b
UC13-1	4.356 fl oz	curative[w]	5.5 abc	50.7 a-e	68.8 a-e	70.6 b
UC13-1	6.6 fl oz	28-d	0.1 fgh	48.2 b-f	56.9 def	56.3 cd
UC13-1	13.2 fl oz	single[v]	4.0 a-d	58.3 ab	62.7 b-f	62.8 bc
UC13-2	1.65 fl oz	7-d	0.7 e-h	41.2 e-h	60.6 c-f	61.3 bc
Briskway	0.3 fl oz	14-d	1.5 d-g	44.6 c-f	54.0 ef	62.8 bc
QP Enclave	3.0 fl oz	14-d	0.0 h	3.2 mn	5.0 k	24.5 e-f
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	0.0 h	6.9 lm	5.7 k	32.8 e
+Foursome	0.4 fl oz					
QP Enclave	3.0 fl oz	14-d	0.0 h	0.0 o	0.0 l	1.4 gh
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	0.0 h	0.0 o	0.0 l	5.0 g
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
Secure	0.5 fl oz	14-d	2.3 b-e	62.4 a	60.3 c-f	62.6 bc
Xzemplar	0.26 fl oz	14-d	6.5 ab	55.4 abc	64.4 b-f	65.4 bc
Plant Food Program 1[z]		7-d	0.1 gh	13.8 kl	19.4 hij	30.7 e
Plant Food Program 2[y]		7-d	0.1 gh	3.1 mn	8.4 k	14.6 f
Untreated			3.9 a-d	47.4 b-f	69.7 a-d	73.0 ab
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	3	3	2	7
		14-d	11	3	9	7
		21-d	18	3	9	21
		28-d	11	17	22	7

[z] Harrell's pH buffer (0.44 fl oz); 16-2-7 (6.0 fl oz); Phosphite 30 (2.0 fl oz); Impulse (2.0 fl oz); 6 Iron (1.5 fl oz); and Flo Thru (2.0 fl oz) were tank mixed and applied on 28 May, 4, 11, 17, 25 Jun, and 2 Jul. Omega (0.36 fl oz) was applied separately on these dates. Plant Food Organic Acid (3.0 fl oz) was tank mixed with all materials previously mentioned beginning on 9 Jul, except 16-2-7 and Harrell's pH buffer which were not applied during the remainder of the trial.

[y] Harrell's pH buffer (0.44 fl oz); 16-2-7 (6.0 fl oz); Phosphite 30 (2.0 fl oz); Impulse (2.0 fl oz); 6 Iron (1.5 fl oz); Flo Thru (2.0 fl oz); and Daconil WeatherStik (0.9 fl oz) were tank mixed and applied on 28 May, 4, 11, 17, 25 Jun, and 2 Jul. Omega (0.36 fl oz) was applied separately on these dates. Plant Food Organic Acid (3.0 fl oz) was tank mixed with all materials beginning on 9 Jul, except 16-2-7 and Harrell's pH buffer which were not applied during the remainder of the trial.

[x] Treatments were initiated on 28 May, prior to disease development. Subsequent 7-d treatments were applied on 4 Jun, 11 Jun, 17 Jun, 25 Jun, 2 Jul, 9 Jul, 16 Jul, 24 Jul; 14-d treatments were applied on 11 Jun, 25 Jun, 9 Jul, 24 Jul; 21-d treatments were applied on 17 Jun and 9 Jul; 28-d treatments were applied on 25 Jun and 24 Jul.

[w] A curative application of UC13-1 was made on 9 Jul, and applied every 21-d thereafter.

[v] A single application of UC13-1 was applied on 28 May.

[u] Data were arcsine transformed; means presented are back-calculated.

[t] Treatment means followed by the same letter, within each column, are not significantly different based on Student-Newman-Kewls test (α = 0.05).

Table 2. Turf quality influenced by various fungicides on annual bluegrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft²	Int	Turf Quality 6 Jun	21 Jun	5 Jul	30 Jul
			---------------- 1-9; 6=min acceptable----------------			
Daconil Action	3.5 fl oz	14-d	7.0 b-e[u]	7.5 cde	6.8 bcd	6.8 abc
+Appear	6.0 fl oz					
+Briskway	0.725 fl oz					
Daconil Action	3.5 fl oz	14-d	7.8 ab	8.0 abc	7.5 ab	7.5 a
+Appear	6.0 fl oz					
+Briskway	0.5 fl oz					
QP Chlorothalonil 720 SFT	3.0 fl oz	14-d	7.0 b-e	7.8 bcd	7.3 ab	6.3 bc
+Chipco Signature	4.0 oz					
+Honor	1.1 oz					
Encartis	3.0 fl oz	14-d	7.3 a-d	7.3 de	5.8 efg	3.0 h
Encartis	4.0 fl oz	21-d	7.0 b-e	7.0 ef	6.3 cde	2.0 i
Daconil WeatherStik	2.99 fl oz	14-d	6.3 efg	6.3 g	5.8 efg	3.5 gh
Torque	0.6 fl oz	21-d	5.8 gh	7.5 cde	6 def	4.5 ef
Daconil Action	3.5 fl oz	14-d	6.0 fgh	7.3 de	6.8 bcd	4.3 fg
+Primo MAXX	0.125 fl oz					
Daconil Action	3.5 fl oz	14-d	6.8 c-f	7.5 cde	7.8a	7.0 ab
+Appear	4.0 fl oz					
+Primo MAXX	0.125 fl oz					
UC13-5	0.5 oz	14-d	6.8 c-f	7.3 de	6.8 bcd	4.8 ef
+Primo MAXX	0.125 fl oz					
UC13-1	1.65 fl oz	7-d	7.5 abc	8.0 abc	5.8 efg	1.5 ij
UC13-1	1.65fl oz	14-d	7.0 b-e	7.0 ef	5.3 fgh	1.3 ij
UC13-1	3.3 fl oz	14-d	7.3 a-d	7.0 ef	4.5 hi	1.3 ij
UC13-1	4.356 fl oz	21-d	7.0 b-e	7.5 cde	6.0 def	1.8 ij
UC13-1	4.356 fl oz	curative[w]	7.3 a-d	7.0 ef	5.0 gh	1.5 ij
UC13-1	6.6 fl oz	28-d	7.0 b-e	7.0 ef	6.3 cde	2.0 i
UC13-1	13.2 fl oz	single[v]	6.3 efg	7.3 de	5.3 fgh	2.0 i
UC13-2	1.65 fl oz	7-d	7.5 abc	8.0 abc	6.0 def	1.3 ij
Briskway	0.3 fl oz	14-d	6.8 c-f	7.0 ef	5.8 efg	1.8 ij
QP Enclave	3.0 fl oz	14-d	7.5 abc	8.3 ab	7.3 ab	5.0 ef
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	7.0 b-e	8.0 abc	7.0 abc	4.5 ef
+Foursome	0.4 fl oz					
QP Enclave	3.0 fl oz	14-d	7.5 abc	8.3 ab	7.8 a	7.3 a
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	7.3 a-d	8.5 a	7.5 ab	6.0 cd
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
Secure	0.5 fl oz	14-d	7.0 b-e	7.3 de	5.0 gh	1.0 j
Xzemplar	0.26 fl oz	14-d	6.5 d-g	6.5 fg	4.8 hi	1.8 ij
Plant Food Program 1[z]		7-d	7.3 a-d	7.8 bcd	7.0 abc	4.3 fg
Plant Food Program 2[y]		7-d	7.5 abc	7.5 cde	7.0 abc	5.3 de
Untreated			6.5 d-g	6.5 fg	5.0 gh	1.5 ij
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	2	4	3	7
		14-d	9	10	11	7
		21-d	9	4	18	21
		28-d	9	23	11	7

[z] Harrell's pH buffer (0.44 fl oz); 16-2-7 (6.0 fl oz); Phosphite 30 (2.0 fl oz); Impulse (2.0 fl oz); 6 Iron (1.5 fl oz); and Flo Thru (2.0 fl oz) were tank mixed and applied on 28 May, 4, 11, 17, 25 Jun, and 2 Jul. Omega (0.36 fl oz) was applied separately on these dates. Plant Food Organic Acid (3.0 fl oz) was tank mixed with all materials previously mentioned beginning on 9 Jul, except 16-2-7 and Harrell's pH buffer which were not applied during the remainder of the trial.

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[v] A single application of UC13-1 was applied on 28 May.

[u] Treatment means followed by the same letter, within each column, are not significantly different based on Student-Newman-Kewls test ($\alpha = 0.05$).

Table 3. Phytotoxicity affected by various fungicides on annual bluegrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Int	Phytotoxicity 6 Jun	21 Jun	5 Jul	30 Jul
			------------- 0-5; 2=max acceptable -------------			
Daconil Action	3.5 fl oz	14-d	0.0 b[u]	0.0	0.0	0.0
+Appear	6.0 fl oz					
+Briskway	0.725 fl oz					
Daconil Action	3.5 fl oz	14-d	0.0 b	0.0	0.0	0.0
+Appear	6.0 fl oz					
+Briskway	0.5 fl oz					
QP Chlorothalonil 720 SFT	3.0 fl oz	14-d	0.0 b	0.0	0.0	0.0
+Chipco Signature	4.0 oz					
+Honor	1.1 oz					
Encartis	3.0 fl oz	14-d	0.0 b	0.0	0.0	0.0
Encartis	4.0 fl oz	21-d	0.0 b	0.0	0.0	0.0
Daconil WeatherStik	2.99 fl oz	14-d	0.0 b	0.0	0.0	0.0
Torque	0.6 fl oz	21-d	1.5 a	0.0	0.0	0.0
Daconil Action	3.5 fl oz	14-d	0.3 b	0.0	0.0	0.0
+Primo MAXX	0.125 fl oz					
Daconil Action	3.5 fl oz	14-d	0.0 b	0.0	0.0	0.0
+Appear	4.0 fl oz					
+Primo MAXX	0.125 fl oz					
UC13-5	0.5 oz	14-d	0.3 b	0.0	0.0	0.0
+Primo MAXX	0.125 fl oz					
UC13-1	1.65 fl oz	7-d	0.0 b	0.0	0.0	0.0
UC13-1	1.65fl oz	14-d	0.0 b	0.0	0.0	0.0
UC13-1	3.3 fl oz	14-d	0.0 b	0.0	0.0	0.0
UC13-1	4.356 fl oz	21-d	0.0 b	0.0	0.0	0.0
UC13-1	4.356 fl oz	curative[w]	0.0 b	0.0	0.0	0.0
UC13-1	6.6 fl oz	28-d	0.0 b	0.0	0.0	0.0
UC13-1	13.2 fl oz	single[v]				
UC13-2	1.65 fl oz	7-d	0.0 b	0.0	0.0	0.0
Briskway	0.3 fl oz	14-d	0.0 b	0.0	0.0	0.0
QP Enclave	3.0 fl oz	14-d	0.0 b	0.0	0.0	0.0
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	0.0 b	0.0	0.0	0.0
+Foursome	0.4 fl oz					
QP Enclave	3.0 fl oz	14-d	0.0 b	0.0	0.0	0.0
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	0.0 b	0.0	0.0	0.0
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
Secure	0.5 fl oz	14-d	0.0 b	0.0	0.0	0.0
Xzemplar	0.26 fl oz	14-d	0.0 b	0.0	0.0	0.0
Plant Food Program 1[z]		7-d	0.0 b	0.0	0.0	0.0
Plant Food Program 2[y]		7-d	0.0 b	0.0	0.0	0.0
Untreated			0.0 b	0.0	0.0	0.0
ANOVA: Treatment (P > F)			0.0003	0.5404	1.0000	1.0000
Days after treatment		7-d	2	4	3	7
		14-d	9	10	11	7
		21-d	9	4	18	21
		28-d	9	23	11	7

[z] Harrell's pH buffer (0.44 fl oz); 16-2-7 (6.0 fl oz); Phosphite 30 (2.0 fl oz); Impulse (2.0 fl oz); 6 Iron (1.5 fl oz); and Flo Thru (2.0 fl oz) were tank mixed and applied on 28 May, 4, 11, 17, 25 Jun, and 2 Jul. Omega (0.36 fl oz) was applied separately on these dates. Plant Food Organic Acid (3.0 fl oz) was tank mixed with all materials previously mentioned beginning on 9 Jul, except 16-2-7 and Harrell's pH buffer which were not applied during the remainder of the trial.

[y] Harrell's pH buffer (0.44 fl oz); 16-2-7 (6.0 fl oz); Phosphite 30 (2.0 fl oz); Impulse (2.0 fl oz); 6 Iron (1.5 fl oz); Flo Thru (2.0 fl oz); and Daconil WeatherStik (0.9 fl oz) were tank mixed and applied on 28 May, 4, 11, 17, 25 Jun, and 2 Jul. Omega (0.36 fl oz) was applied separately on these dates. Plant Food Organic Acid (3.0 fl oz) was tank mixed with all materials beginning on 9 Jul, except 16-2-7 and Harrell's pH buffer which were not applied during the remainder of the trial.

[x] Treatments were initiated on 28 May, prior to disease development. Subsequent 7-d treatments were applied on 4 Jun, 11 Jun, 17 Jun, 25 Jun, 2 Jul, 9 Jul, 16 Jul, 24 Jul; 14-d treatments were applied on 11 Jun, 25 Jun, 9 Jul, 24 Jul; 21-d treatments were applied on 17 Jun and 9 Jul; 28-d treatments were applied on 25 Jun and 24 Jul.

[w] A curative application of UC13-1 was made on 9 Jul, and applied every 21-d thereafter.

[v] A single application of UC13-1 was applied on 28 May.

[u] Treatment means followed by the same letter, within each column, are not significantly different based on Student-Newman-Kewls test ($\alpha = 0.05$).

PREVENTIVE BROWN PATCH AND DOLLAR SPOT CONTROL WITH SDHI FUNGICIDES AND CHITOSAN BASED PRODUCTS ON A COLONIAL BENTGRASS FAIRWAY TURF, 2013

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INTRODUCTION

Succinate dehydrogenase inhibitor (SDHI) fungicides are a relatively new class of fungicides in turf. Older-generation SDHI materials (e.g., Emerald or ProStar) are highly effective fungicides; however they may only provide control of one or two diseases. Conversely, second generation SDHI fungicides (e.g., Velista or Xzemplar) may have a broader spectrum of activity, providing effective control of a wider range of turfgrass diseases.

Recently, chemicals which induce plant defense responses have been developed as an additional tool to suppress plant disease. Omega is a chitosan-based material, derived from shrimp exoskeletons, and is chemically similar to fungal cell walls. Chitosan has been shown to elicit plant defenses and reduce the incidence and severity of some plant diseases. The objective of this study was to evaluate the effectiveness of first- and second-generation SDHI fungicides, and chitosan based Omega in preventing and controlling brown patch and dollar spot diseases on a colonial bentgrass fairway turf.

MATERIALS & METHODS

A field study was conducted on an 'SR-7150' colonial bentgrass (*Agrostis capillaris*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Nitrogen was applied to the study area to encourage brown patch development. A total of 2.6 lb N 1000-ft^{-2} was applied as water soluble sources from April through July. A low rate (1.8 oz.) of Daconil Ultrex was applied on 22 June to prevent brown patch development prior to initiation of treatments. Acelepryn was applied on 22 June for the control of white grubs and surface feeding caterpillars. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of fungicides and applied individually, or as tank mixes. Initial applications were made on 27 June prior to disease developing in the trial area. Subsequent applications were made at specified treatment intervals through 12 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi. Granular treatments were applied by hand using a shaker jar. Immediately following application, the equivalent of 0.1 inch of irrigation was applied with a watering can to plots receiving granular treatments.

Brown patch was assessed visually as a percentage of the plot area blighted by *Rhizoctonia solani*. Dollar spot incidence was assessed as a count of individual disease foci within each plot. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Brown patch incidence data were arcsine transformed for ANOVA and mean separation tests, although means presented are back-calculated values.

RESULTS

Brown Patch

Disease developed throughout the trial beginning 7 days after initial treatment. Untreated plots increased to 40% blighted turf on 4 July (Table 1), and increased to 87% plot area blighted by 19 July. High humidity and night time temperatures provided favorable brown patch conditions in early- and mid-July resulting in a rigorous assessment of fungicide efficacy.

Most treatments provided excellent control at the beginning of the epidemic (4 Jul), except for the low rate of Emerald (0.13 oz) and Omega. However, the chitosan based material (Omega) did provide a 56% average reduction in disease compared to the untreated control.

By 11 July, Enclave tank mixes, Signature+26GT, Heritage TL, QP TM4.5, Honor, and all of the SDHI fungicides (e.g., ProStar, Velista, Xzemplar) except Emerald provided excellent brown patch control (i.e., 0-2%) (Table 1). Daconil Action, Heritage G, and QP Chlorothalonil 720SFT provided good control (i.e., 3-5%) . Emerald (0.18 oz), Daconil Weather Stik, Secure, Daconil Weather Stik+Omega provided acceptable control (i.e., $\leq$ 10%) on this date.

During the peak of the epidemic (19 Jul), most treatments continued to provide the same level of control observed on 11 Jul. However, disease control in Emerald (0.18 oz), Daconil Weather Stik and Secure declined to unacceptable levels, albeit less than in the untreated control.

Dollar Spot

Dollar spot also developed throughout the trial during the same time as brown patch. Nearly all treatments provided excellent dollar spot control, although a few treatments enhanced disease or did not reduce dollar spot compared to untreated turf (Table 2). Omega consistently enhanced dollar spot compared to untreated turf. Heritage TL and G each increased dollar spot on one of the two observation dates, although neither formulation ever reduced dollar spot compared to untreated. ProStar (1.5 and 3.0 oz) and QP TM 4.5 provided no dollar spot control on either observation date.

Turf Quality and Phytotoxicity

Turf quality (Table 3) was primarily influenced by disease incidence. Quality was good to excellent throughout the trial for treatments that provided excellent control of both brown patch and dollar spot, particularly in plots treated with Velista (0.5 oz) and Honor, as well as in treatments that included a green pigment, such as Foursome, in the mix. There was no phytotoxicity (Table 4) observed in any of the treatments.

DISCUSSION

Brown patch and dollar spot pressure was high in this trial providing a rigorous evaluation of fungicide efficacy. Moreover, the occurrence of both these diseases within this trial provided a unique opportunity to compare the spectrum of activity of 1st and 2nd generation SDHI fungicides.

First-generation SDHIs, such as ProStar and Emerald are very effective in controlling a limited number of diseases included on their label. As expected, ProStar provided excellent brown patch control and Emerald provided excellent dollar spot control in the current trial. However, neither fungicide controlled both dollar spot and brown patch (albeit Emerald did provide some suppression of brown patch, particularly at the high rate). Interestingly, the 2nd generation SDHI fungicides Velista and Xzemplar provided excellent brown patch and dollar spot control in this trial, reflecting the increased spectrum of activity inherent in these newest members of SDHI fungicides. All members of the SDHI chemical class provided good turf quality in the absence of the disease, and did not cause any phytotoxicity in the current trial.

Omega alone provided inadequate control of brown patch, but still exhibited a 56% average reduction in disease relative to untreated plots. This would suggests that plant defenses may indeed activated by the application of Omega, however it remains necessary to include a fungicide suited for brown patch control in order to bring disease incidence to acceptable levels. While plots treated with Daconil Weather Stik + Omega did display adequate control of brown patch, disease on these plots was not significantly different from disease on plots treated with Daconil Weather Stik alone. In addition, plots treated with Omega showed enhanced dollar spot activity relative to untreated plots, but the inclusion of Daconil Weather Stik negated this effect. No phytotoxicity was observed on any of the plots treated with Omega.

As has been reported in other studies, plots treated with Heritage G and Heritage TL had greater dollar spot incidence than untreated turf. Although both formulations provided adequate control of brown patch, Plots treated with Hertitage G contained small, non-uniform brown patch symptoms. This was likely a consequence of uneven application of the granular fungicide, and turf managers who apply Hertitage G ensure the product is evenly applied and irrigated following application to optimize coverage.

While plots treated with QP TM 4.5 displayed adequate control of brown patch, there was little to no control of dollar spot in these plots. The *Sclerotinia homoeocarpa* isolates at the trial site have been shown to be resistant to thiophanate-methyl fungicides, and so the lack of control provided by this treatment was to be expected.

While many treatments initially provided good control of brown patch, by 11 July (14 days after initial treatment) Secure (14-d) and Daconil Weather Stik (14-d) provided only minimally acceptable control. This suggests that these treatments may not reliably control of brown patch at these rates and application intervals when disease pressure is especially high.

QP Enclave + Foursome provided excellent brown patch and dollar spot control throughout the trial, regardless of rate and interval. The inclusion of QP Fosetyl-Al as an additional tank mix partner did not improve disease control or turf quality in the current trial. Based on data from this trial, it is likely that adequate brown patch and dollar spot control and excellent turf quality could be maintained with applications of QP Enclave at 4.0 oz and Foursome every 21-d; resulting in fewer applications, and less active ingredient applied during the season compared to Enclave applied on a 14-d interval at 3.0 oz.

Table 1. Brown patch severity affected by various fungicides applied preventively to ‘SR 7150’ colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Int[w]	Brown Patch Severity 4 Jul	11 Jul	19 Jul
			----------% plot area blighted----------		
QP Enclave	3.0 fl oz	14-d	0.0[v] d[u]	0.0 f	0.0 h
+Foursome	0.4 fl oz				
QP Enclave	4.0 fl oz	21-d	0.0 d	0.0 f	0.0 h
+Foursome	0.4 fl oz				
QP Enclave	0.3 fl oz	14-d	0.0 d	0.0 f	0.0 h
+QP Fosetyl-Al	4.0 oz				
+Foursome	0.4 fl oz				
QP Enclave	4.0 fl oz	21-d	0.0 d	0.0 f	0.3 gh
+QP Fosetyl-Al	4.0 oz				
+Foursome	0.4 fl oz				
Secure	0.5 fl oz	14-d	0.0 d	10.8 d	11.2 de
Daconil Action	2.0 fl oz	14-d	0.0 d	4.5 de	4.4 efg
Daconil Weather Stik	2.0 fl oz	14-d	0.0 d	9.1 d	12.6 de
Emerald	0.13 oz	21-d	18.5 b	54.1 b	67.0 b
Emerald	0.18 oz	21-d	0.4 cd	5.2 de	22.3 d
ProStar	1.5 oz	21-d	0.0 d	0.0 f	1.3 fgh
ProStar	3.0 oz	21-d	0.0 d	0.0 f	0.0 h
Velista	0.3 oz	21-d	0.0 d	0.0 f	0.0 h
Velista	0.5 oz	21-d	0.0 d	0.0 f	0.0 h
Xzemplar	0.157 fl oz	21-d	0.0 d	0.0 f	0.4 gh
Xzemplar	0.26 fl oz	21-d	0.0 d	0.0 f	0.0 h
Omega[z]	0.36 fl oz	14-d	13.2 b	32.4 c	47.6 c
Daconil Weather Stik	2.0 fl oz	14-d	0.1 d	7.8 de	8.6 e
+Omega[zy]	0.36 fl oz				
Chipco Signature	4.0 oz	14-d	0.0 d	0.7 ef	0.3 gh
+26GT	2.0 fl oz				
Hertiage TL	1.0 fl oz	21-d	0.0 d	0.0 f	0.0 h
Hertiage G	2.0 lb	21-d	2.9 c	5.0 de	6.6 ef
+Post-application irrigation[x]					
QP TM 4.5	2.0 fl oz	14-d	0.0 d	0.7 ef	0.3 gh
QP Chlorothalonil 720 SFT	2.0 fl oz	14-d	0.0 d	3.8 def	3.8 efg
Honor	0.8125 oz	21-d	0.0 d	0.0 f	0.0 h
Untreated			40.1 a	75.0 a	87.1 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001
Days after treatment		14-d	7	14	8
		21-d	7	14	1

[z] Carrier was buffered to a pH of 5.5 before addition of Omega

[y] Daconil Weather Stik was added after Omega

[x] Individual plots received 0.10 inches of irrigation with a watering can immediately after fungicide application.

[w] All treatments initiated on 27 Jun prior to disease development. Subsequent 14-d treatments were applied on 12 Jul, 25 Jul, and 12 Aug; 21-d treatments were applied on 18 Jul and 12 Aug.

[v] Data were arc-sin transformed; means presented are back calculated

[u] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher’s protected least significant difference test (α = 0.05).

Table 2. Dollar spot incidence affected by various fungicides on 'SR 7150' colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Int[w]	Dollar Spot Incidence 4 Jul	19 Jul
			------------ # of spots 18ft^{-2} -------------	
QP Enclave	3.0 fl oz	14-d	0.0 d[v]	0.2 cd
+Foursome	0.4 fl oz			
QP Enclave	4.0 fl oz	21-d	0.0 d	0.2 cd
+Foursome	0.4 fl oz			
QP Enclave	0.3 fl oz	14-d	0.0 d	2.0 cd
+QP Fosetyl-Al	4.0 oz			
+Foursome	0.4 fl oz			
QP Enclave	4.0 fl oz	21-d	0.0 d	0.0 d
+QP Fosetyl-Al	4.0 oz			
+Foursome	0.4 fl oz			
Secure	0.5 fl oz	14-d	0.0 d	0.8 cd
Daconil Action	2.0 fl oz	14-d	0.6 d	4.0 c
Daconil Weather Stik	2.0 fl oz	14-d	0.8 d	3.0 cd
Emerald	0.13 oz	21-d	0.6 d	0.6 cd
Emerald	0.18 oz	21-d	0.0 d	0.4 cd
ProStar	1.5 oz	21-d	21.6 abc	19.4 ab
ProStar	3.0 oz	21-d	20.5 abc	17.2 ab
Velista	0.3 oz	21-d	1.5 d	2.9 cd
Velista	0.5 oz	21-d	0.6 d	1.7 cd
Xzemplar	0.157 fl oz	21-d	0.2 d	0.9 cd
Xzemplar	0.26 fl oz	21-d	0.0 d	0.5 cd
Omega[z]	0.36 fl oz	14-d	33.6 a	22.9 a
Daconil Weather Stik	2.0 fl oz	14-d	0.0 d	3.2 cd
+Omega[zy]	0.36 fl oz			
Chipco Signature	4.0 oz	14-d	0.4 d	0.5 cd
+26GT	2.0 fl oz			
Hertiage TL	1.0 fl oz	21-d	12.0 c	24.2 a
Hertiage G	2.0 lb	21-d	29.3 ab	17.8 ab
+Post-application irrigation[x]				
QP TM 4.5	2.0 fl oz	14-d	17.5 bc	17.4 ab
QP Chlorothalonil 720 SFT	2.0 fl oz	14-d	0.2 d	3.5 cd
Honor	0.8125 oz	21-d	0.4 d	0.4 cd
Untreated			13.2 c	11.6 b
ANOVA: Treatment (P > F)			0.0001	0.0001
Days after treatment		14-d	7	8
		21-d	7	1

[z] Carrier was buffered to a pH of 5.5 before addition of Omega

[y] Daconil Weather Stik was added after Omega

[x] Individual plots received 0.10 inches of irrigation with a watering can immediately after fungicide application.

[w] All treatments initiated on 27 Jun. Subsequent 14-d treatments were applied on 12 Jul, 25 Jul, and 12 Aug; Subsequent 21-d treatments were applied on 18 Jul and 12 Aug.

[v] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

Table 3. Turf quality and phytotoxicity influenced by various fungicides on 'SR 7150' colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft²	Int[w]	Turf Quality 5 Jul	Turf Quality 19 Jul	Phytotoxicity 5 Jul	Phytotoxicity 19 Jul
			----- 1-9; 6=min acceptable -----		--- 0-5; 2=max acceptable ---	
QP Enclave	3.0 fl oz	14-d	8.0 ab[v]	9.0 a	0.0	0.0
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	8.5 a	9.0 a	0.0	0.0
+Foursome	0.4 fl oz					
QP Enclave	0.3 fl oz	14-d	8.0 ab	9.0 a	0.0	0.0
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
QP Enclave	4.0 fl oz	21-d	8.0 ab	9.0 a	0.0	0.0
+QP Fosetyl-Al	4.0 oz					
+Foursome	0.4 fl oz					
Secure	0.5 fl oz	14-d	7.8 abc	6.5 cd	0.0	0.0
Daconil Action	2.0 fl oz	14-d	7.0 cde	7.0 bcd	0.0	0.0
Daconil Weather Stik	2.0 fl oz	14-d	7.3 b-e	6.5 cd	0.0	0.0
Emerald	0.13 oz	21-d	4.8 ij	4.0 e	0.0	0.0
Emerald	0.18 oz	21-d	6.8 def	6.0 d	0.0	0.0
ProStar	1.5 oz	21-d	6.0 fgh	6.5 cd	0.0	0.0
ProStar	3.0 oz	21-d	5.8 gh	6.8 cd	0.0	0.0
Velista	0.3 oz	21-d	7.0 cde	7.8 a-d	0.0	0.0
Velista	0.5 oz	21-d	7.0 cde	8.8 ab	0.0	0.0
Xzemplar	0.157 fl oz	21-d	7.5 bcd	8.3 abc	0.0	0.0
Xzemplar	0.26 fl oz	21-d	7.5 bcd	8.3 abc	0.0	0.0
Omega[z]	0.36 fl oz	14-d	4.5 ij	4.3 e	0.0	0.0
Daconil Weather Stik	2.0 fl oz	14-d	7.0 cde	7.3 a-d	0.0	0.0
+Omega[zy]	0.36 fl oz					
Chipco Signature	4.0 oz	14-d	7.3 b-e	8.0 abc	0.0	0.0
+26GT	2.0 fl oz					
Hertiage TL	1.0 fl oz	21-d	6.5 efg	6.8 cd	0.0	0.0
Hertiage G	2.0 lb	21-d	5.3 hi	6.0 d	0.0	0.0
+Post-application irrigation[x]						
QP TM 4.5	2.0 fl oz	14-d	5.8 gh	6.5 cd	0.0	0.0
QP Chlorothalonil 720 SFT	2.0 fl oz	14-d	7.0 cde	7.3 a-d	0.0	0.0
Honor	0.8125 oz	21-d	7.3 b-e	8.8 ab	0.0	0.0
Untreated			4.0 j	3.3 e	0.0	0.0
ANOVA: Treatment (P > F)			0.0001	0.0001	1.0000	1.0000
Days after last treatment		14-d	8	8	8	8
		21-d	8	1	8	1

[z] Carrier was buffered to a pH of 5.5 before addition of Omega

[y] Daconil Weather Stik was added after Omega

[x] Individual plots received 0.10 inches of irrigation with a watering can immediately after fungicide application.

[w] All treatments initiated on 27 Jun. Subsequent 14-d treatments were applied on 12 Jul, 25 Jul, and 12 Aug; Subsequent 21-d treatments were applied on 18 Jul and 12 Aug.

[v] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

PREVENTIVE DOLLAR SPOT CONTROL ON A 'PUTTER' CREEPING BENTGRASS FAIRWAY TURF, 2013

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INTRODUCTION

Dollar spot (caused by *Sclerotinia homoeocarpa*) is the most common disease affecting golf course fairways from May to October throughout the Northeastern United States. Control of the disease often includes selecting tolerant cultivars, maintaining proper nitrogen fertility, and minimizing leaf wetness period. However, routine fungicide applications are often necessary to provide adequate disease control in many locations.

Several new fungicides have been recently introduced or are anticipated to be released in the next year. These include: QP Enclave, a 4-way premix fungicide containing tebuconazole, thiophanate-methyl, iprodione, and clorothalonil; Secure, a new multi-site mode of action, contact fungicide; and Xzemplar and Lexicon Intrinsic which both contain fluxapyroxad a new active ingredient within the SDHI/carboximide class of fungicides. Lexicon Intrinsic is a premix of fluxapyroxad and pyraclostrobin. The objective of this study was to examine the efficacy of these new fungicides applied alone or as tank mixtures, and fertilizer programs for dollar spot control on a creeping bentgrass fairway turf.

MATERIALS & METHODS

A field study was conducted on a 'Putter' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage dollar spot development. A total of 1.0 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through September. Acelepryn was applied on 22 June for the control of white grubs and surface feeding caterpillars. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new and currently available fungicides applied individually, or as tank mixes. Additionally, nutrient based programs with and without fungicides were evaluated. Initial applications were made on 23 May prior to disease developing in the trial area. Subsequent applications were made at specified treatment intervals through 15 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual disease foci within each plot from 24 May to 30 August. Dollar spot severity was assessed as a visual estimate of the percent plot area blighted by *S. homoeocarpa*, once dollar spot foci were too numerous to count on 6 and 13 September. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Dollar spot incidence and severity data were square-root and arcsine transformed, respectively, for ANOVA and mean separation tests. Means presented are back-calculated values.

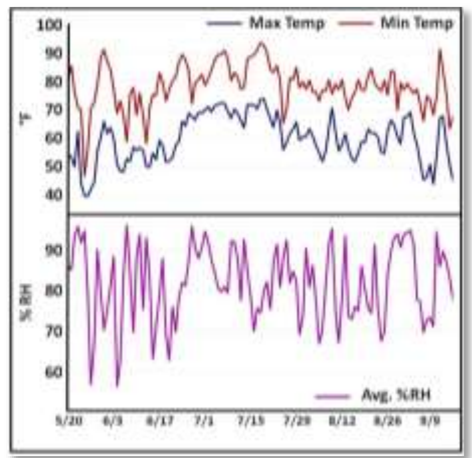

Fig. 1. High and low temperatures and average relative humidity in Storrs, CT during 20 May to 15 Sep 2013.

RESULTS & DISCUSSION

Dollar Spot Incidence and Severity

Limited dollar spot symptoms were observed in all treatments one day after initial application through mid-June (Table 1); however, symptoms subsided (< 1 dollar spot infection center per plot) in nearly all treatments by 21 June. Significant dollar spot development occurred by 4 July (Table 2) as overnight temperatures and daily average relative humidity increased (Figure 1). Most treatments provided excellent dollar spot control from this time through August.

Enclave, a premix fungicide containing tebuconazole, thiophanate-methyl, iprodione and chlorothalonil, tank mixed with Foursome with and without QP Fosetyl-Al performed well throughout the trial, except for the three-way tank mix applied on 21-d interval during August. Similarly, a tank mix of Torque, Spectro 90, 26/36, and Anuew applied every 14-d also provided excellent disease control. Interestingly, dollar spot control was better in tank mixes containing Anuew compared to the same mixtures without it. Anuew is a new GA inhibiting growth regulator.

Xzemplar, Lexicon Intrinsic, and Honor Intrinsic provided excellent dollar spot control on a 28-d interval, and were significantly better during late-August than Emerald and Velista applied every 28-d.

Secure applied every 14-d, alone or as a tank mix was among the best treatments evaluated in this trial, and was significantly better than Daconil Action (2.0 fl oz) on all observation dates. Interestingly, when Secure was tank mixed with Sync (fungicide activator) the solution routinely turned a bright orangish pink (Figure 2). No precipitate was observed and efficacy was unaffected. This phenomenon has been reported to occur when Secure is diluted in solutions with increased pH. Despite the obvious color change, no detrimental effects on disease control or turf quality have been observed. Sync had no effect on dollar spot incidence when applied alone or tank mixed with Daconil Action or Secure.

Fig. 2. Color of spray solution when Secure is tank mixed with Sync (left) or other high pH solutions compared to Secure alone (right).

UC13-4 provided near complete dollar spot control in July and August. UC13-5 was statistically similar when applied every 14-d at 0.3 or 0.5 oz rates. However, on a 21-d interval the 0.5 oz rate of UC13-5 did not provide acceptable disease control. The addition of Secure as a tank mix partner to UC13-5 (0.5 oz) on a 21-d interval did result in excellent dollar spot control throughout July and August. Conversely, Daconil Action tank mixed with UC13-5 did not improve control on a 21-d interval.

Plant Food Programs 1 and 2 contained, a foliar 16-2-7 fertilizer plus micronutrients, Phosphite 30, 6 Iron, (nitrogen and iron source), Impulse (biostimulant containing salicylic acid), and Omega (experimental chitin based biostimulant) applied every 14-d. Plant Food Program 2 also contained a reduced rate of Banner MAXX (0.5 fl oz). Plant Food Program 1 generally did not reduce dollar spot compared the untreated control. However, Plant Food Program 2 containing Banner MAXX (0.5 fl oz) provided acceptable dollar spot control on most observation dates throughout the trial.

Turf Quality and Phytotoxicity

Turf quality in the trial was predominantly influenced by dollar spot and phytotoxicity. Most treatments provided good turf quality during May and June (Table 3), prior to significant disease development.

Phytotoxicity was observed with both rates of Anuew which were initiated on 20 June (Table 4). However, damage was most noticeable in the “low rate treatment” due to two applications at 10 times the intended rate of 0.09 oz. Both Anuew treatments (10 x 0.09 oz and 0.18 oz) resulted in an initial bronzing of turf 6 days after initial treatment, coarse leaf texture, and non-uniform turf. Following repeat applications, bronzing and non-unifomrity symptoms subsided to the point where the level of phytotoxicity was considered acceptable by 29 July. A period of phytotoxicity is not uncommon when growth regulator applications are initiated, particularly during increased temperatures. Phytotoxicity in Anuew treatments in this trial is certainly related to the inadvertent application of a 10 x rate and possibly initiating treatments during summer stress. More research with this new growth regulator is necessary to determine rates and timing in New England for optimal turf quality.

Slight (2 on 0-5 scale), phytotoxicity (bronzed turf) was observed in plots treated with Secure and Primo MAXX (8 DAIT) (Table 4). However, these symptoms subsided after the initial application period, and no subsequent phytotoxcity was observed in any treatments throughout the remainder of the trial.

Table 1. Dollar spot incidence influenced by fungicides applied preventatively to a 'Putter' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Int[w]	Dollar Spot Incidence					
			24 May	31 May	6 Jun	16 Jun	21 Jun	27 Jun
			# of spots 18ft^{-2}					
QP Enclave	3.0 fl oz	14-d	2.0[v]	1.1	0.8	0.9	0.0	0.2 b[u]
+Foursome	0.4 fl oz							
QP Enclave	4.0 fl oz	21-d	5.6	3.7	3.2	4.7	0.4	0.0 b
+Foursome	0.4 fl oz							
QP Enclave	3.0 fl oz	14-d	3.0	2.9	0.7	0.4	0.0	0.0 b
+QP Fosetyl-Al	4.0 oz							
+Foursome	0.4 fl oz							
QP Enclave	4.0 fl oz	21-d	6.9	1.4	1.7	4.2	0.0	0.0 b
+QP Fosetyl-Al	4.0 oz							
+Foursome	0.4 fl oz							
UC13-4	0.34 fl oz	14-d	4.0	2.6	1.5	3.7	0.2	0.0 b
UC13-4	0.34 fl oz	21-d	11.0	6.3	2.4	2.7	0.0	0.0 b
UC13-5	0.3 oz	14-d	1.7	1.0	2.7	4.2	0.2	0.0 b
UC13-5	0.5 oz	14-d	2.5	0.7	0.7	6.6	0.0	0.0 b
UC13-5	0.5 oz	21-d	14.0	10.9	6.7	6.9	0.4	0.0 b
UC13-5	0.3 oz	14-d	6.0	3.3	1.2	4.7	0.4	0.0 b
+Daconil Action	2.0 fl oz							
UC13-5	0.5 oz	14-d	2.3	0.5	0.9	3.6	0.0	0.0 b
+Daconil Action	2.0 fl oz							
UC13-5	0.5 oz	21-d	1.8	1.4	0.4	2.8	0.0	0.0 b
+Daconil Action	2.0 fl oz							
UC13-5	0.3 oz	14-d	3.0	0.5	1.5	3.1	0.4	0.0 b
+Secure	0.5 fl oz							
UC13-5	0.5 oz	14-d	7.1	1.3	1.7	1.1	0.0	0.0 b
+Secure	0.5 fl oz							
UC13-5	0.5 oz	21-d	2.5	2.2	1.5	6.4	0.0	0.0 b
+Secure	0.5 fl oz							
UC13-3	0.236 fl oz	21-d	4.6	2.8	0.8	5.7	0.2	0.0 b
+Secure	0.5 fl oz							
Secure	0.5 fl oz	14-d	12.9	9.9	6.0	0.7	0.2	0.2 b
+Primo MAXX	0.125 fl oz							
Secure	0.5 fl oz	14-d	7.6	4.6	1.6	1.4	0.0	0.0 b
+Daconil Action	2.0 fl oz							
Secure	0.5 fl oz	14-d	5.0	2.2	0.9	1.7	0.0	0.0 b
Secure	0.5 fl oz	14-d	8.3	5.9	2.4	3.4	0.8	0.0 b
+Sync	0.16 fl oz							
Daconil Action	2.0 fl oz	14-d	10.0	6.6	6.1	5.8	0.0	0.2 b
Daconil Action	2.0 fl oz	14-d	4.5	1.1	0.4	2.1	0.2	0.0 b
+Sync	0.16 fl oz							
Sync	0.16 fl oz	14-d	4.9	10.4	5.8	7.2	0.7	0.8 b

Continued…

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Table 1 *(cont.)* Dollar spot incidence influenced by fungicides applied preventatively to a 'Putter' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

			Dollar Spot Incidence					
Treatment	Rate per 1000ft^2	Int	24 May	31 May	6 Jun	16 Jun	21 Jun	27 Jun
			# of spots 18ft^{-2}					
Curalan EG	1.0 oz	21-d	6.2	3.5	1.6	2.6	0.0	0.0 b
Encartis	4.0 fl oz	21-d	8.5	2.4	0.8	5.1	0.4	0.0 b
Velista	0.5 oz	28-d	6.6	7.1	3.8	7.3	0.6	0.0 b
Emerald	0.18 oz	28-d	5.3	1.0	0.8	3.7	0.2	0.0 b
Xzemplar	0.26 fl oz	28-d	4.0	4.1	3.9	4.2	0.2	0.0 b
Honor	1.1 oz	28-d	5.6	3.0	1.2	3.4	0.0	0.0 b
Lexicon Intrinsic	0.46 fl oz	28-d	8.1	1.2	2.1	5.5	0.9	0.0 b
Torque	0.75 fl oz	14-d	7.5	4.3	2.1	4.8	0.4	0.0 b
+Spectro 90	3.6 oz							
+26/36	4.0 fl oz							
Torque	0.75 fl oz	14-d	4.5	4.5	2.0	6.0	0.0	0.0 b
+Spectro 90	3.6 oz							
+Anuew	0.09 oz[zy]							
+26/36	4.0 fl oz							
Torque	0.75 fl oz	14-d	8.8	4.2	3.2	5.4	0.2	0.0 b
+Spectro 90	3.6 oz							
+Anuew	0.18 oz[z]							
+26/36	4.0 fl oz							
16-2-7	6.0 fl oz	14-d	5.7	5.9	6.8	1.5	0.6	0.8 b
+6 Iron	2.0 fl oz							
+Impulse	2.0 fl oz							
+Phosphite 30	2.0 fl oz							
+Omega	0.36 fl oz[x]							
16-2-7	6.0 fl oz	14-d	8.0	8.8	4.8	2.7	0.2	0.0 b
+6 Iron	2.0 fl oz							
+Impulse	2.0 fl oz							
+Phosphite 30	2.0 fl oz							
+Omega	0.36 fl oz[x]							
+Banner MAXX	0.5 fl oz							
Untreated			3.8	5.1	5.1	2.8	0.6	2.9 a
ANOVA: Treatment (P > F)			0.9197	0.1929	0.1654	0.0614	0.8361	0.0234
Days after treatment		14-d	1	8	1	10	1	7
		21-d	1	8	14	1	7	14
		28-d	1	8	14	23	1	7

[z] Initial application of Anuew was made on 20 Jun.

[y]Anuew was initially applied at 10 times the intended rate on 20 Jun and 4 July. Thereafter, the rate was reduced to 0.09 fl oz 1000ft^{-2} beginning on 18 Jul.

[x]Carrier was buffered to a pH of 5.5 before addition of Omega. Other ingredients were added after the addition of Omega.

[w]Treatments were initiated on 23 May, prior to symptom development. Subsequent 14-d treatments were applied on 6 Jun, 20 Jun, 5 Jul, 18 Jul, 31 Jul, 15 Aug; 21-d treatments were applied on 15 Jun, 5 Jul, 25 Jul, 15 Aug; 28-d treatments were applied on 20 Jun, 18 Jul, and 15 Aug.

[v]Data were square-root transformed and means back calculated for presentation.

[u]Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

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Table 2. Dollar spot incidence and severity influenced by fungicides applied preventatively to a ‘Putter’ creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per $1000ft^2$	Int[w]	Dollar Spot Incidence 4 Jul	12 Jul	19 Jul	29 Jul	7 Aug	14 Aug	23 Aug	30 Aug	Dollar Spot Severity 6 Sept	13 Sept
			# of spots $18ft^{-2}$								% plot area blighted	
QP Enclave	3.0 fl oz	14-d	12.1[v] e-i[u]	3.6 def	2.8 fgh	1.1 fg	0.0 f	9.3 g-j	3.6 g-j	5.8 f-j	4.2[t] e-k	8.1 d-h
+Foursome	0.4 fl oz											
QP Enclave	4.0 fl oz	21-d	5.1 g-j	0.9 ef	0.2 gh	0.2 g	0.4 f	12.0 f-i	2.4 g-j	3.9 g-j	3.5 e-l	6.6 d-i
+Foursome	0.4 fl oz											
QP Enclave	3.0 fl oz	14-d	1.1 hij	0.0 f	0.0 h	0.0 g	0.0 f	0.6 ij	0.0 j	0.0 j	1.2 i-o	2.8 g-i
+QP Fosetyl-Al	4.0 oz											
+Foursome	0.4 fl oz											
QP Enclave	4.0 fl oz	21-d	4.5 g-j	0.4 ef	0.2 gh	0.4 fg	14.0 de	89.2 bcd	23.2 def	13.1 efg	7.3 c-h	13.0 c-f
+QP Fosetyl-Al	4.0 oz											
+Foursome	0.4 fl oz											
UC13-4	0.34 fl oz	14-d	0.2 j	0.0 f	0.4 gh	0.0 g	0.0 f	0.0 j	0.8 hij	0.0 j	0.0 no	0.6 i-l
UC13-4	0.34 fl oz	21-d	1.7 hij	0.4 ef	0.0 h	0.0 g	0.0 f	4.3 hij	1.2 hij	0.4 ij	1.1 jo	2.3 g-l
UC13-5	0.3 oz	14-d	14.5 d-h	6.4 c-f	7.1 e-h	1.2 fg	0.6 f	11.2 f-j	3.0 g-j	4.0 g-j	3.1 g-m	5.5 e-j
UC13-5	0.5 oz	14-d	3.9 g-j	0.9 ef	3.6 e-h	0.0 g	0.0 f	0.4 ij	0.8 hij	0.0 j	0.3 mno	2.0 g-l
UC13-5	0.5 oz	21-d	18.3 d-g	9.1 cde	8.6 efg	4.3 ef	14.7 de	91.1 bc	36.5 cd	10.2 e-i	7.8 c-g	10.8 c-g
UC13-5	0.3 oz	14-d	12.3 e-i	3.8 def	8.0 e-h	0.4 fg	0.0 f	5.4 hij	0.9 hij	1.1 hij	1.9 i-n	3.4 f-l
+Daconil Action	2.0 fl oz											
UC13-5	0.5 oz	14-d	0.7 ij	0.0 f	0.2 gh	0.0 g	0.0 f	0.4 ij	0.0 j	0.0 j	0.4 l-o	0.7 i-l
+Daconil Action	2.0 fl oz											
UC13-5	0.5 oz	21-d	25.6 def	5.7 c-f	10.2 ef	8.8 de	26.9 c	119.5 b	55.2 bc	30.2 de	9.9 cde	17.4 cde
+Daconil Action	2.0 fl oz											
UC13-5	0.3 oz	14-d	0.0 j	0.0 f	1.1 fgh	0.0 g	0.0 f	1.1 ij	0.0 j	0.0 j	0.0 o	0.1 kl
+Secure	0.5 fl oz											
UC13-5	0.5 oz	14-d	0.2 j	0.0 f	0.0 h	0.0 g	0.0 f	0.4 ij	0.0 j	0.0 j	0.0 o	0.1 kl
+Secure	0.5 fl oz											
UC13-5	0.5 oz	21-d	0.8 ij	0.2 f	0.9 fgh	0.2 g	0.4 f	10.2 g-j	1.6 g-j	0.0 j	0.1 no	1.4 h-l
+Secure	0.5 fl oz											
UC13-3	0.236 fl oz	21-d	1.4 hij	0.2 f	0.4 gh	0.0 g	0.0 f	3.2 ij	0.6 ij	0.0 j	0.4 l-o	1.5 h-l
+Secure	0.5 fl oz											
Secure	0.5 fl oz	14-d	0.0 j	0.0 f	1.3 fgh	0.0 g	0.0 f	0.4 ij	0.0 j	0.0 j	0.0 o	0.3 jkl
+Primo MAXX	0.125 fl oz											
Secure	0.5 fl oz	14-d	0.0 j	0.0 f	0.4 gh	0.0 g	0.2 f	0.5 ij	0.0 j	0.2 j	0.0 o	0.0 l
+Daconil Action	2.0 fl oz											
Secure	0.5 fl oz	14-d	0.0 j	0.0 f	0.9 fgh	0.0 g	0.0 f	0.0 j	0.0 j	0.0 j	0.0 o	0.5 i-l
Secure	0.5 fl oz	14-d	0.0 j	0.0 f	0.2 gh	0.0 g	0.0 f	0.0 j	0.0 j	0.0 j	0.0 o	0.3 jkl
+Sync	0.16 fl oz											
Daconil Action	2.0 fl oz	14-d	41.8 bcd	19.5 bc	33.6 cd	12.9 cd	7.2 e	78.4 bcd	69.4 b	133.8 b	27.6 b	35.6 b
Daconil Action	2.0 fl oz	14-d	36.9 cde	27.9 b	29.9 cd	22.2 c	7.8 e	86.3 bcd	32.4 cde	77.8 c	14.8 c	23.2 bc
+Sync	0.16 fl oz											
Sync	0.16 fl oz	14-d	78.2 ab	79.6 a	81.3 a	60.7 b	130.9 ab	268.0 a	305.1 a	372.2 a	74.2 a	69.4 a

Continued…

Table 2 *(cont.)* Dollar spot incidence and severity influenced by fungicides applied preventatively to a ‘Putter’ creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Int	Dollar Spot Incidence 4 Jul	12 Jul	19 Jul	29 Jul	7 Aug	14 Aug	23 Aug	30 Aug	Dollar Spot Severity 6 Sept	13 Sept
			# of spots 18ft^{-2}								% plot area blighted	
Curalan EG	1.0 oz	21-d	2.8 g-j	0.0 f	0.8 fgh	0.2 g	1.3 f	45.5 de	10.3 fgh	3.3 g-j	4.6 d-j	9.3 c-h
Encartis	4.0 fl oz	21-d	6.9 f-j	2.0 ef	1.7 fgh	0.4 fg	1.0 f	31.9 efg	9.9 f-i	1.7 g-j	1.5 i-o	3.4 f-l
Velista	0.5 oz	28-d	12.7 e-i	36.9 b	42.8 bc	1.7 fg	18.2 cd	114.8 b	55.1 bc	26.3 de	0.7 j-o	1.5 h-l
Emerald	0.18 oz	28-d	1.5 hij	5.8 c-f	8.3 efg	0.2 g	1.1 f	36.8 ef	32.2 cde	19.8 def	3.5 f-m	6.0 e-j
Xzemplar	0.26 fl oz	28-d	0.2 j	0.6 ef	4.0 e-h	0.0 g	0.2 f	10.1 g-j	2.7 g-j	0.2 j	0.5 l-o	2.0 g-l
Honor	1.1 oz	28-d	0.2 j	2.3 ef	6.1 e-h	0.0 g	0.2 f	6.7 hij	3.0 g-j	0.9 hij	1.3 i-o	2.6 g-l
Lexicon Intrinsic	0.46 fl oz	28-d	0.0 j	1.4 ef	2.8 fgh	0.2 g	0.0 f	3.9 hij	1.2 hij	0.4 ij	11.4 cd	17.3 cde
Torque	0.75 fl oz	14-d	0.6 ij	0.2 f	1.8 fgh	0.0 g	1.4 f	53.1cde	12.8 efg	11.3 e-h	5.6 d-i	10.3 c-g
+Spectro 90	3.6 oz											
+26/36	4.0 fl oz											
Torque	0.75 fl oz	14-d	0.0 j	0.0 f	0.0 h	0.0 g	0.0 f	0.5 ij	0.0 j	0.4 ij	0.6 k-o	3.1 f-l
+Spectro 90	3.6 oz											
+Anuew	0.09 oz[zy]											
+26/36	4.0 fl oz											
Torque	0.75 fl oz	14-d	0.5 ij	0.8 ef	0.0 h	0.0 g	0.0 f	0.0 j	0.0 j	1.1 hij	2.2 h-n	4.7 f-k
+Spectro 90	3.6 oz											
+Anuew	0.18 oz[z]											
+26/36	4.0 fl oz											
16-2-7	6.0 fl oz	14-d	68.8 abc	77.9 a	71.5 ab	73.2 ab	103.5 b	314.4 a	279.2 a	342.0 a	70.4 a	80.1 a
+6 Iron	2.0 fl oz											
+Impulse	2.0 fl oz											
+Phosphite 30	2.0 fl oz											
+Omega	0.36 fl oz[x]											
16-2-7	6.0 fl oz	14-d	26.0 def	15.0 bcd	16.3 de	8.3 de	0.8 f	21.4 e-h	9.1 f-i	41.5 d	9.4 c-f	18.5 cd
+6 Iron	2.0 fl oz											
+Impulse	2.0 fl oz											
+Phosphite 30	2.0 fl oz											
+Omega	0.36 fl oz[x]											
+Banner MAXX	0.5 fl oz											
Untreated			94.7 a	110.5 a	86.8 a	94.3 a	152.7 a	270.9 a	332.3 a	393.1 a	79.2 a	85.4 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	14	7	1	11	6	13	8	15	22	29
		21-d	21	7	14	4	13	21	8	15	22	29
		28-d	14	21	1	11	20	27	8	15	22	29

[z] Initial application of Anuew was made on 20 Jun.

[y] Anuew was initially applied at 10 times the intended rate on 20 Jun and 4 July. Thereafter, the rate was reduced to 0.09 fl oz 1000ft^{-2} beginning on 18 Jul.

[x] Carrier was buffered to a pH of 5.5 before addition of Omega. Other ingredients were added after the addition of Omega.

[w] Treatments were initiated on 23 May, prior to symptom development. Subsequent 14-d treatments were applied on 6 Jun, 20 Jun, 5 Jul, 18 Jul, 31 Jul, 15 Aug; 21-d treatments were applied on 15 Jun, 5 Jul, 25 Jul, 15 Aug; 28-d treatments were applied on 20 Jun, 18 Jul, and 15 Aug.

[v] Data were square-root transformed and means back calculated for presentation.

[u] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher’s protected least significant difference test ($\alpha = 0.05$).

[t] Data were arc-sin transformed and means back calculated for presentation.

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Table 3. Turf quality influenced by fungicides applied preventatively to a 'Putter' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft²	Int[w]	Turf Quality 5 Jun	21 Jun	5 Jul	19 Jul	29 Jul	14 Aug	30 Aug
			1-9; 6=min acceptable						
QP Enclave +Foursome	3.0 fl oz 0.4 fl oz	14-d	8.0 ab[v]	8.0 a	6.3 c-g	8.8 ab	7.3 b-e	7.5 cde	7.0 b-f
QP Enclave +Foursome	4.0 fl oz 0.4 fl oz	21-d	8.3 a	8.0 a	6.5 b-g	9.0 a	8.3 a	7.8 bcd	7.3 a-e
QP Enclave +QP Fosetyl-Al +Foursome	3.0 fl oz 4.0 oz 0.4 fl oz	14-d	8.3 a	8.0 a	8.3 a	9.0 a	7.8 abc	9.0 a	8.3 a
QP Enclave +QP Fosetyl-Al +Foursome	4.0 fl oz 4.0 oz 0.4 fl oz	21-d	8.0 ab	8.0 a	6.5 b-g	8.8 ab	8.0 ab	5.8 f-i	6.3 e-i
UC13-4	0.34 fl oz	14-d	7.3 cde	7.0 cde	6.5 b-g	8.3 a-d	7.0 c-f	8.3 abc	7.3 a-e
UC13-4	0.34 fl oz	21-d	7.3 cde	7.3 bcd	7.8 ab	8.8 ab	7.3 b-e	8.3 abc	7.5 a-d
UC13-5	0.3 oz	14-d	7.5 bcd	7.3 bcd	6.3 c-g	8.0 a-e	6.8 d-g	7.8 bcd	7.5 a-d
UC13-5	0.5 oz	14-d	7.0 de	7.0 cde	7.0 a-e	8.5 abc	7.8 abc	8.5 abc	7.5 a-d
UC13-5	0.5 oz	21-d	7.3 cde	7.3 bcd	5.8 e-i	8.0 a-e	7.0 c-f	5.3 hi	6.3 e-i
UC13-5 +Daconil Action	0.3 oz 2.0 fl oz	14-d	7.8 abc	7.0 cde	6.5 b-g	8.0 a-e	7.5 a-d	7.5 cde	7.5 a-d
UC13-5 +Daconil Action	0.5 oz 2.0 fl oz	14-d	7.3 cde	7.0 cde	7.5 abc	8.0 a-e	7.5 a-d	8.5 abc	7.5 a-d
UC13-5 +Daconil Action	0.5 oz 2.0 fl oz	21-d	7.8 abc	7.3 bcd	6.0 d-h	7.5 c-f	6.0 ghi	5.3 hi	5.0 jk
UC13-5 +Secure	0.3 oz 0.5 fl oz	14-d	7.3 cde	7.3 bcd	7.0 a-e	7.8 b-f	7.0 c-f	8.5 abc	8.3 a
UC13-5 +Secure	0.5 oz 0.5 fl oz	14-d	7.5 bcd	7.5 abc	7.5 abc	8.5 abc	7.5 a-d	8.8 ab	7.8 abc
UC13-5 +Secure	0.5 oz 0.5 fl oz	21-d	8.3 a	7.5 abc	7.5 abc	8.8 ab	7.8 abc	8.0 abc	7.8 abc
UC13-3 +Secure	0.236 fl oz 0.5 fl oz	21-d	7.3 cde	7.0 cde	7.0 a-e	8.5 abc	7.5 a-d	7.3 bcd	7.8 abc
Secure +Primo MAXX	0.5 fl oz 0.125 fl oz	14-d	7.8 abc	6.5 e	7.3 a-d	8.5 abc	7.5 a-d	8.3 abc	8.3 a
Secure +Daconil Action	0.5 fl oz 2.0 fl oz	14-d	7.3 cde	7.0 cde	7.3 a-d	6.3 ghi	6.5 e-h	7.8 bcd	7.8 abc
Secure	0.5 fl oz	14-d	7.8 abc	7.3 bcd	7.5 abc	8.0 a-e	7.3 b-e	8.5 abc	8.3 a
Secure +Sync	0.5 fl oz 0.16 fl oz	14-d	7.3 cde	7.8 ab	7.8 ab	8.5 abc	7.8 abc	8.3 abc	8.0 ab
Daconil Action	2.0 fl oz	14-d	7.3 cde	7.0 cde	4.8 c-f	6.8 b-f	5.8 hi	5.5 ghi	4.0 k
Daconil Action +Sync	2.0 fl oz 0.16 fl oz	14-d	7.5 bcd	7.3 bcd	5.5 a-e	6.8 b-f	5.8 hi	6.0 f-i	5.0 jk
Sync	0.16 fl oz	14-d	6.8 e	6.5 e	4.5 def	5.5 ef	4.5 k	3.5 j	2.5 l
Curalan EG	1.0 oz	21-d	7.0 de	6.5 e	6.3 c-g	7.0 a-f	6.3 f-i	6.8 def	6.5 d-h
Encartis	4.0 fl oz	21-d	7.5 bcd	7.3 bcd	6.8 b-f	8.3 a-d	7.0 c-f	6.5 efg	7.3 a-e
Velista	0.5 oz	28-d	7.0 de	7.0 cde	6.3 c-g	6.3 ghi	7.3 b-e	5.0 i	5.5 hij
Emerald	0.18 oz	28-d	7.3 cde	7.0 cde	7.0 a-e	7.5 c-f	7.0 c-f	6.8 def	6.0 f-j
Xzemplar	0.26 fl oz	28-d	7.0 de	7.0 cde	7.0 a-e	7.8 b-f	7.3 b-e	7.5 cde	6.5 d-h
Honor	1.1 oz	28-d	7.3 cde	7.3 bcd	6.8 b-f	7.8 b-f	7.0 c-f	7.5 cde	6.3 e-i
Lexicon Intrinsic	0.46 fl oz	28-d	7.0 de	6.8 de	7.8 ab	8.5 abc	7.5 a-d	7.8 bcd	7.5 a-d

Continued...

Table 3 *(cont)*. Turf quality influenced by fungicides applied preventatively to a 'Putter' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per $1000ft^2$	Int	Turf Quality 5 Jun	21 Jun	5 Jul	19 Jul	29 Jul	14 Aug	30 Aug
			------ 1-9; 6=min acceptable ------						
Torque	0.75 fl oz	14-d	7.3 cde	6.8 de	7.0 a-e	7.3 d-g	6.5 e-h	6.5 efg	6.3 e-i
+Spectro 90	3.6 oz								
+26/36	4.0 fl oz								
Torque	0.75 fl oz	14-d	7.0 de	6.5 e	3.0 k	3.8 j	4.8 jk	6.3 fgh	6.8 c-g
+Spectro 90	3.6 oz								
+Anuew	0.09 oz[zy]								
+26/36	4.0 fl oz								
Torque	0.75 fl oz	14-d	7.0 de	6.8 de	5.3 g-j	5.5 i	5.5 ij	6.0 f-i	5.8 g-j
+Spectro 90	3.6 oz								
+Anuew	0.18 oz[z]								
+26/36	4.0 fl oz								
16-2-7	6.0 fl oz	14-d	7.5 bcd	7.3 bcd	4.8 hij	5.8 hi	4.0 k	3.5 j	2.5 l
+6 Iron	2.0 fl oz								
+Impulse	2.0 fl oz								
+Phosphite 30	2.0 fl oz								
+Omega	0.36 fl oz[x]								
16-2-7	6.0 fl oz	14-d	7.0 de	7.3 bcd	5.5 f-j	7.0 efg	6.3 f-i	6.5 efg	5.3 ij
+6 Iron	2.0 fl oz								
+Impulse	2.0 fl oz								
+Phosphite 30	2.0 fl oz								
+Omega	0.36 fl oz[x]								
+Banner MAXX	0.5 fl oz								
Untreated		14-d	7.3 cde	7.3 bcd	4.3 jk	5.3 i	4.0 k	3.3 j	2.0 l
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	13	1	1	1	11	13	15
		21-d	13	7	1	14	4	21	15
		28-d	13	1	15	1	11	27	15

[z] Initial application of Anuew was made on 20 Jun.

[y] Anuew was initially applied at 10 times the intended rate on 20 Jun and 4 July. Thereafter, the rate was reduced to 0.09 fl oz $1000ft^{-2}$ beginning on 18 Jul.

[x] Carrier was buffered to a pH of 5.5 before addition of Omega. Other ingredients were mixed after the addition of Omega.

[w] Treatments were initiated on 23 May, prior to disease development. Subsequent 14-d treatments were applied on 6 Jun, 20 Jun, 5 Jul, 18 Jul, 31 Jul, 15 Aug; 21-d treatments were applied on 15 Jun, 5 Jul, 25 Jul, 15 Aug; 28-d treatments were applied on 20 Jun, 18 Jul, and 15 Aug.

[v] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

Table 4. Phytotoxicity influenced by fungicides applied preventatively to a 'Putter' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft²	Int[w]	Phytotoxicity							
			31 May	21 Jun	27 Jun	5 Jul	19 Jul	29 Jul	14 Aug	30 Aug
			0-5; 2=max acceptable							
QP Enclave	3.0 fl oz	14-d	0.0 c[v]	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Foursome	0.4 fl oz									
QP Enclave	4.0 fl oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Foursome	0.4 fl oz									
QP Enclave	3.0 fl oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+QP Fosetyl-Al	4.0 oz									
+Foursome	0.4 fl oz									
QP Enclave	4.0 fl oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+QP Fosetyl-Al	4.0 oz									
+Foursome	0.4 fl oz									
UC13-4	0.34 fl oz	14-d	0.0 c	0.0 e	0.3 de	0.0 d	0.0 e	0.0 c	0.0 c	0.0
UC13-4	0.34 fl oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
UC13-5	0.3 oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
UC13-5	0.5 oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
UC13-5	0.5 oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
UC13-5	0.3 oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Daconil Action	2.0 fl oz									
UC13-5	0.5 oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Daconil Action	2.0 fl oz									
UC13-5	0.5 oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Daconil Action	2.0 fl oz									
UC13-5	0.3 oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Secure	0.5 fl oz									
UC13-5	0.5 oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Secure	0.5 fl oz									
UC13-5	0.5 oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Secure	0.5 fl oz									
UC13-3	0.236 fl oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Secure	0.5 fl oz									
Secure	0.5 fl oz	14-d	2.0 a	0.5 c	0.8 c	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Primo MAXX	0.125 fl oz									
Secure	0.5 fl oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.3 de	0.0 c	0.0 c	0.0
+Daconil Action	2.0 fl oz									
Secure	0.5 fl oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Secure	0.5 fl oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
+Sync	0.16 fl oz									
Daconil Action	2.0 fl oz	14-d	0.0 c	0.0 e	0.3 de	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Daconil Action	2.0 fl oz	14-d	0.0 c	0.0 e	0.3 de	0.0 d	0.3 de	0.0 c	0.0 c	0.0
+Sync	0.16 fl oz									
Sync	0.16 fl oz	14-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Curalan EG	1.0 oz	21-d	0.0 c	0.3 d	0.3 de	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Encartis	4.0 fl oz	21-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Velista	0.5 oz	28-d	0.0 c	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Emerald	0.18 oz	28-d	0.0 c	0.0 e	0.5 cd	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Xzemplar	0.26 fl oz	28-d	0.0 c	0.3 d	0.0 de	0.0 d	0.3 de	0.0 c	0.0 c	0.0
Honor	1.1 oz	28-d	0.0 c	0.0 e	0.3 de	0.0 d	0.0 e	0.0 c	0.0 c	0.0
Lexicon Intrinsic	0.46 fl oz	28-d	0.5 b	0.0 e	0.0 e	0.0 d	0.0 e	0.0 c	0.0 c	0.0

Continued...

Table 4 *(cont)*. Phytotoxicity influenced by fungicides applied preventatively to a 'Putter' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft²	Int	Phytotoxicity							
			31 May	21 Jun	27 Jun	5 Jul	19 Jul	29 Jul	14 Aug	30 Aug
			---------- 0-5; 2=max acceptable ----------							
Torque	0.75 fl oz	14-d	0.0 c	0.0 d	0.5 cd	0.0 d	0.8 c	0.0 c	0.0 c	0.0
+Spectro 90	3.6 oz									
+26/36	4.0 fl oz									
Torque	0.75 fl oz	14-d	0.0 c	0.0 d	3.0 a	3.8 a	3.3 a	2.0 a	1.0 a	0.0
+Spectro 90	3.6 oz									
+Anuew	0.09 oz[zy]									
+26/36	4.0 fl oz									
Torque	0.75 fl oz	14-d	0.0 c	0.0 d	2.3 b	2.6 b	2.3 b	1.5 b	1.0 a	0.0
+Spectro 90	3.6 oz									
+Anuew	0.18 oz[z]									
+26/36	4.0 fl oz									
16-2-7	6.0 fl oz	14-d	0.0 c	0.8 b	0.0 e	0.0 d	0.3 de	0.0 c	0.0 c	0.0
+6 Iron	2.0 fl oz									
+Impulse	2.0 fl oz									
+Phosphite 30	2.0 fl oz									
+Omega	0.36 fl oz[x]									
16-2-7	6.0 fl oz	14-d	0.0 c	1.0 a	0.0 e	0.5 c	0.5 cd	0.0 c	0.3 b	0.0
+6 Iron	2.0 fl oz									
+Impulse	2.0 fl oz									
+Phosphite 30	2.0 fl oz									
+Omega	0.36 fl oz[x]									
+Banner MAXX	0.5 fl oz									
Untreated		14-d	0.0 c	0.0 d	0.0 e	0.0 d	0.3 de	0.0 c	0.0 c	0.0
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	1.0000
Days after treatment		14-d	8	1	7	1	1	11	13	15
		21-d	8	7	14	1	14	4	21	15
		28-d	8	1	7	15	1	11	27	15

[z] Initial application of Anuew was made on 20 Jun.

[y] Anuew was initially applied at 10 times the intended rate on 20 Jun and 4 July. Thereafter, the rate was reduced to 0.09 fl oz 1000ft^{-2} beginning on 18 Jul.

[x] Carrier was buffered to a pH of 5.5 before addition of Omega. Other ingredients were mixed after the addition of Omega.

[w] Treatments were initiated on 23 May, prior to disease development. Subsequent 14-d treatments were applied on 6 Jun, 20 Jun, 5 Jul, 18 Jul, 31 Jul, 15 Aug; 21-d treatments were applied on 15 Jun, 5 Jul, 25 Jul, 15 Aug; 28-d treatments were applied on 20 Jun, 18 Jul, and 15 Aug.

[v] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

PREVENTIVE DOLLAR SPOT CONTROL USING NEW AND EXISTING FUNGICIDE FORMULATIONS ON A CREEPING BENTGRASS FAIRWAY TURF, 2013

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INTRODUCTION

Formulation chemistry can have a significant impact on the performance of fungicides used for control of turfgrass diseases. Potential impacts extend beyond disease control, possibly affecting phytosafety, compatibility with other materials in tank mixes, and pesticide applicator exposure. Therefore, new fungicide formulations should be tested prior to commercial release to evaluate performance under controlled conditions. The objective of this trial was to assess dollar spot efficacy, creeping bentgrass phytosafety, and tank mix compatibility of newly formulated fungicides applied at various application rates and intervals.

MATERIALS & METHODS

A field study was conducted on an 'L-93' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage dollar spot development. A total of 1.0 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through July. Acelepyrn was applied on 22 June for the control of white grubs and surface feeding caterpillars. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new fungicide formulations and currently available products applied individually, or as tank mixes. Initial applications were made on 23 May prior to disease developing in the trial area. Subsequent applications were made at specified treatment intervals through 24 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. All treatment applications of UC13-8 from 23 May through 3 July were from lot #: JMO4242013; UC13-8 treatments applied on 24 July were from lot #: JMO5312013.

Dollar spot incidence was assessed as a count of individual disease foci within each plot from 24 May to 29 July. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Dollar spot incidence data were square-root transformed for ANOVA and mean separation tests, although means presented are back-calculated values.

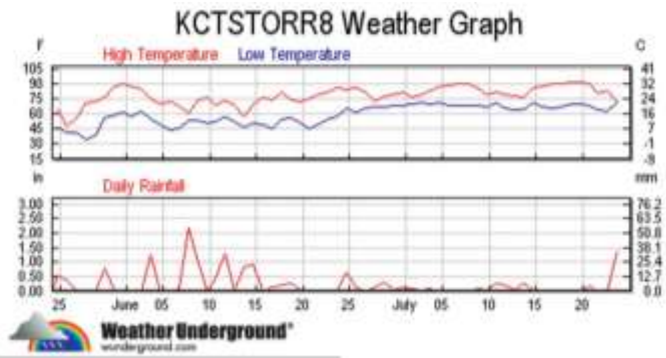

Fig. 1. High and low temperatures and daily rainfall in Storrs, CT during 24 May to 24 July 2013.

RESULTS

Dollar Spot Incidence

Dollar spot pressure was high during late-June and early-July when warm overnight temperatures and increased relative humidity persisted (Fig. 1). Initial dollar spot symptoms developed in the trial from a natural infestation on 24 May, although disease was limited until late-June (Table 1). Most treatments provided good dollar spot control through mid-June (Table 1). However, low rates of UC13-9 (1.34 & 2.68 fl.oz.), Daconil Ultrex (0.81 & 1.63 oz.), Torque, and Alude applied on a 21-d interval failed to improve dollar spot control compared to untreated turf by 27 June.

Highly favorable environmental conditions for dollar spot occurring at the end of the 14- and 21-d reapplication interval resulted in most treatments in this trial providing unacceptable dollar spot control on 4 July (Table 1). During this period of high dollar spot pressure, Secure applied every 14-d resulted in excellent dollar spot control. Good control was provided by the high rate of UC13-7 (1.47 fl.oz.) applied every 28-d, and acceptable disease control was observed in UC13-9 (5.36 fl.oz.) and Daconil Ultrex (3.25 oz.) applied every 14-d; UC13-7 (1.47 fl.oz.), 26GT+UC13-8, Curalan+UC13-8, and Torque+UC13-8 every 21-d; and Emerald (0.18 oz.) applied every 28-d. Interestingly, the addition of UC13-8 as a tank mix partner with 26GT, or Torque improved efficacy of the latter products applied on a 21-d interval.

By late-July (29 July) dollar spot incidence decreased in many treatments following reapplication of 14-, 21-, and 28-d intervals (Table 1). Few statistical differences between top performing treatments were observed at that time (Table 1). However, near complete control of dollar spot (≤ 5 foci $plot^{-1}$; excellent) was achieved with the high rate of UC13-7 (1.47 fl.oz.) applied every 28- or 21-d, 26GT+UC13-8, Banner

MAXX (2.0 fl.oz.), and Emerald (0.18 oz.) applied every 21-d, and Daconil Ultrex (3.25 oz.) and Secure applied every 14-d.

Turf Quality and Phytotoxicity

Turf quality in the trial was predominantly influenced by dollar spot incidence and phytotoxicity. All treatments provided good turf quality in early-June (13 DAIT) (Table 2), prior to significant dollar spot development and increased temperatures. However slight, albeit acceptable (≤ 2 on 0-5 scale), phytotoxicity (light green turf color) was observed in plots treated with UC13-8 (Table 3) during moderate temperatures throughout June.

Temperatures increased during late June and July (Fig. 1). Concurrently, a significant increase in phytotoxicity of creeping bentgrass turf treated with UC13-8 alone or in tank mixes with other fungicides was evident compared to untreated on 4 July, one day after application (Table 3). Phytotoxicity was considered unacceptable, appearing as chlorotic to bronze, thinned turf (Fig. 2). However, damage appeared to be masked when UC13-8 was tank mixed with Par, a green pigmented spray indicator.

Only turf treated with UC13-7 (1.47 fl.oz.) every 21- or 28-d, Emerald (0.18 oz.) every 21-d, or Secure every 14-d provided acceptable turf quality throughout the trial (Table 2).

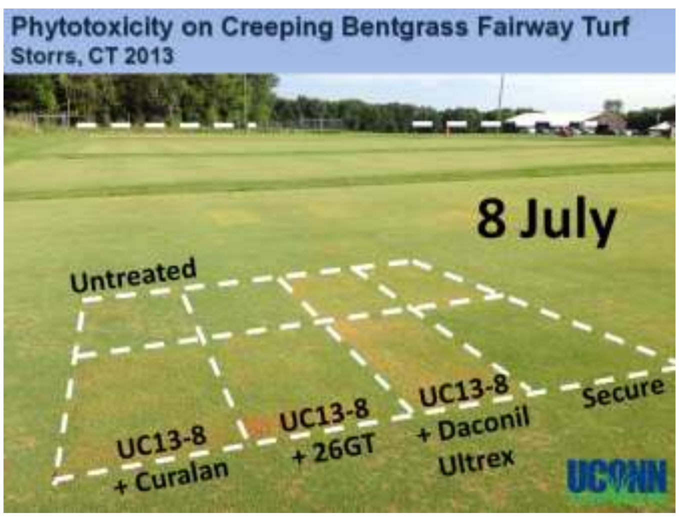

Fig. 2. Phytotoxicity of 'L-93' creeping bentgrass during high temperatures on 8 July 2013, 5 days after treatment.

DISCUSSION

The high rate (1.47 fl.oz.) of UC13-7 applied every 28-d provided good dollar spot control throughout this trial; including at the peak of the epidemic on 4 July. However, this date corresponded to 15 days after the last application of the 28-d interval. Conversely, the same rate of UC13-7 applied every 21-d did not provide acceptable dollar spot control on this date, presumably because the increased disease pressure coincided with the end of the 21-d reapplication interval. Therefore, UC13-7 probably would not likely provide acceptable dollar spot control when applied at the high rate on a 28-d interval during sustained high disease pressure. A 21-d interval at that rate would provide more consistent acceptable disease control.

UC13-9 and Daconil Ultrex failed to provide acceptable dollar spot control when applied on a 14- or 21-d interval, regardless of rate. Daconil Ultrex is a contact fungicide, and typically does provide disease control greater than 14 days, due to turf growth and breakdown of the fungicide on the surface of the plant. The high rate of both UC13-9 and Daconil Ultrex applied every 14-d did provide good control of dollar spot in this trial, although Secure, a new contact fungicide, provided significantly improved control on a 14-d interval.

Severe phytotoxicity occurred to UC13-8 treated turf when applied alone or as a tank mix during increased temperatures (85 F / 70 F; day / night). Both discoloration and turf thinning observed in these treatments resulted in unacceptable turf quality. Some discoloration also occurred at lower temperatures, although the use of pigmented spray pattern indicators could effectively mask yellowing under cooler temperatures.

Table 1. Dollar spot incidence influenced by new and existing formulations of fungicides on an ‘L-93’ creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per $1000ft^2$	Int[z]	Dollar Spot Incidence 24 May	31 May	6 Jun	16 Jun	21 Jun	27 Jun	4 Jul	29 Jul
			# of spots $18ft^{-2}$							
UC13-7	0.367 fl oz	21-d	0.2[y]	3.9	2.0 ab[x]	4.3 bcd	1.9 b-e	12.9 c-g	125.9 a-g	54.9 f-m
UC13-7	0.735 fl oz	21-d	0.7	2.1	0.0 b	2.6 cd	0.2 de	2.4 efg	92.6 c-k	27.9 i-o
UC13-7	1.47 fl oz	21-d	0.6	5.4	0.0 b	3.3 bcd	1.6 b-e	1.4 efg	46.2 h-n	0.8 o
UC13-7	0.367 fl oz	28-d	0.4	1.7	0.7 b	1.8 d	1.1 b-e	3.1 efg	72.6 e-m	44.3 g-n
UC13-7	0.735 fl oz	28-d	0.4	3.4	0.2 b	3.4 bcd	1.7 b-e	2.8 efg	65.8 f-m	32.4 h-o
UC13-7	1.47 fl oz	28-d	0.4	2.8	0.0 b	1.0 d	0.8 b-e	0.0 g	10.5 n	4.1 no
Banner MAXX	1.0 fl oz	21-d	0.9	3.9	2.7 ab	3.9 bcd	0.4 cde	14.8 c-g	120.1 a-h	21.9 j-o
Banner MAXX	2.0 fl oz	21-d	1.3	8.2	0.2 b	3.4 bcd	0.4 cde	2.2 efg	67.2 f-m	3.1 no
Emerald	0.13 oz	21-d	0.7	3.6	0.6 b	1.8 d	1.0 b-e	8.3 c-g	118.1 a-h	17.2 k-o
Emerald	0.18 oz	21-d	1.2	3.7	0.9 ab	2.9 cd	0.2 de	2.6 efg	81.4 d-m	1.6 o
Emerald	0.18 oz	28-d	1.9	7.8	0.6 b	4.3 bcd	1.4 b-e	1.9 efg	34.6 j-n	10.2 l-o
UC13-9	1.34 fl oz	14-d	1.2	5.0	3.6 ab	5.4 bcd	2.2 a-e	7.0 d-g	154.9 a-f	175.6 a-d
UC13-9	2.68 fl oz	14-d	0.2	3.8	1.7 ab	2.3 cd	1.0 b-e	2.4 efg	106.5 b-i	75.5 c-k
UC13-9	5.36 fl oz	14-d	0.6	2.5	0.4 b	1.5 d	0.8 b-e	0.5 g	33.9 j-n	7.7 l-o
Daconil Ultrex	0.8125 oz	14-d	0.4	3.4	4.4 ab	14.7 abc	8.6 ab	11.1 c-g	225.0 a	188.5 abc
Daconil Ultrex	1.625 oz	14-d	2.4	4.1	2.4 ab	3.4 bcd	3.6 a-e	3.4 efg	138.5 a-g	110.2 a-h
Daconil Ultrex	3.25 oz	14-d	0.5	2.2	0.0 b	0.8 d	0.7 b-e	0.0 g	29.0 lmn	2.9 no
UC13-9	1.34 fl oz	21-d	1.8	10.4	7.4 a	25.4 a	7.9 abc	74.3 a	228.6 a	209.4 ab
UC13-9	2.68 fl oz	21-d	0.4	2.3	0.5 b	4.3 bcd	1.4 b-e	20.6 b-e	149.0 a-f	152.7 a-f
UC13-9	5.36 fl oz	21-d	0.5	4.4	0.4 b	5.5 bcd	0.4 cde	4.0 efg	158.4 a-e	125.9 a-g
Daconil Ultrex	0.8125 oz	21-d	1.6	3.9	7.6 a	16.6 ab	10.7 a	74.4 a	182.6 abc	203.2 ab
Daconil Ultrex	1.625 oz	21-d	0.8	2.8	0.9 ab	6.0 bcd	2.6 a-e	34.7 bc	197.1 ab	162.1 a-e
Daconil Ultrex	3.25 oz	21-d	0.6	1.6	0.2 b	1.3 d	0.6 b-e	8.4 c-g	136.5 a-g	89.7 b-j
UC13-8	8.0 fl oz	21-d	0.9	1.9	3.5 ab	8.9 bcd	1.9 b-e	8.0 c-g	95.8 b-k	125.4 a-g
UC13-8	8.0 fl oz	21-d	1.3	3.0	0.7 b	4.8 bcd	0.0 e	11.2 c-g	117.4 a-h	124.8 a-g
+UC13-9	2.68 fl oz									
UC13-8	8.0 fl oz	21-d	0.2	2.7	0.0 b	2.0 d	0.6 b-e	1.1 efg	88.7 c-l	69.3 d-k
+UC13-9	5.36 fl oz									
UC13-8	8.0 fl oz	21-d	1.5	3.9	1.3 ab	4.9 bcd	0.4 cde	7.7 c-g	136.3 a-g	137.9 a-g
+Daconil Ultrex	1.625 oz									
UC13-8	8.0 fl oz	21-d	0.6	3.4	0.4 b	3.2 bcd	0.6 b-e	2.5 efg	99.6 b-j	97.1 b-i
+Daconil Ultrex	3.25 oz									
26GT	3.0 fl oz	21-d	0.9	3.1	0.5 b	0.6 d	0.2 de	8.4 c-g	94.8 b-k	18.9 k-o
26GT	3.0 fl oz	21-d	0.8	2.8	0.2 b	2.3 cd	0.4 cde	0.5 g	27.6 mn	5.2 mno
+UC13-8	8.0 fl oz									
Curalan	1.0 oz	21-d	0.0	3.1	0.9 ab	3.3 bcd	0.0 e	0.2 g	56.2 g-m	6.0 mno
Curalan	1.0 oz	21-d	1.1	1.7	0.2 b	3.9 bcd	0.9 b-e	0.2 g	31.8 k-n	17.4 k-o
+UC13-8	8.0 fl oz									
Torque	0.6 fl oz	21-d	0.4	2.4	1.8 ab	4.5 bcd	0.9 b-e	19.7 b-f	121.3 a-h	25.2 i-o
Torque	0.6 fl oz	21-d	1.4	4.4	0.2 b	3.8 bcd	0.4 cde	0.8 fg	42.0 i-n	46.2 g-n
+UC13-8	8.0 fl oz									
Alude	3.0 fl oz	21-d	0.4	5.1	4.7 ab	5.1 bcd	4.1 a-e	33.8 bcd	176.1 a-d	180.9 a-d
Alude	3.0 fl oz	21-d	0.4	3.7	1.7 ab	2.9 cd	0.6 b-e	4.3 efg	92.5 c-k	99.2 a-i
+UC13-8	8.0 fl oz									
UC13-8	8.0 fl oz	21-d	1.2	6.6	1.1 ab	2.0 d	0.2 de	3.6 efg	70.1 e-m	59.4 e-l
+Par	0.37 fl oz									
UC13-8	8.0 fl oz	21-d	0.9	4.6	4.4 ab	5.6 bcd	0.2 de	6.3 efg	128.8 a-g	91.1 b-j
+Daconil Ultrex	3.25 oz									
+Par	0.37 fl oz									
Secure	0.5 fl oz	14-d	2.0	4.5	0.4 b	1.1 d	0.7 b-e	0.0 g	0.2 o	0.0 o
Untreated			0.4	3.0	7.3 a	14.3 abc	7.7 a-d	44.8 ab	177.3 a-d	226.1 a
ANOVA: Treatment (P > F)			0.3905	0.5269	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	1	8	1	10	2	8	1	12
		21-d	1	8	14	4	8	14	1	5
		28-d	1	8	14	24	2	8	15	12

[z]Treatments were initiated on 23 May, prior to disease development. Subsequent 14-d treatments were applied on 5 Jun, 19 Jun, 3 Jul, 16 Jul; 21-d treatments were applied on 12 Jun, 3 Jul, 24 Jul; 28-d treatments were applied on 19 Jun and 16 Jul.

[y]Data were square-root transformed; means presented are back calculated

[x]Treatment means followed by the same letter, within each column, are not significantly different based on the Student-Newman-Kewls test (α = 0.05).

Table 2. Turf quality influenced by new and existing formulations of fungicides on an 'L-93' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Int[z]	Turf Quality 5 Jun	21 Jun	4 Jul	29 Jul
			------------- 1-9; 6=min acceptable	-------------		
UC13-7	0.367 fl oz	21-d	7.3 ab[y]	6.8 abc	4.0 e-j	4.3 ghi
UC13-7	0.735 fl oz	21-d	7.5 ab	6.8 abc	4.5 c-i	5.8 bcd
UC13-7	1.47 fl oz	21-d	6.8 ab	6.0 abc	6.0 bc	6.8 a
UC13-7	0.367 fl oz	28-d	7.3 ab	6.5 abc	4.5 c-i	5.5 cde
UC13-7	0.735 fl oz	28-d	7.3 ab	7.0 ab	5.5 b-e	5.3 def
UC13-7	1.47 fl oz	28-d	7.3 ab	6.8 abc	6.3 b	6.5 ab
Banner MAXX	1.0 fl oz	21-d	7.0 ab	6.3 abc	4.3 d-j	5.5 cde
Banner MAXX	2.0 fl oz	21-d	6.8 ab	5.8 bc	5.3 b-f	6.3 abc
Emerald	0.13 oz	21-d	7.3 ab	7.0 ab	4.5 c-i	6.0 a-d
Emerald	0.18 oz	21-d	6.8 ab	6.5 abc	4.8 b-h	6.3 abc
Emerald	0.18 oz	28-d	6.8 ab	6.3 abc	6.0 bc	6.3 abc
UC13-9	1.34 fl oz	14-d	7.5 ab	6.3 abc	3.5 g-j	3.8 h-k
UC13-9	2.68 fl oz	14-d	7.0 ab	6.8 abc	4.5 c-i	4.5 fgh
UC13-9	5.36 fl oz	14-d	7.5 ab	7.0 ab	5.8 bcd	6.0 a-d
Daconil Ultrex	0.8125 oz	14-d	7.8 ab	6.0 abc	3.5 g-j	3.3 jk
Daconil Ultrex	1.625 oz	14-d	7.3 ab	6.3 abc	3.8 f-j	4.3 ghi
Daconil Ultrex	3.25 oz	14-d	7.0 ab	6.3 abc	5.8 bcd	6.0 a-d
UC13-9	1.34 fl oz	21-d	7.5 ab	6.0 abc	3.0 ij	3.3 jk
UC13-9	2.68 fl oz	21-d	8.0 a	7.5 a	3.8 f-j	3.8 h-k
UC13-9	5.36 fl oz	21-d	7.8 ab	6.8 abc	4.0 e-j	4.3 ghi
Daconil Ultrex	0.8125 oz	21-d	7.5 ab	5.8 bc	3.5 g-j	4.3 ghi
Daconil Ultrex	1.625 oz	21-d	7.5 ab	6.5 abc	3.8 f-j	3.5 ijk
Daconil Ultrex	3.25 oz	21-d	7.8 ab	7.5 a	4.0 e-j	4.5 fgh
UC13-8	8.0 fl oz	21-d	6.3 b	5.8 bc	2.8 j	4.5 fgh
UC13-8	8.0 fl oz	21-d	6.3 b	5.5 bc	3.0 ij	4.3 ghi
+UC13-9	2.68 fl oz					
UC13-8	8.0 fl oz	21-d	6.8 ab	5.8 bc	3.8 f-j	4.8 efg
+UC13-9	5.36 fl oz					
UC13-8	8.0 fl oz	21-d	6.5 ab	5.8 bc	2.8 j	4.0 g-j
+Daconil Ultrex	1.625 oz					
UC13-8	8.0 fl oz	21-d	7.0 ab	5.3 c	2.8 j	4.3 ghi
+Daconil Ultrex	3.25 oz					
26GT	3.0 fl oz	21-d	7.5 ab	7.0 ab	5.0 b-g	5.8 bcd
26GT	3.0 fl oz	21-d	6.8 ab	5.8 bc	3.3 hij	5.5 cde
+UC13-8	8.0 fl oz					
Curalan	1.0 oz	21-d	7.5 ab	6.8 abc	5.3 b-f	6.5 ab
Curalan	1.0 oz	21-d	6.5 ab	6.0 abc	3.3 hij	5.5 cde
+UC13-8	8.0 fl oz					
Torque	0.6 fl oz	21-d	6.8 ab	6.3 abc	4.3 d-j	5.3 def
Torque	0.6 fl oz	21-d	6.8 ab	5.3 c	2.8 j	4.8 efg
+UC13-8	8.0 fl oz					
Alude	3.0 fl oz	21-d	7.0 ab	6.8 abc	3.3 hij	3.3 jk
Alude	3.0 fl oz	21-d	6.5 ab	6.5 abc	3.8 f-j	4.5 fgh
+UC13-8	8.0 fl oz					
UC13-8	8.0 fl oz	21-d	7.5 ab	6.5 abc	4.5 c-i	4.8 efg
+Par	0.37 fl oz					
UC13-8	8.0 fl oz	21-d	7.8 ab	7.0 ab	3.8 f-j	4.3 ghi
+Daconil Ultrex	3.25 oz					
+Par	0.37 fl oz					
Secure	0.5 fl oz	14-d	7.3 ab	6.5 abc	7.8 a	6.5 ab
Untreated			7.3 ab	6.3 abc	3.5 g-j	3.0 k
ANOVA: Treatment (P > F)			0.0004	0.0001	0.0001	0.0001
Days after treatment		14-d	13	2	1	12
		21-d	13	8	1	5
		28-d	13	2	15	12

[z]Treatments were initiated on 23 May, prior to disease development. Subsequent 14-d treatments were applied on 5 Jun, 19 Jun, 3 Jul, 16 Jul; 21-d treatments were applied on 12 Jun, 3 Jul, 24 Jul; 28-d treatments were applied on 19 Jun and 16 Jul.

[y]Treatment means followed by the same letter, within each column, are not significantly different based on the Student-Newman-Kewls test ($\alpha = 0.05$).

Table 3. Phytotoxicity influenced by new and existing formulations of fungicides on an ‘L-93’ creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2013.

			Phytotoxicity				
Treatment	Rate per 1000ft²	Int[z]	5 Jun	21 Jun	27 Jun	4 Jul	29 Jul
			-------------------- 0-5; 2=max acceptable ------------------				
UC13-7	0.367 fl oz	21-d	0.0 b[y]	0.0 b	0.0 b	0.0 e	0.0 g
UC13-7	0.735 fl oz	21-d	0.3 ab	0.0 b	0.0 b	0.0 e	0.0 g
UC13-7	1.47 fl oz	21-d	0.3 ab	0.5 b	0.0 b	0.0 e	0.0 g
UC13-7	0.367 fl oz	28-d	0.3 ab	0.0 b	0.0 b	0.0 e	0.0 g
UC13-7	0.735 fl oz	28-d	0.3 ab	0.0 b	0.0 b	0.0 e	0.0 g
UC13-7	1.47 fl oz	28-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
Banner MAXX	1.0 fl oz	21-d	0.5 ab	0.0 b	0.0 b	0.0 e	0.0 g
Banner MAXX	2.0 fl oz	21-d	0.5 ab	0.5 b	0.0 b	0.0 e	0.0 g
Emerald	0.13 oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.3 fg
Emerald	0.18 oz	21-d	0.8 ab	0.3 b	0.3 b	0.0 e	0.3 fg
Emerald	0.18 oz	28-d	0.8 ab	0.3 b	0.0 b	0.0 e	0.3 fg
UC13-9	1.34 fl oz	14-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
UC13-9	2.68 fl oz	14-d	0.3 ab	0.0 b	0.0 b	0.0 e	0.0 g
UC13-9	5.36 fl oz	14-d	0.0 b	0.0 b	0.0 b	0.0 e	0.3 fg
Daconil Ultrex	0.8125 oz	14-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
Daconil Ultrex	1.625 oz	14-d	0.0 b	0.3 b	0.0 b	0.0 e	0.0 g
Daconil Ultrex	3.25 oz	14-d	0.0 b	0.0 b	0.0 b	0.0 e	0.8 d-g
UC13-9	1.34 fl oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
UC13-9	2.68 fl oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
UC13-9	5.36 fl oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
Daconil Ultrex	0.8125 oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
Daconil Ultrex	1.625 oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
Daconil Ultrex	3.25 oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
UC13-8	8.0 fl oz	21-d	1.0 ab	2.0 a	1.3 a	4.3 ab	2.0 abc
UC13-8 +UC13-9	8.0 fl oz 2.68 fl oz	21-d	0.8 ab	1.3 b	0.8 ab	4.0 ab	1.3 cde
UC13-8 +UC13-9	8.0 fl oz 5.36 fl oz	21-d	0.8 ab	0.3 b	0.8 ab	3.0 c	1.3 cde
UC13-8 +Daconil Ultrex	8.0 fl oz 1.625 oz	21-d	0.8 ab	0.5 b	1.5 a	4.3 ab	2.3 ab
UC13-8 +Daconil Ultrex	8.0 fl oz 3.25 oz	21-d	0.3 ab	0.5 b	0.8 ab	4.3 ab	1.0 def
26GT	3.0 fl oz	21-d	0.0 b	0.3 b	0.0 b	0.0 e	0.0 g
26GT +UC13-8	3.0 fl oz 8.0 fl oz	21-d	1.0 b	0.8 b	0.3 b	3.5 bc	1.5 bcd
Curalan	1.0 oz	21-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
Curalan +UC13-8	1.0 oz 8.0 fl oz	21-d	1.3 a	1.0 b	0.8 b	4.0 ab	2.5 a
Torque	0.6 fl oz	21-d	0.3 ab	0.0 b	0.0 b	0.0 e	0.5 efg
Torque +UC13-8	0.6 fl oz 8.0 fl oz	21-d	0.8 ab	2.5 a	1.5 a	4.5 a	2.5 a
Alude	3.0 fl oz	21-d	0.5 ab	0.0 b	0.0 b	0.0 e	0.3 fg
Alude +UC13-8	3.0 fl oz 8.0 fl oz	21-d	0.5 ab	0.3 b	0.3 b	3.8 ab	2.0 abc
UC13-8 +Par	8.0 fl oz 0.37 fl oz	21-d	0.0 b	0.0 b	0.0 b	0.5 e	0.8 d-g
UC13-8 +Daconil Ultrex +Par	8.0 fl oz 3.25 oz 0.37 fl oz	21-d	0.0 b	0.0 b	0.0 b	2.0 d	0.5 efg
Secure	0.5 fl oz	14-d	0.0 b	0.0 b	0.0 b	0.0 e	0.0 g
Untreated			0.0 b	0.3 b	0.0 b	0.0 e	0.0 g
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	13	2	8	1	12
		21-d	13	8	14	1	5
		28-d	13	2	8	15	12

[z]Treatments were initiated on 23 May, prior to disease development. Subsequent 14-d treatments were applied on 5 Jun, 19 Jun, 3 Jul, 16 Jul; 21-d treatments were applied on 12 Jun, 3 Jul, 24 Jul; 28-d treatments were applied on 19 Jun and 16 Jul.

[y]Treatment means followed by the same letter, within each column, are not significantly different based on the Student-Newman-Kewls test ($\alpha = 0.05$).

CURATIVE DOLLAR SPOT CONTROL USING NEW AND EXISTING FUNGICIDE FORMULATIONS ON A CREEPING BENTGRASS FAIRWAY TURF, 2013

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INTRODUCTION

Dollar spot (caused by *Sclerotinia homoeocarpa*) is a common disease of golf course fairway turf occurring from May to October throughout New England. Control of this disease is achieved through integrated management plans utilizing improved bentgrass varieties, cultural, and chemical approaches. However, when environmental conditions are particularly favorable for dollar spot development, the disease may occur despite preventive management. In these cases, curative fungicide applications are required to arrest the disease and prevent further turf loss. The objective of this study was to evaluate the curative efficacy of new and commonly used fungicides against *S. homoeocarpa*.

MATERIALS & METHODS

A field study was conducted on an 'L-93' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage disease development. A total of 1.0 lb 1000-ft^{-2} was applied as water soluble sources between 24 April and 15 June, thereafter no further nitrogen was applied to the study area prior to the initiation of treatments. Acelepryn was applied on 22 June for the control of white grubs and surface feeding caterpillars. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new and currently available fungicides. Initial applications were made on 30 August after disease had developed, and repeated 14-d later. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi. Nitrogen was applied at a rate of 0.5 lbs 1000-ft^{-2} on 31 August to assist with turf recovery. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Aerial mycelium was visually assessed the morning of 3 Sept on a 0 to 5 scale, where 0 represented no visible mycelium and 5 represented abundant dense, white aerial mycelium in all infection centers. Dollar spot severity was assessed as a percentage of the plot area blighted by disease from 3 Sept to 27 Sept. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

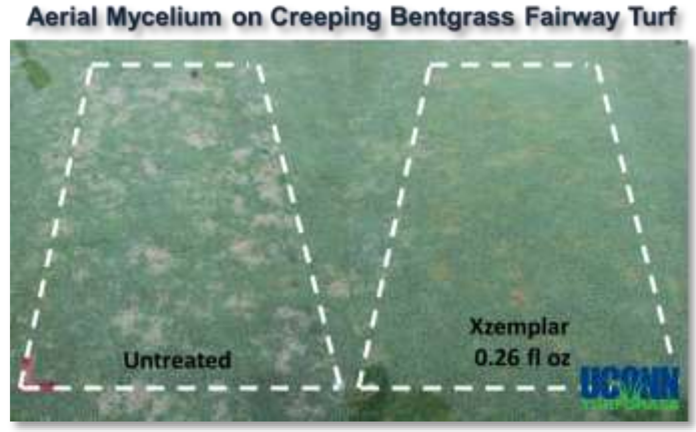

Fig. 1. Aerial mycelium on untreated and Xzemplar (0.26 fl oz) treated turf 4 days after initial treatment.

RESULTS

Dollar spot had developed uniformly throughout the study area prior to the initiation of the trial. Plot area blighted was approximately 50% when initial applications were made, and disease pressure remained high throughout the trial providing a rigorous assessment of curative control.

Four days after the initial treatment (DAIT; 3 Sept) all treatments resulted in a reduction in aerial mycelium relative to untreated plots (Table 1). QP Enclave and both rates of Xzemplar resulted in the greatest reduction; completely, or near completely eliminating visible mycelium (Fig. 1). Emerald and Velista were less effective at suppressing aerial mycelium than Xzemplar 4 DAIT. Secure and Daconil WeatherStik also substantially reduced mycelium. On the same date, QP Enclave, Xzemplar, Secure, Daconil WeatherStik, and Velista (0.5 oz) reduced disease by 50% or more (Table 1).

By 7 DAIT (6 Sept), Xzemplar and Secure each provided acceptable dollar spot control (i.e., < 5%), reducing disease from ~50% to ≤ 5% in only 7 days. QP Enclave and 26GT also reduced disease to less than 10% on this date. However by 10 DAIT (9 Sept),dollar spot in these treatments as well as Velista (0.5 oz), QP Ipro 2SE, and Daconil WeatherStik began to increase; suggesting that a shorter re-application interval may be necessary when using these fungicides curatively.

At 14 DAIT (13 Sept), Xzemplar was the only fungicide to provide acceptable dollar spot control (i.e., < 5%) with the high rate (0.26 fl oz) providing near complete control. Disease increased in most treatments at this time as residual fungicide activity decreased at the end of the application interval. Secure-treated turf had a slight disease increase although, still remained under 10% turf area blighted. All other treatments provided unacceptable levels of control at this time, with

Daconil WeatherStik and Velista (0.3 oz) increasing to over 40% diseased turf.

After a re-application of fungicides (13 Sept), recovery occurred in all treatments 11 days later (24 Sept). Velista (0.5 oz), Xzemplar, 26GT, QP Ipro 2SE, Secure, and QP Enclave all provided acceptable dollar spot control (< 5%). On the last observation date (27 Sept), disease increased to unacceptable levels in all plots except Xzemplar, 26GT, Secure, and QP Enclave. Interestingly, 26GT provided better disease control than an equivalent amount of the same active ingredient applied as QP Ipro 2SE on this date

DISCUSSION

Xzemplar is a new succinate dehydrogenase inhibitor (SDHI) fungicide, and its ability to act quickly as a curative fungicide was significantly better in this study when compared to other SDHI fungicides such as Emerald and Velista. Just four days after initial treatment, Xzemplar plots exhibited almost no visible mycelium, and by 7 DAIT the percentage of blighted turf had decreased from approximately 50% to ≤ 5%. Conversely, Emerald and the low rate of Velista, still contained over 20% blighted turf after the same time period. Emerald and Velista have been demonstrated to provide effective preventive dollar spot control; however they appear to be less effective than Xzemplar when applied curatively.

Secure treated turf exhibited more aerial mycelium than Xzemplar-treated plots (4 DAIT), although both fungicides provided excellent curative disease control within 7 DAT in the current trial. Moreover, Secure, a new contact fungicide with a multi-site mode of action, provided significantly better dollar spot control compared to the contact fungicide Daconil WeatherStik.

QP Enclave provided the greatest initial suppression of aerial mycelium and initially reduced disease; however 10 DAIT disease began to increase again. Similar disease increases were observed among all treatments except Xzemplar by 14 DAIT. These data suggest that in order to curatively control disease outbreaks a follow up application 7 to10 days after an initial fungicide application may be necessary to adequately arrest the disease epidemic.

The rate of recovery of all treatments was likely improved by the application of 0.5 lbs 1000-ft^{-2} of water soluble nitrogen the day after initial treatments were made. Turf managers curatively treating dollar spot outbreaks should consider shorter application intervals (i.e., 7 to10-d) and at least a 0.25 N 1000-ft^{-2} applied as a water soluble source for the quickest recovery.

Table 1. Dollar spot aerial mycelium and severity affected by various fungicides on ‘L-93’ creeping bentgrass fairway turf at the Plant Science Research Facility in Storrs, CT during 2013.

		Aerial Mycelium	Dollar Spot Severity					
Treatment[z]	Rate per 1000ft^2	3 Sept	3 Sept	6 Sept	9 Sept	13 Sept	24 Sept	27 Sept
		(0-5; 0 = none)	% area blighted					
Emerald	0.13 oz	3.0 bc[y]	38.4[x] b	29.0 b	31.0 b	26.9 cd	7.3 cd	10.7 cd
Emerald	0.18 oz	3.0 bc	32.3 bcd	23.0 b	22.3 bc	30.8 bcd	5.9 cde	13.1 c
Velista	0.3 oz	3.5 b	33.3 bcd	29.5 b	29.5 bc	42.1 abc	8.9 bc	12.4 c
Velista	0.5 oz	3.0 bc	26.7 b-e	17.3 bc	18.3 bcd	27.7 cd	4.1 c-g	7.5 cd
Xzemplar	0.157 fl oz	0.3 f	21.0 e	4.4 d	3.9 efg	4.1 ef	0.7 gh	2.0 ef
Xzemplar	0.26 fl oz	0.3 f	22.3 de	5.7 d	3.0 fg	0.9 f	0.2 h	0.6 f
26GT	4.0 fl oz	2.0 de	32.9 bcd	8.0 cd	9.4 def	19.9 d	0.8 fgh	2.3 ef
QP Ipro 2SE	4.0 fl oz	2.5 cd	37.4 bc	17.1 bc	17.0 cd	27.5 cd	4.6 c-f	10.8 cd
Secure	0.5 fl oz	1.5 e	18.3 e	3.4 d	2.3 g	6.6 e	1.5 e-h	1.9 ef
Daconil WeatherStik	4.0 fl oz	1.5 e	26.2 cde	17.2 bc	19.2 bcd	43.5 ab	16.0 b	23.4 b
QP Enclave	4.0 fl oz	0.0 f	23.2 de	8.3 cd	10.6 de	29.7 bcd	3.2 d-g	4.6 de
Untreated		4.8 a	55.9 a	49.4 a	52.7 a	56.4 a	30.3 a	45.6 a
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		4	4	7	10	14	11	14

[z]Treatments were initiated on 30 August, after disease development. Subsequent 14-d treatments were applied on 13 September

[y]Treatment means followed by the same letter, within each column, are not significantly different based on Fisher’s protected least significant difference test (α = 0.05).

[x]Data were square-root transformed; means presented are back calculated

DOLLAR SPOT EFFICACY OF SECURE CONTACT FUNGICIDE FOLLOWING SIMULATED RAINFALL ON CREEPING BENTGRASS FAIRWAY TURF, 2013

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INTRODUCTION

Contact fungicides and localized penetrant fungicides prevent disease primarily by interacting with fungal pathogens on the leaf surface. The duration of control with these materials is largely dependent on the amount of fungicide present on external leaf surfaces over time. Several processes contribute to degradation or removal of fungicide residues on leaf surfaces; however a common one in the Northeast during May and June 2013 was frequent rainfall events. Sometimes unexpected rain events may occur shortly after fungicides have been applied. Under these circumstances superintendents may question how the efficacy of the recently applied fungicide may be affected. Secure is a new contact fungicide, and its efficacy when applied just prior to rainfall is unknown. The objective of this trial was to evaluate the duration of dollar spot control of Secure and other contact or local penetrant fungicides receiving simulated rainfall at various time intervals following application.

MATERIALS & METHODS

A field study was conducted on a 'Crenshaw' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage dollar spot development. A total of 1.0 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through July. Daconil Ultrex was applied on 22 May and Secure was applied on 29 May to prevent dollar spot development prior to initiation of treatments. Acelepryn was applied on 22 June for the control of white grubs and surface feeding caterpillars. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of three contact or local penetrant fungicides applied at various intervals prior to a simulated rain event. Fungicides were applied before sunrise, over heavy dew, when relative humidity was 70 to 90%. These conditions were selected to approximate those preceding a rain event which would not favor rapid canopy drying. Treatments applied at the same time of day without simulated rainfall were also included as a comparison. Initial applications were made on 6 June, with subsequent applications made on a 14-d interval through 4 July. Simulated rainfall equivalent to 0.1 inch was applied with a watering can to individual plots, 15, 30, or 60 minutes after fungicide application. All fungicide treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual disease foci within each plot from 6 June to 18 July. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Dollar spot incidence data were square-root transformed for ANOVA and mean separation tests, although means presented are back-calculated values.

RESULTS

Dollar spot initially developed in the study on 21 June, 15 days after initial treatment (DAIT), and increased rapidly during extremely favorable environmental conditions from late-June through mid-July (Table 1). Treatment differences became evident 7 days later (27 June). Simulated rainfall had no effect on dollar spot control in Secure and Daconil WeatherStik treated turf 7 days after treatment (DAT). Efficacy of Chipco 26GT was reduced when simulated rainfall occurred 15 to 30 minutes after application compared to no simulated rainfall. However, at 60 minutes post application, no reduction in efficacy was observed compared to no rainfall, on this observation date.

By 11 DAT (1 July), only Secure provided acceptable dollar spot control (i.e., ≤ 25 infection centers per plot). Simulated rainfall did not significantly reduce dollar spot efficacy of any fungicides compared to no simulated rainfall treatments on this date, except Chipco 26GT applied 60 minutes before rainfall which was less effective than when no simulated rain was applied. At 14 DAT (4 July), no fungicides receiving simulated rainfall had acceptable dollar spot levels. Among treatments not receiving simulated rainfall, only Secure maintained acceptable disease control on this date.

Following reapplication of all treatments, little symptom recovery occurred during mid-July when conditions were highly favorable for disease. On 18 July (14 days after the last application), Secure and Chipco 26GT applied without simulated rainfall had less disease than similarly treated turf receiving rainfall. However, only Secure without rain had an acceptable level of disease. Disease incidence was extremely high in all Daconil WeatherStik treatments on this date, and no effects of simulated rainfall were apparent.

DISCUSSION

Disease pressure was extremely high in this trial due to the high humidity and night temperatures, use of a highly susceptible bentgrass variety (i.e., 'Crenshaw'), and experimental application conditions. Under these conditions, Secure provided excellent dollar spot control and demonstrated superior rainfastness at 7 to 11 DAT compared to Daconil

WeatherStik or Chipco 26GT. It is important to note that no fungicide treatment receiving simulated rainfall post application provided a full 14-d of control in this trial. This is to be expected, since rain events occurring prior to the fungicide drying on the leaf surface would likely remove some of the material and shorten its residual efficacy. However, it appears that a rainfall event of 0.1 inch or less occurring as little as 15 minutes following an application of Secure will provide acceptable dollar spot control for up to 11 days. In contrast, Daconil WeatherStik or Chipco 26GT may only provide up 7 days of acceptable dollar spot control.

Table 1. Dollar spot incidence influenced by contact fungicides and simulated rainfall on ‘Crenshaw’ creeping bentgrass fairway turf at the Plant Science Research Facility in Storrs, CT during 2013.

Treatment	Rate per 1000ft^2	Simulated Rainfall Timing[z]	Dollar Spot Incidence						
			21 Jun	27 Jun	1 Jul	4 Jul	9 Jul	12 Jul	18 Jul
			# of spots 18 ft^{-2}						
Secure	0.5 fl oz	no rain	0.0	0.0 f[x]	1.2 e	8.0 d	5.8 d	0.7 h	2.1 f
Secure	0.5 fl oz	60 min after app	0.2	0.0 f	4.6 de	26.8 d	17.6 d	13.7 gh	44.2 e
Secure	0.5 fl oz	30 min after app	0.0	0.2 ef	10.7 de	38.8 cd	23.6 d	29.2 fg	43.8 e
Secure	0.5 fl oz	15 min after app	0.2	0.2 ef	10.5 de	38.5 cd	22.1 d	17.2 gh	50.1 de
Daconil WeatherStik	2.0 fl oz	no rain	1.2	2.2 c-f	46.0 bc	131.4 ab	118.7 abc	128.5 bcd	129.4 bc
Daconil WeatherStik	2.0 fl oz	60 min after app	0.0	4.8 b-f	74.1 ab	125.0 ab	132.1 ab	173.2 ab	183.3 ab
Daconil WeatherStik	2.0 fl oz	30 min after app	0.2	8.6 bc	74.9 ab	141.8 ab	125.3 abc	160.5 abc	177.3 ab
Daconil WeatherStik	2.0 fl oz	15 min after app	0.0	5.2 b-f	56.3 bc	117.3 ab	96.2 bc	138.7 bcd	148.2 bc
Chipco 26GT	2.0 fl oz	no rain	0.8	0.8 def	24.5 cd	83.6 bc	67.8 c	31.8 efg	42.8 e
Chipco 26GT	2.0 fl oz	60 min after app	0.2	7.3 bcd	62.2 ab	123.0 ab	104.4 bc	74.6 def	95.1 cd
Chipco 26GT	2.0 fl oz	30 min after app	0.4	8.1 bc	58.0 bc	122.2 ab	101.3 bc	79.4 de	120.7 bc
Chipco 26GT	2.0 fl oz	15 min after app	1.1	11.8 b	56.4 bc	149.5 ab	120.0 abc	92.2 cd	120.9 bc
Untreated			1.9	46.5 a	116.1 a	189.8 a	198.5 a	246.8 a	244.6 a
ANOVA: Treatment (P > F)			0.1010	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after last treatment			1	7	11	14	5	8	14

[z] Individual plots received 0.1 inch of simulated rainfall applied with a watering can 15, 30, or 60 minutes after fungicides were applied, except those indicated as “no rain”. Treatments were applied on a 14-d interval on 6-Jun, 20-Jun, and 4-Jul.

[y] Data were square-root transformed; means presented are back calculated.

[x] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher’s protected least significant difference test ($\alpha = 0.05$).

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ANNUAL BLUEGRASS CONTROL WITH XONERATE IN CREEPING BENTGRASS FAIRWAY TURF, 2013

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INTRODUCTION

Annual bluegrass (*Poa annua*) is a common component of golf course fairways throughout the northern United States. The species is capable of forming a dense, fine-textured, turf under low mowing which makes it well adapted for fairway and putting green areas. However, annual bluegrass possesses only fair tolerance to high temperatures and medium tolerance to low temperatures. Poor tolerance to environmental stress limits survival of this turf species either directly or indirectly by predisposing ABG to diseases such as dollar spot, summer patch and anthracnose. Management inputs required to maintain healthy annual bluegrass playing surfaces are generally greater than turfgrass species such as creeping bentgrass which benefit from breeding programs intended to improve disease resistance and environmental stress tolerance. Selective herbicides to reduce annual bluegrass in established creeping bentgrass fairways would help turf managers transition fairways to more sustainable turfgrass species

Xonerate (amicarbazone) is an herbicide recently introduced for annual bluegrass control in established creeping bentgrass fairways. However, some trials have reported injury to bentgrass following Xonerate applications. Irrigating Xonerate treated turf 3 hours following application has been proposed to reduce bentgrass injury. A new SC formulation of Xonerate has also been developed. The objective of the current trial was to evaluate current formulations of Xonerate and post-application irrigation on the efficacy and phytosafety of Xonerate and Velocity (bispyribac-sodium) in controlling annual bluegrass in a creeping bentgrass fairway turf.

MATERIALS & METHODS

A field study was conducted on a 'MacKenzie' creeping bentgrass (*Agrostis stolonifera*) fairway turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. A total of 0.55 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through June. Scimitar GC was applied on 7 May and Dylox 80 was applied on 25 May for control of annual bluegrass weevil adults and larvae. ProStar and Emerald were applied on 17 June for control of brown patch and dollar spot, respectively. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of Xonerate, applied as SC or WDG formulations as well as Velocity. Initial treatments were applied on 20 May, and subsequent applications were made on a 7-d or 14-d interval through 17 June on days with maximum air temperatures less than 85 F (Fig. 1). Treatments that were irrigated post-application received 0.1 inch of water applied to respective plots with a watering can 3 hours after herbicide application. All herbicide treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Annual bluegrass injury was visually assessed on a 0-5 scale from 27 May through 25 June; where 0 represented no injury and 5 represented total plant death. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. Volumetric soil water content in the top 3 inches of the rootzone was measured with a FieldScout TDR 300 Soil Moisture meter (Spectrum Technologies, Inc., Plainfield, IL). All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

Fig. 1. Maximum and minimum temperature recorded at the Plant Science Research and Education Facility in Storrs, CT from 9 May to 8 June.

RESULTS & DISCUSSION

Xonerate SC treatments resulted in a severe reduction in turf quality 11 days after initial treatment (31 May; DAIT) which persisted through the end of the trial in June (Table 1). This reduction in turf quality was primarily due to injury to bentgrass (Table 2) and annual bluegrass (Table 3) within treated plots. Both 7- and 14-d intervals resulted in unacceptable turf quality and phytotoxicity to bentgrass; however 7-d application intervals generally had worse turf quality and more severe phytotoxicity than 14-d intervals. Post-application irrigation did not reduce the phytotoxic effects of Xonerate SC on bentgrass, and occasionally enhanced toxicity to bentgrass (31 May and 17 Jun). It has been suggested that damage to bentgrass may occur if Xonerate is applied to turf growing under low soil moisture conditions. However, volumetric soil moisture measurements taken just prior to each application indicate that adequate soil moisture was present in this trial (Table 4). It is important to note that Xonerate SC is a developmental formulation that is different from the commercially available WDG formulation.

Xonerate WDG had little effect on annual bluegrass injury, turf quality or phytotoxicity in this trial. These results are strikingly different compared to Xonerate SC, despite both materials being applied at the same amount of active ingredient on the same days. This year's Xonerate WDG results are also surprisingly different than similar treatments applied at this same site in 2012. Last year, Xonerate WDG resulted in unacceptable turf damage, comparable to Xonerate SC in this year's trial.

Velocity resulted in slight annual bluegrass discoloration (i.e., mild injury) beginning 7 DAIT (27 May) and persisting throughout the trial (Table 3). The initial application of Velocity also caused an unacceptable level of phytotoxicity to bentgrass 7 DAIT (Table 2), however bentgrass toxicity subsided to acceptable levels by 11 DAIT. This temporary phytotoxicity is routinely observed following initial Velocity applications, and has not been reported to have lasting detrimental effects to creeping bentgrass. Reductions in annual bluegrass populations were not observed during this trial, which is expected due to the short duration of the study.

Results from trials containing Xonerate conducted at UCONN and other locations have been inconsistent with respect to annual bluegrass control and injury to bentgrass. The latter, being the most concerning point at this time. Reasons associated with herbicide efficacy and phytosafety have been associated with soil moisture, ambient air temperatures, formulation, plant vigor, among other factors. Ongoing research throughout the country is looking to address these issues.

Table 1. Turf quality of a mixed creeping bentgrass and annual bluegrass fairway turf treated with selective herbicides at the Plant Science Research and Education Facility in Storrs, CT during 2013.

				Turf Quality					
Treatment	Rate per acre	lbs a.i. acre^{-1}	Int^{z}	21 May	27 May	31 May	7 June	17 June	25 June
				----------------------- 1-9; 6=min acceptable -----------------------					
Xonerate WDG	1.0 oz	0.049	7-d	6.5 ab^{y}	6.0 c	6.8 ab	6.3 a	6.8 a	6.3 a
Xonerate WDG +Post app irrigation	1.0 oz 0.1 in.	0.049	7-d	7.0 a	6.5 c	7.0 a	6.8 a	6.8 a	6.5 a
Xonerate SC	1.4 fl oz	0.049	7-d	7.0 a	6.8 ab	2.0 e	2.0 c	1.8 d	2.3 b
Xonerate SC +Post app irrigation	1.4 fl oz 0.1 in.	0.049	7-d	7.0 a	7.0 a	2.3 e	2.3 bc	1.8 d	2.3 b
Xonerate SC	1.4 fl oz	0.049	14-d	6.8 ab	6.5 abc	3.5 d	3.0 b	3.5 b	2.3 b
Xonerate SC +Post app irrigation	1.4 fl oz 0.1 in.	0.049	14-d	7.0 a	6.8 ab	3.0 d	2.5 bc	2.8 c	2.8 b
Velocity EG	6.0 oz	0.066	14-d	6.3 b	5.3 d	6.3 bc	6.0 a	6.8 a	5.5 a
Untreated				6.3 b	6.3 bc	6.0 c	6.8 a	6.8 a	6.3 a
ANOVA: Treatment (P > F)				0.022	0.0022	0.0001	0.0001	0.0001	0.0001
Days after first treatment			int	1	7	11	18	28	36
Days after last treatment			7-d	1	7	4	3	7	15
			14-d	1	7	11	3	7	8

^{z} Treatments were applied on a 7-d interval on 20 May, 27 May, 4 June and 10 June; or 14-d interval on 20 May, 4 June, and 17 June

^{y} Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

Table 2. Phytotoxicity of creeping bentgrass fairway turf treated with selective herbicides at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per acre	lbs a.i. $acre^{-1}$	Int[z]	Phytotoxicity 27 May	31 May	7 June	17 June	25 June
				-------------- 0-5; 2=max acceptable ---------------				
Xonerate WDG	1.0 oz	0.049	7-d	0.8 bc [v]	0.0 e	0.0 c	0.0 d	0.3 c
Xonerate WDG	1.0 oz	0.049	7-d	0.0 d	0.0 e	0.3 c	0.0 d	0.3 c
+Post app irrigation	0.1 in.							
Xonerate SC	1.4 fl oz	0.049	7-d	0.3 cd	4.3 a	5.0 a	4.8 ab	5.0 a
Xonerate SC	1.4 fl oz	0.049	7-d	0.3 cd	4.0 ab	5.0 a	5.0 a	5.0 a
+Post app irrigation	0.1 in.							
Xonerate SC	1.4 fl oz	0.049	14-d	0.3 cd	3.0 c	4.0 b	3.5 c	5.0 a
Xonerate SC	1.4 fl oz	0.049	14-d	0.0 d	3.8 b	4.3 b	4.3 b	5.0 a
+Post app irrigation	0.1 in.							
Velocity EG	6.0 oz	0.066	14-d	2.5 a	1.3 d	0.5 c	0.5 d	1.8 b
Untreated				1.0 b	0.3 e	0.3 c	0.0 d	0.3 c
ANOVA: Treatment (P > F)				0.0001	0.0001	0.0001	0.0001	0.0001
Days after first treatment			int	7	11	18	28	36
Days after last treatment			7-d	7	4	3	7	15
			14-d	7	11	3	7	8

[z] Treatments were applied on a 7-d interval on 20 May, 27 May, 4 June and 10 June; or 14-d interval on 20 May, 4 June, and 17 June

[y] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

Table 3. Injury of annual bluegrass in a mixed creeping bentgrass and annual bluegrass fairway turf treated with selective herbicides at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per acre	lbs a.i. $acre^{-1}$	Int[z]	Annual bluegrass injury 27 May	31 May	7 June	17 June	25 June
				-------------------- 0-5; 5=dead --------------------				
Xonerate WDG	1.0 oz	0.049	7-d	0.3 b [y]	0.8 bc	0.8 cd	0.0 b	0.0 c
Xonerate WDG	1.0 oz	0.049	7-d	0.0 b	0.0 d	0.0 d	0.3 b	0.3 c
+Post app irrigation	0.1 in.							
Xonerate SC	1.4 fl oz	0.049	7-d	0.3 b	4.0 a	5.0 a	5.0 a	5.0 a
Xonerate SC	1.4 fl oz	0.049	7-d	0.0 b	4.3 a	4.8 ab	5.0 a	3.8 a
+Post app irrigation	0.1 in.							
Xonerate SC	1.4 fl oz	0.049	14-d	0.0 b	4.0 a	4.0 b	5.0 a	5.0 a
Xonerate SC	1.4 fl oz	0.049	14-d	0.0 b	4.0 a	5.0 a	5.0 a	5.0 a
+Post app irrigation	0.1 in.							
Velocity EG	6.0 oz	0.066	14-d	1.0 a	1.3 b	1.5 c	0.5 b	2.0 b
Untreated				0.0 b	0.5 cd	0.3 d	0.0 b	0.3 c
ANOVA: Treatment (P > F)				0.0002	0.0001	0.0001	0.0001	0.0001
Days after first treatment			int	7	11	18	28	36
Days after last treatment			7-d	7	4	3	7	15
			14-d	7	11	3	7	8

[z] Treatments were applied on a 7-d interval on 20 May, 27 May, 4 June and 10 June; or 14-d interval on 20 May, 4 June, and 17 June

[y] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

Table 4. Volumetric soil water content of a mixed creeping bentgrass and annual bluegrass fairway turf treated with selective herbicides at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Treatment	Rate per acre	lbs a.i. $acre^{-1}$	Int[z]	Volumetric Water Content			
				20 May	27 May	10 June	17 June
				---------------------- percent ------------------			
Xonerate WDG	1.0 oz	0.049	7-d	42	43	51	53 a[y]
Xonerate WDG +Post app irrigation	1.0 oz 0.1 in.	0.049	7-d	40	44	50	53 a
Xonerate SC	1.4 fl oz	0.049	7-d	41	43	50	50 b
Xonerate SC +Post app irrigation	1.4 fl oz 0.1 in.	0.049	7-d	40	43	50	49 b
Xonerate SC	1.4 fl oz	0.049	14-d	41	44	50	51 ab
Xonerate SC +Post app irrigation	1.4 fl oz 0.1 in.	0.049	14-d	41	44	49	50 b
Velocity EG	6.0 oz	0.066	14-d	42	43	51	52 a
Untreated				40	44	51	53 a
ANOVA: Treatment (P > F)				0.5516	0.8385	0.6603	0.0001
Days after first treatment				0	7	21	28

[z] Treatments were applied on a 7-d interval on 20 May, 27 May, 4 June and 10 June; or 14-d interval on 20 May, 4 June, and 17 June

[y] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

HOST PLANT FEEDING PREFERENCES AND SEASONAL OCCURRENCE OF THE ADULT ASIATIC GARDEN BEETLE (*Maladera castanea* Arrow)

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INTRODUCTION

The Asiatic garden beetle (AGB), *Maladera castanea* Arrow, is a member of the white grub complex of the northeastern United States, the most damaging group of turfgrass insect pests in the region. White grubs are root-feeding larvae of beetles in the scarab family (Coleoptera: Scarabaeidae), some of which also feed in the adult form (Koppenhöfer, 2002). The AGB feeds in both its larval and adult forms, and can be a serious pest of ornamental and crop plants, in addition to turf (Hallock, 1932; Heller, 1995).

A better understanding of the AGB, which has been minimally studied, could lead to improved management strategies. Of particular interest are the habits of the adult beetle, the most mobile life stage. AGB adult habits influence not only damage caused in this stage, but also larval damage, as adult females determine the location of future larvae through egg-laying.

The objectives of this study were to investigate two aspects of AGB adult behavior: seasonal occurrence and feeding preferences. The peak seasonal AGB adult occurrence in the Storrs area of Connecticut was estimated in 2011 and 2012 using counts of beetles from black light traps at irregular intervals throughout the field season. Feeding preferences within a set of six landscape plants were quantitatively tested by measuring mass and area change of leaf circles given to adult beetles in a controlled setting.

MATERIALS & METHODS

Black light trapping

Adult AGBs were collected using black light traps for purposes of population monitoring in 2011 and 2012. In 2012, beetles were also kept for later use in laboratory experiments. During the 2011 field season, beetles were collected using three black light traps: one located at the University of Connecticut's Storrs campus, the second at the University's Depot campus, and the third at the University's Plant Science Research and Education Facility.

In 2012, the Depot campus location was repeated, a second trap was placed at a University farm property in Mansfield, CT, and a third was placed on the Storrs campus, in a different location than used in 2011. A modified trap using white light was placed at the Research Facility near the 2011 site. Adult AGBs were collected and counted at irregular intervals from June 17 to September 6 in 2011, and from June 14 to September 13 in 2012.

No-choice feeding experiment

In 2012, adult AGBs collected with black light traps were kept in the lab until needed for no-choice feeding experiments. Beetles were fed carrot pieces, and kept in 236 mL plastic deli containers with moist sponge pieces and paper towel. Dishes were kept in incubators at 22.2°C with no light.

Two shrubs were tested, elderberry (*Sambucus canadensis*) and arrowwood viburnum (*Viburnum dentatum*), along with four trees, green ash (*Fraxinus pennsylvanica*), red maple (*Acer rubrum*), sugar maple (*Acer saccharum*), and American sweetgum (*Liquidambar styraciflua*). Nine edible plant cultivars were tested in the same experiment; these are not discussed in this paper. Leaves were collected from nine individuals of each landscape species tested, two leaves from each plant. Leaves were collected up to three days prior to testing dates, and were stored cold in sealed plastic bags with moist sponge pieces. Two 1.7 cm diameter circles, a control and an experimental circle, were cut from each leaf using a piece of copper pipe, except for viburnum, in which circles were cut from opposite leaves due to small leaf size. Ash and elderberry circles were cut from the same leaflet.

On each of two test starting dates (August 1 and 18, 2012), leaf circles were cut, weighed on an analytical balance, and scanned to digital images. One leaf circle was placed on a 9 cm diameter filter paper moistened with 1 mL distilled water in a closed, upside-down 8.5 cm diameter polystyrene petri dish. One adult AGB, starved for at least 24 hours, was added to each experimental petri dish. Control leaf circles were not exposed to beetles. Petri dishes were arranged in a completely randomized design in sealed plastic bags to prevent moisture loss, and placed in incubators at 22.2°C with no light for the 48 hour minimum duration of the experiment.

Beetles were removed from experimental petri dishes at the end of the experiment, and leaf circles were scanned once more. Leaf circles were then dried in an oven at 70°C until they reached a constant weight, which was then recorded.

The ImageJ program (National Institutes of Health) was used to calculate area of leaf circles from the scanned images. Control data were used to correct for changes in area and mass not caused by beetle presence. Area consumed was calculated for each experimental leaf circle as: *initial area – (final area / (1 + proportion area change in control circle)).* Mass consumed was calculated as: *initial mass – (final dry mass / proportion dry mass in control circle).*

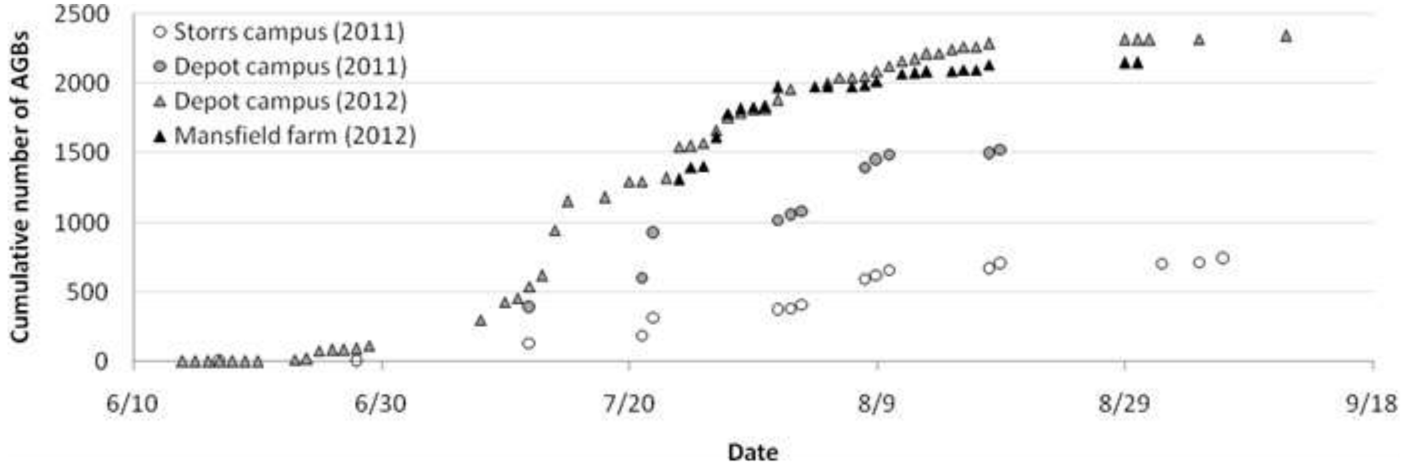

Figure 1. Cumulative number of Asiatic garden beetle adults in each black light trap throughout the 2011 and 2012 field seasons.

Analyses of variance were performed separately on mass and area consumption values, using SAS 9.3 (SAS Institute Inc.). A block design accounted for the two test dates. To meet parametric analysis of variance assumptions, mass consumed was transformed by $(1/(x^2 + 8)^{0.25})$, and area consumed was transformed by $(1/\sqrt{(x + 20)})$. Class contrasts within the main analyses were used to compare landscape plants only.

RESULTS & DISCUSSION

Seasonal occurrence of adult beetles

In 2012, the first AGB adults of the season were caught on June 20. The majority of AGB adults were observed to occur before September in both 2011 and 2012. The cumulative number of adult AGBs caught over the course of the field season can be seen in Figure 1 for both 2011 and 2012, as recorded from the two main traps used in each year. The section of each curve with the highest slope is indicative of the period of highest AGB adult activity recorded using that trap. In 2011, peak population sizes occurred between July 22 and August 10. In 2012, peak population sizes occurred between July 10 and August 18.

No-choice feeding preferences

Mass and area consumed are presented in Figures 2 and 3. Replicates in which beetles did not survive the experimental period were removed from the analyses. Mass and area measurements and calculations produced similar results with similar levels of precision in this experiment (Figures 2 and 3), suggesting that they are equally valid variables to observe in a no-choice laboratory feeding experiment.

Class contrasts within the main analyses of variance using mass and area consumption both showed significant differences in beetle feeding on landscape plants (Figure 2; $F = 2.85$; $df = 5, 163$; $P = 0.0170$; Figure 3; $F = 2.28$; $df = 5, 163$; $P = 0.0492$). However, the Tukey-Kramer test for mean separation, performed to identify the differences detected in the main analyses, did not find any significant differences.

A one degree of freedom contrast was also included in the analyses for both mass and area data to look for differences between beetle consumption of red maple and sugar maple. Contrasts between other landscape plants were not performed so that comparisons remained orthogonal (contrasts for edible plants were also performed, but are not discussed in this paper). Using both mass and area data, red maple was found to be significantly more consumed than sugar maple (mass $F = 4.76$; $df = 1, 163$; $P = 0.0305$; area $F = 4.82$; $df = 1, 163$; $P = 0.0296$).

The lesser consumption of sugar maple compared to red maple indicates that sugar maple may be a less preferred food plant for the AGB. Although sugar maple was not specifically compared with any of the other four landscape plants tested, numeric values suggest that sugar maple, the plant with the lowest mean mass and area consumption, may also be less preferred than some of these other species, particularly arrowwood viburnum, the plant with the highest mean mass and area consumption. Repeating this experiment with more replications could lead to statistical evidence of significantly lower preference of AGBs for sugar maple leaves compared to some or all of the other experimental landscape plants.

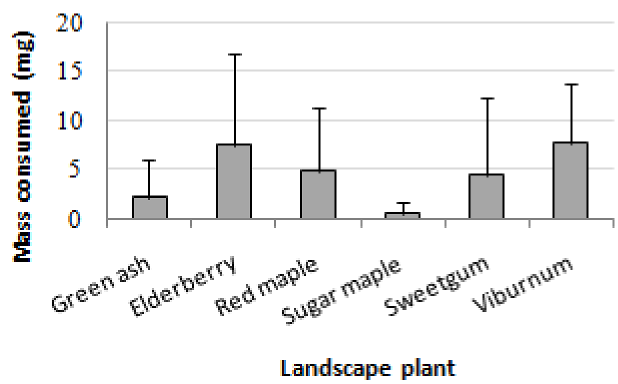

Figure 2. Leaf mass consumed by one Asiatic garden beetle adult over 48 hours, shown for six landscape plants. Values = average + SE, n = 13, 11, 13, 12, 12, 10.

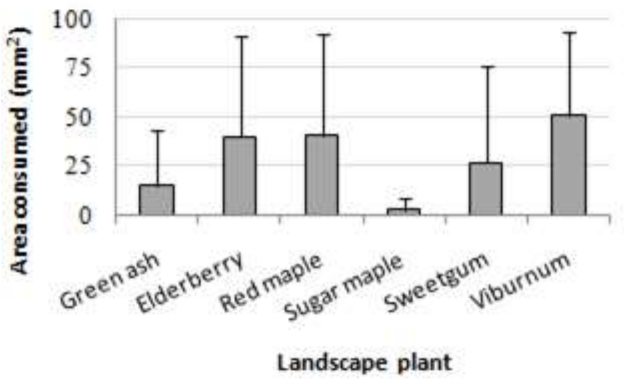

Figure 3. Leaf area consumed by one Asiatic garden beetle adult over 48 hours, shown for six landscape plants. Values = average + SE, *n* = 13, 11, 13, 12, 12, 10.

If sugar maple proves to be less favored by the AGB than other landscape plants, it could be recommended for preferential use in areas where AGB damage is a significant pest problem. The use of less preferred landscape plants could improve the aesthetics of an area, reduce insecticide usage, and possibly even lead to smaller AGB populations, which could help limit AGB damage to nearby turf, gardens, and crop fields.

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INFLUENCE OF GRASS SPECIES ON THE DEVELOPMENT AND SURVIVAL OF ORIENTAL BEETLES

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INTRODUCTION

Several species of white grubs are the most widespread and damaging turfgrass insect pests in the Northeast and along the eastern seaboard of the USA. Within the complex of white grubs, oriental beetles (*Anomala orientalis* Waterhouse) have become a major pest in turfgrasses in New Jersey, southern New York, Connecticut, and Rhode Island (Alm et al., 1999). Although oriental beetle grubs cause severe damage to the roots of turfgrasses very little is known about how different species of turfgrasses could affect their development and survival. In a previous study, Potter et al., (1992) examined the suitability of six different cool season turfgrasses to root feeding grubs of Japanese beetle (*Popillia japonica* Newman) and the southern masked chafer (*Cyclocephala lurida* Bland). First instar grubs of *P. japonica* showed a relatively poor survival and weight gain when they fed upon the roots of Kentucky bluegrass (*Poa pratensis* L.). Therefore the aims of this study were: 1) to examine the survival, weight gain, and development of *A. orientalis* first instar larvae that had been feeding on different grasses; and 2) to examine whether the survival, development, weight gain of first instar *A. orientalis* larvae vary when they feed upon endophyte-infected and endophyte-free tall fescue.

MATERIALS & METHODS

Seeds of Kentucky bluegrass (*Poa pratensis* L.) cultivar 'America', tall fescue (*Festuca arundinacea* Schreb) endophyte-infected and endophyte-free cultivar 'Jesup', and perennial ryegrass (*Lolium perenne* L.) cultivar 'Quebec' were planted in regular potting soil (Canadian sphagnum peat (50%), processed pine bark, perlite and vermiculite) in 9 cm (diam.) x 9 cm (deep) plastic pots. The 'Jesup' tall fescue was selected because it had an endophyte-infected and endophyte-free line representing the same genetic stock. Tall fescue seeds were infected with fungal endophyte *Neotyphodium coenophialum* and the percent infection was 97.8%. Seeding rates were 40 g/m^2 for both endophyte-infected and endophyte-free tall fescue, for perennial ryegrass 29 g/m^2, and for Kentucky bluegrass 15 g/ m^2. Twenty pots containing each grass species were placed in a complete random design in a growth chamber at 25^{o}C, 70% relative humidity, and 16L:8D light:dark regime for 8 weeks.

Adult *A. orientalis* were collected using light traps that were set in the field during the night from mid-June to July. The adults were kept in 14 L clear plastic boxes (36 x 27 x 17cm) filled with 10 cm of field-collected autoclaved, moist, and sifted soil. Freshly laid eggs were collected every 2 days and transferred to plastic containers (8 cm diameter) containing autoclaved, moist, and sifted soil and held in room temperature (22-25°C) for roughly three weeks until they hatched. Four first instar grubs were introduced into each pot on July 24. There were twenty replicates of each grass species. The pots with first instar grubs were kept in a growth chamber at 25^{o}C, 70% relative humidity, and 16L:8D light:dark regime for an additional 7 weeks. The potting soil was then destructively sampled and the surviving grubs, now all second and third instars were counted, sorted by instar, and individually weighed. The mean survival, mean weight, and instar distribution of *A. orientalis* grubs were compared using analysis of variance (ANOVA) followed by Tukey's HSD test using SAS GLIMMIX procedure (SAS 9.3, SAS Institute, Cary, NC, USA).

RESULTS & DISCUSSION

Survival rate, weight, and instar distribution of *A. orientalis* grubs introduced into the pots containing different grass species as neonates are shown in Figures 1, 2, and 3. Significant differences were found among grass species for survival rate ($F = 5.21$; df = 3; $P = 0.003$), weight after 7 weeks ($F = 9.58$; df = 3; $P < 0.0001$), and number of third instar grubs surviving ($F = 9.79$; df = 3; $P < 0.0001$). The endophyte-free tall fescue and perennial ryegrass had a significantly greater number of surviving grubs per pot compared to Kentucky bluegrass (Fig.1). There was no significant difference in the mean number of grubs per pot between perennial ryegrass and both endophyte-free and endophyte-infected tall fescue. However, the number of surviving grubs was significantly different between endophyte-free and endophyte-infected tall fescues.

A. orientalis grubs fed on Kentucky bluegrass had the lowest mean weight compared to grubs feeding on the other three grass species (Fig. 2). Grubs feeding on the roots of perennial ryegrass had the highest mean weight of 193 mg. Grub mean weights were not significant different between perennial ryegrass vs. endophyte-infected and endophyte-free tall fescue. Further, the weights of grubs fed upon endophyte-infected and endophyte-free tall fescue were not statistically significant different. The number of third instar grubs surviving per pot was significantly greater for perennial ryegrass and endophyte-free tall fescue compared with Kentucky bluegrass and endophyte-infected tall fescue (Figure 3). Kentucky bluegrass had the lowest mean number of third instar grubs per pot which was significantly different from that of endophyte-infected tall fescue. Mean number of third instars per pot was significantly different between endophyte-free vs. endophyte-infected tall fescue. In addition, mean number of second instars per pot did not show a difference among the four grass species ($F = 0.71$; df = 3; $P = 0.549$). However, the highest ratio for mean number of second instars to third instars per pot was shown by Kentucky bluegrass (Fig. 3).

The survival, growth, and development of scarabaeid grubs could vary based on the nutritional quality of their food (Potter et al., 1992). In this study we examined the survival, weight gain, and instar distribution of larvae of *A. orientalis* that had been feeding on three species of cool season grasses including endophyte-free and endophyte-infected tall fescues. The larvae fed on endophyte-free tall fescue and perennial ryegrass had a relatively high survival rate and high mean grub weight compared with those of grubs fed on Kentucky bluegrass. Further, the mean number of third instar grubs per pot was greater for perennial ryegrass and endophyte-free tall fescues than for Kentucky bluegrass. It is known that grubs may compensate for developing on poor quality diets by continuing to feed longer to reach pupal weight (Prestidge et al., 1985). In fact, our findings showed that the grubs developing in Kentucky bluegrass appeared to be phenologically behind (i.e., with a majority of second instars) compared to those in tall fescue and perennial ryegrass (Fig. 3). In tall fescue, endophyte infection had reduced *A. orientalis* survival without affecting its weight gain. This observation was similar to Koppenhöfer et al. (2003), who observed a negative effect of tall fescue endophytes on larval development of first instar *A. orientalis*. Several studies have shown that these negative effects appear to be limited to the young larval stages (Potter et al., 1992, Koppenhöfer and Fuzy 2003, Koppenhöfer et al., 2003). The results presented here highlight the influence of grass species on the oriental beetle grub development and survival.

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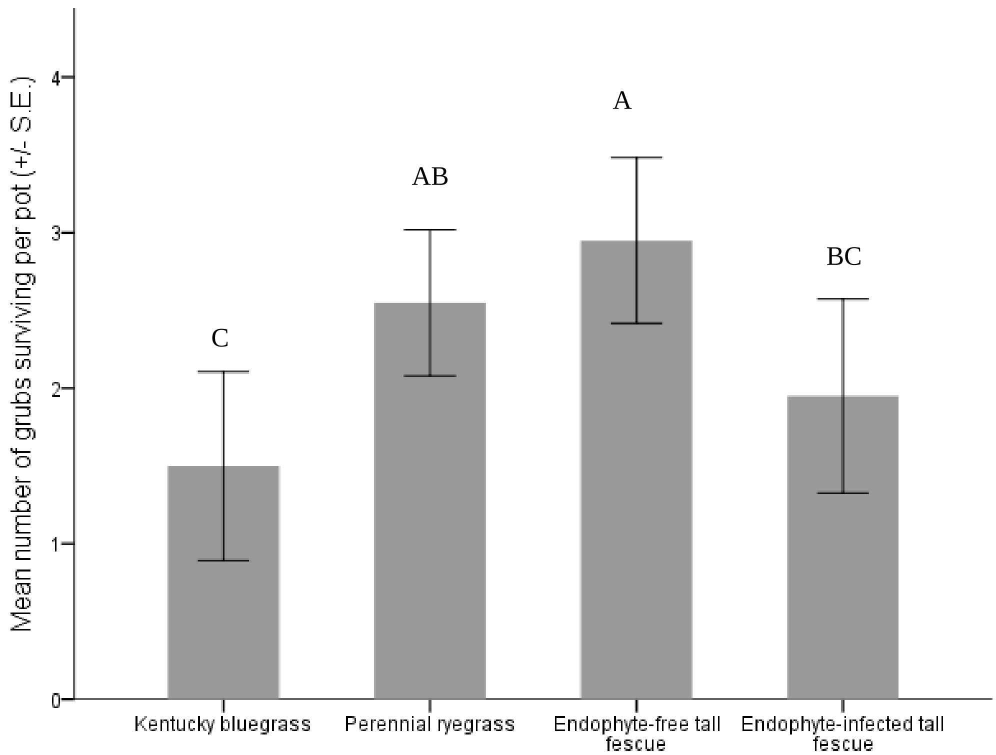

Figure 1. Mean number (± S. E.) of oriental beetle grubs surviving in each grass species. Grubs were implanted as neonate larvae and reared for seven weeks. Means with the same letter do not differ significantly (ANOVA and Tukey's HSD test, $P < 0.05$).

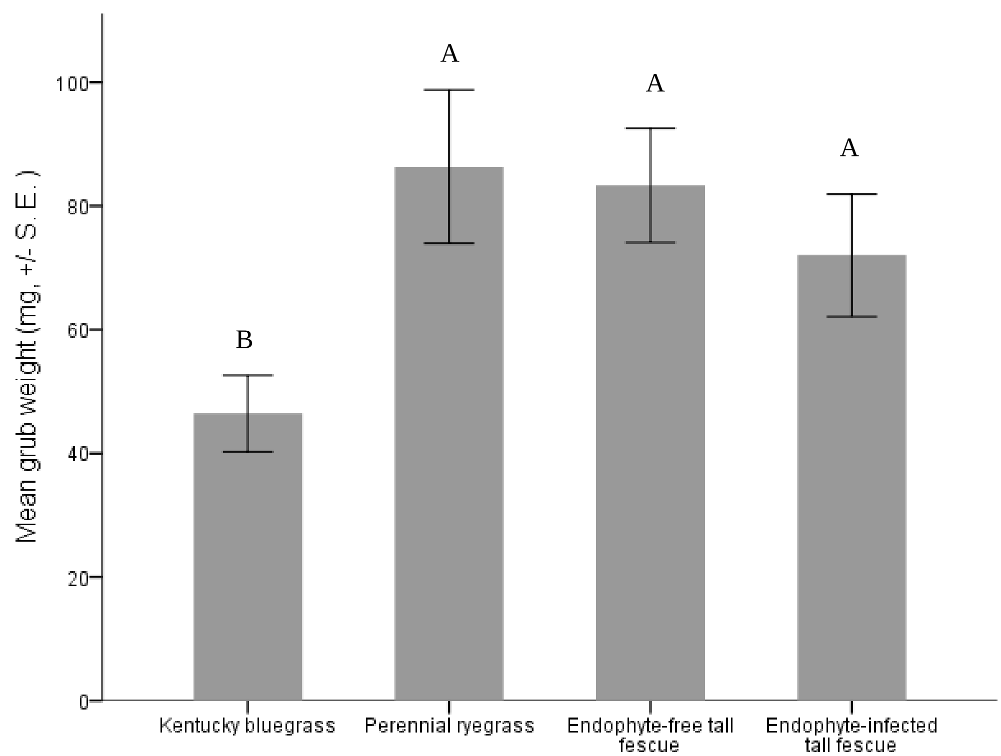

Figure 2. Mean weight (± S.E.) of oriental beetle grubs reared in each grass species. Grubs were implanted as neonate larvae and reared for seven weeks. Means with the same letter do not differ significantly (ANOVA and Tukey's HSD test, $P < 0.05$).

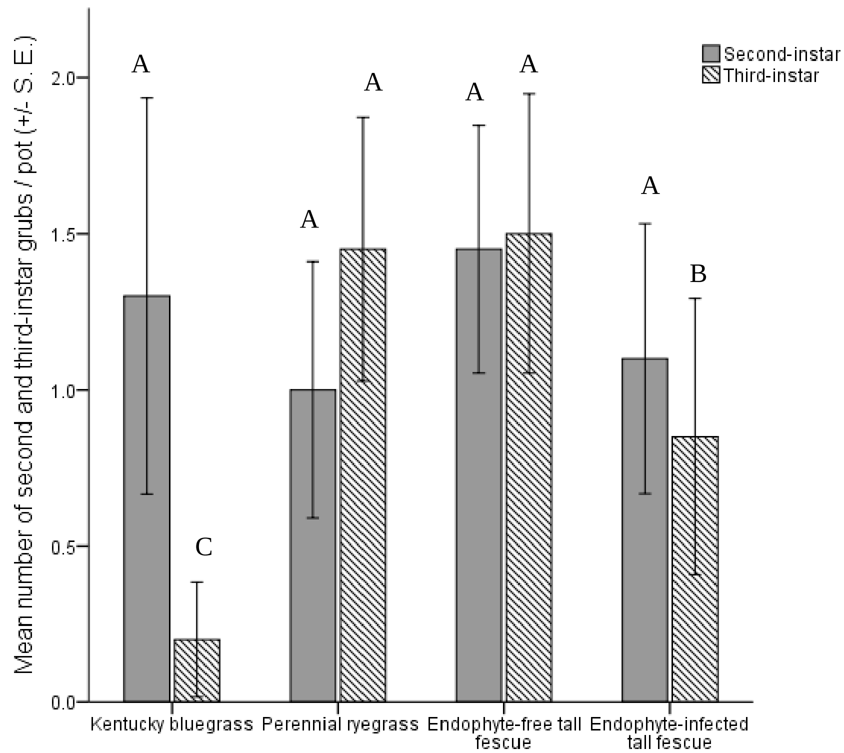

Figure 3. Mean number (± S.E.) of second and third-instar oriental beetles surviving in each grass species. Grubs were implanted as neonate larvae and reared for seven weeks. Means with the same letter do not differ significantly (ANOVA and Tukey's HSD test, $P < 0.05$).

OPTIMIZING PRE-GERMINATION TECHNIQUES FOR THREE TURFGRASS SPECIES: CREEPING BENTGRASS, KENTUCKY BLUEGRASS AND PERENNIAL RYEGRASS

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INTRODUCTION

Turfgrass establishment is a challenging process that oftentimes must occur under suboptimal growing conditions in a very short time period. For many golf course superintendents, sports turf managers and lawn care professionals, seeding at the "agronomically appropriate time" is often not an option when turf cover is lost due to high traffic, excessive divoting, unseasonable weather conditions, or as a result of pest damage. Priming and pre-germinating seed are two processes that can be utilized to speed turfgrass establishment. Priming seed is a procedure where water is added at sufficient levels to induce biological activity without causing radical protrusion (Bush et al., 2000). Conversely, pre-germinating seed is an irreversible action where radical protrusion is imminent. Primed seed has advantages such as ease of spreading and temporary storage, but pre-germinating seed is generally preferred where time is a concern because it is more likely to produce turfgrass cover faster since it has already started the germination process (Stier, 2011).

Currently, many "recipes" exist for pre-germinating seed in various professional publications to increase the rate of seedling development (Brede, 1992; Trulio, 1994; Stier, 2011). Additionally, many variables such as turfgrass species, soaking duration, water temperature, and the moisture content of the seed at seeding are suggested to be important factors in the success of pre-germination (Zapiola and Mallory-Smith, 2010; Stier, 2011). However, none of these studies cite peer-reviewed research with objectives related to pre-germinating seed for the purpose of increasing the establishment rate of turfgrasses. Additionally, previous research investigating methods of pre-germination have limited levels of soaking duration, do not evaluate water temperature as a variable, and do not include some of the most widely used cool-season turfgrass species (Dudeck and Peacock, 1986; Bush et al., 2000). The overall objective of this research was to determine the effect of critical factors such as aeration, soaking duration, and water temperature on the success of pre-germinating turfgrass seed and to optimize these factors by three of the most commonly used species, Kentucky bluegrass (KBG), perennial ryegrass (PRG) and creeping bentgrass (CBG).

MATERIALS AND METHODS

This research consisted of two separate studies. Both studies were conducted in environmentally controlled growth chambers located in the Agricultural Biotechnology Laboratory Building, University of Connecticut, Storrs, CT. Seeds of three species of turfgrass 'Wild Horse' Kentucky bluegrass (Pennington Seed Co., Lebanon, OR - Lot #Z1-10-1182), 'Soprano' perennial ryegrass (Pennington Seed Co., Lebanon, OR - Lot #MG10SOP771) and 'Penn A-4' creeping bentgrass (Tee-2-Green Corp., Canby, OR -Lot #M33-9-139) were used. Seeds for each experiment were taken from the same lot to maintain consistency across both studies. Seed bags were stored at 20 ˚C in an environmental growth chamber until needed.

Study 1: The Effect of Soaking Duration and Aeration on Mean Germination Time (MGT)

The first experiment investigated the effects of soaking duration and aeration on MGT for the three turfgrass species. This study was designed as a 3 x 4 x 2 factorial with an untreated control. Treatments were arranged in a split plot design with aeration as the main plot and species by soaking duration plus the control as the sub-plots. Treatments were replicated by completing three separate runs at 20˚ C in the growth chamber. The first factor, species, had three levels: perennial ryegrass, Kentucky bluegrass, and creeping bentgrass. The second factor, soaking duration, had four levels: 8, 24, 48, and 72 hours (h). The third factor, aeration, had two levels: aeration and no aeration. Plastic buckets (15L) were used as the experimental units and were placed in a growth chamber maintained at 20 ˚C. Deionized (DI) water (8L) was added to each bucket 24h prior to the start of the soaking period to allow the temperature of the water to equilibrate to 20 ˚C. A 6 inch air stone was utilized at the bottom of each bucket containing an aerated treatment to produce a uniform column of bubbles. An air compressor, manifold, and vinyl tubing were used to provide constant air flow throughout each soaking duration to the twelve aerated treatments.

Seeds (900g per bucket) of the appropriate species were then added to each bucket starting with the 72h soaking duration and then continuing sequentially to 48, 24 and 8 h so the seeds could be removed from all the buckets at the same time to allow for simultaneous testing of all treatments. Following pretreatment, 90 seeds were individually placed on moistened, unbleached blotter paper and placed in 15cm x 23cm germination boxes. Untreated seed was used as a control for each species. Each germination box was sealed with HVAC aluminum tape to prevent the blotter paper from drying prematurely. The germination boxes were placed in a growth chamber at 25°C for an 8h photoperiod and were then reduced to 15°C for 16h of darkness. The germination boxes were rotated daily on each shelf to minimize any difference in light intensity. Light intensity was maintained at 750-1150 lux. Radicle protrusion counts were conducted daily for each treatment for a total of 10 days and a final germination count was taken on the 28th day.

Study 2: The Effect of Soaking Duration and Water Temperature on Mean Germination Time

This experiment looked at the effect of various soaking durations and water temperatures on seed germination for the three species, KBG, PRG and CBG. This study was a 3x3x3 factorial nested, split plot with an untreated control. The factors were species, temperature and soaking duration. Soaking duration was nested within soaking temperature. The treatments were arranged in a completely randomized design. Treatments were replicated three times within each run in the growth chamber and three runs were completed. Plastic buckets (15L) were filled with 8L of DI water and allowed to acclimate for 24 h prior to the start of soaking to either 4, 20, or 30 °C depending on the treatment in an environmental growth chamber. Grass seed (900g) was added to each bucket at either 8, 24 or 48h prior to being placed in germination boxes. After soaking times were complete, all the seeds were removed. Ninety seeds were subsampled from each experimental unit and placed onto damp blotter paper and sealed with HVAC aluminum tape in plastic germination boxes. Boxes were placed in an environmental growth chamber set with an 8h photoperiod at 25/15 °C (day/night) temperatures. Germination box positions were rotated daily along each shelf to minimize any differences in light intensity among individual boxes. Light levels were maintained between 750-1150 lux. Radicle emergence was counted daily for each treatment and final counts were taken on day 28.

Mean Germination Time (MGT) is a calculation using a weighted average to determine how long seed will take to germinate. MGT was calculated using the following equation taken from Salehzade, et al. (2009):

$$\text{MGT} = \sum Dn / \sum n$$

where:

n = The number of seeds, which were germinated on day *D*

D = The number of days counted from the beginning of germination

Data were analyzed by analysis of variance and orthogonal contrasts using SAS software (SAS Institute Inc., SAS 9.3, Cary, NC).

RESULTS AND DISCUSSION

Creeping bentgrass

An overall soaking duration main effect was observed for CBG indicating a minimum of 24h soak time is required to increase the speed of germination compared to the control. This main effect must be interpreted with caution since a significant interaction was also observed (Table 1). CBG soaked for 48h with no aeration, had significantly faster germination than the control, as well as the 8 and 24h soak durations. There was no observed detriment to soaking the seed for 72h. For instance the 48 and 72h durations had MGTs of 6.1 and 6.6 days, respectively. When treatments were not aerated, 48 and 72h were less than 8, 24h and the control (Figure 1). Given there was no significant difference between 48 and 72h soaking duration there is no benefit to the additional soak time. However, increased soaking time did not have detrimental effects on seed germination. When treatments were aerated, soak durations of 24, 48 and 72h produced faster MGT than the control. Therefore, the seed soak time could be reduced to 24h if the seed is aerated.

In the study examining the effects of water temperature and soaking duration, a significant temperature and soaking duration interaction can be found (Table 1). Seed soaked for 48h at 20 °C had lowest MGT (Figure 2). At 4 °C, only 8 and 24h decreased MGT compared to the control.

An overall recommendation of soaking at 20 °C for 48 h without aeration would be the optimal speed of germination for CBG. However, if the seed is aerated, soaking time could be reduced to 24h and still achieve statistically equivalent germination time as soaking for 48h with no aeration.

Kentucky bluegrass

Overall soaking duration and aeration main effects were observed for KBG. An 8h soak time reduced MGT compared to the control. However, 24h soak time showed the greatest reduction in MGT. Aerated seeds showed significantly higher MGT (7.1 days) than non-aerated seeds (6.6 days) (Table 1). However, these main effects need to be interpreted with caution since there was also a significant interaction. Soaking seeds at 24, 48 and 72h with no aeration had significantly lower MGT than the control and 8h soaked duration (Figure 3). For this reason turf managers wishing to speed up MGT should not aerate when soaking KBG and there is no additional benefit to soaking for more than 24h.

In the soak duration and temperature optimization study, a significant temperature and soaking duration interaction occurred (Table 1). Results indicate soaking seed at 20 °C for 24h proved to be most beneficial in lowering the MGT. It is also worth noting that even soaking at 4 °C was significantly better than the untreated control (Figure 4). Soaking KBG seed at 20 °C for 24h without aeration would be optimal to speed the germination of KBG.

Perennial ryegrass

No significant differences for soaking duration were observed for PRG in the study examining the effect of aeration and soaking duration on MGT. However, an aeration main effect was observed. Aeration was significant; decreasing MGT to 2.8 days as compared to 3.4 days with no aeration (Table 1). However, aeration requires special equipment and is not always practical when dealing with large volumes of seed. For this reason and for practicality when designing the subsequent experiment aeration was not a factor even though it was significant in the initial experiment.

In the water temperature and soaking duration study, there was no significant difference in soak duration alone (Table 1). There was also no water temperature main effect. However, when an orthogonal contrast comparison was preformed, comparing all the treated seeds (all seeds that had been soaked) to the control, the soaked seeds had lower MGT compared to the untreated control (Table 1). This indicates that the optimal soak duration may be less than 8h. When pre-germinating perennial ryegrass, turf managers should soak the seed for 8h with aeration using water at 20 ºC.

CONCLUSIONS

Overall, aeration had little effect on treatments across turfgrass species with the exception of PRG. Therefore, aeration would is not recommended for pre-germinating KBG and CBG. Soaking duration and temperature had significant effects for KBG and CBG only. KBG MGT was optimal at 20 ˚C water temperature for 24h. CBG MGT was optimal at 20 ˚C for 48h. To optimize MGT of PGR, the seed should be aerated and soaked for 8h, potentially less. These data indicate that soaking duration and water temperature were not critical factors for this species.

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Table 1. Effects of soaking duration, aeration, and temperature on creeping bentgrass (CBG), Kentucky bluegrass (KBG), and perennial ryegrass (PRG) seed Mean Germination Time (MGT).

Main Effects	MGT CBG	MGT KBG	MGT PRG
Duration (DU)			
Control	8.1a†	7.7a	4.2a
8h	7.9a	7.0b	3.2a
24h	7.3b	6.7d	3.1a
48h	6.1c	7.0cb	3.2a
72h	6.6c	6.8cd	3.0a
Aeration (AE)			
Control	8.1a	7.7a	4.2a
No	7.2a	6.6c	3.4b
Yes	7.0a	7.1b	2.8c
Variation Source			
DU	***	**	NS
AE	NS	***	**
DU x AE	*	**	NS

Main Effects	MGT CBG	MGT KBG	MGT PRG
Duration (DU)			
Control	14.0a	8.8a	4.7
8h	12.9b	7.2b	4.2
24h	11.9c	7.0c	4.1
48h	11.1c	6.7d	4.1
Temperature (TP)			
Control	14.0a	8.8a	4.7
4 °C	12.5b	7.5b	4.3
20 °C	11.0c	6.7c	4.1
30 °C	12.3b	6.7c	4.1
Variation Source			
DU	***	***	NS
TP	**	***	NS
DU x TP	**	**	NS
Orthogonal Contrast Control vs. Soaked Seed			***

*, **, ***, NS, Significant at the 0.05, 0.01, 0.001 probability levels, and not significant ($p > 0.05$), respectively.

† Means in a column for a main effect followed by the same letter are not significantly different according to Fisher's Protected LSD (P<0.05).

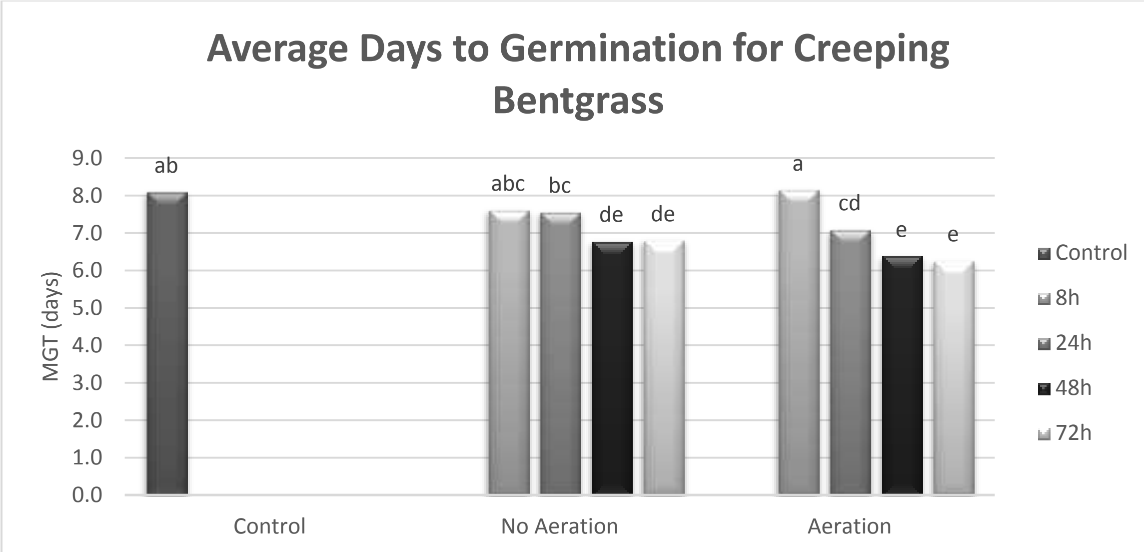

Figure 1. Effects of soaking duration and aeration on mean germination time for creeping bentgrass. (Columns with the same lettering are not significantly different from one another according to Fisher's Protected LSD (P<0.05).)

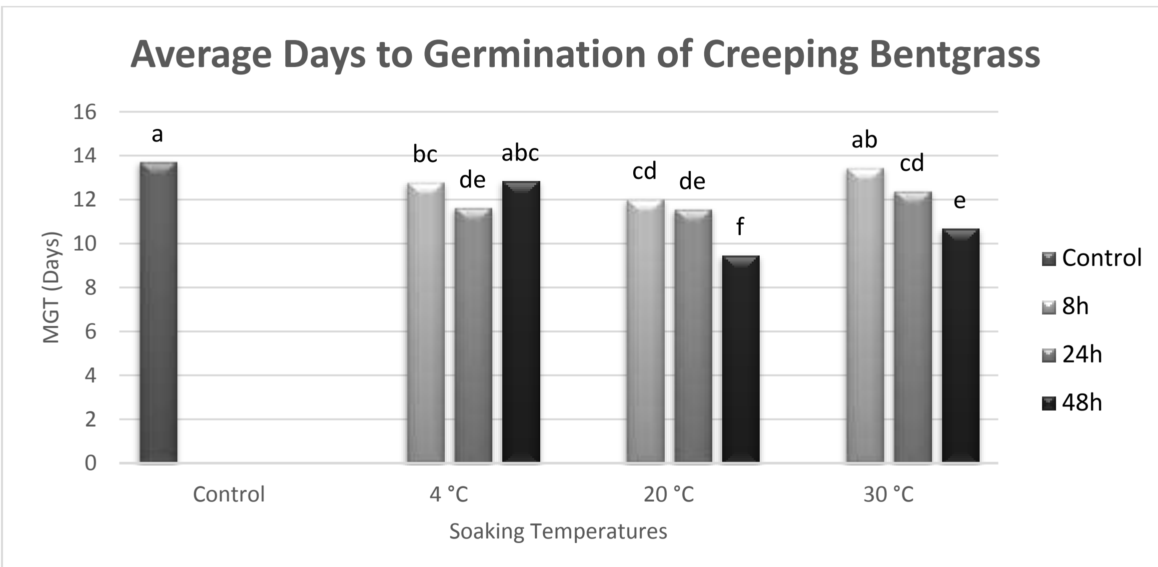

Figure 2. Effects of soaking duration and temperature on mean germination time for creeping bentgrass. (Columns with the same lettering are not significantly different from one another according to Fisher's Protected LSD (P<0.05).)

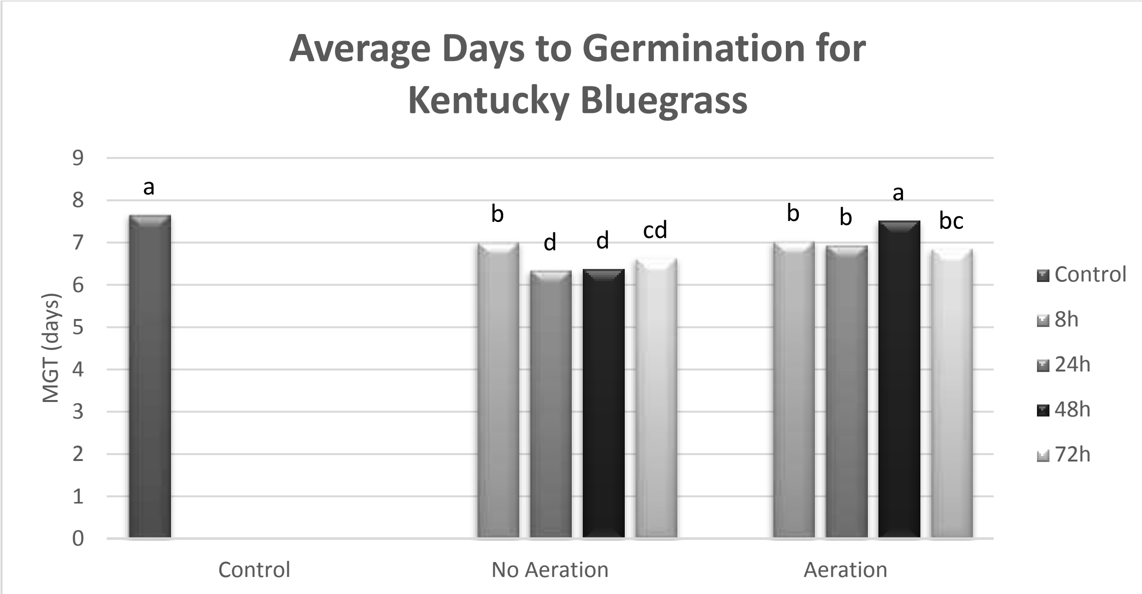

Figure 3. Effects of soaking duration and aeration on mean germination time for Kentucky bluegrass. (Columns with the same lettering are not significantly different from one another according to Fisher's Protected LSD ($P<0.05$).)

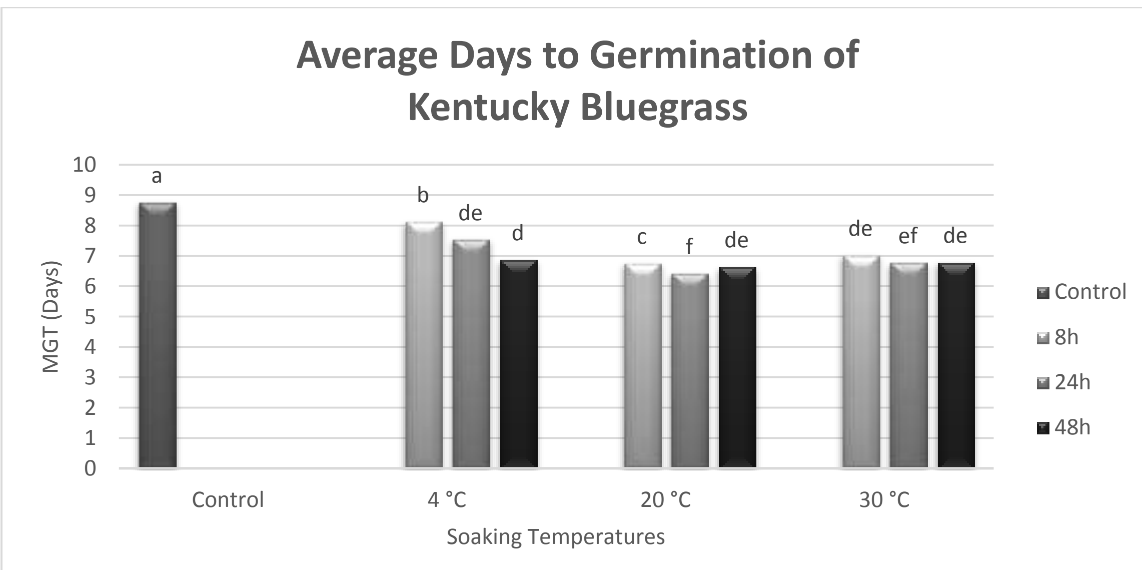

Figure 4. Effects of soaking duration and temperature on mean germination time for Kentucky bluegrass.. (Columns with the same lettering are not significantly different from one another according to Fisher's Protected LSD ($P<0.05$).)

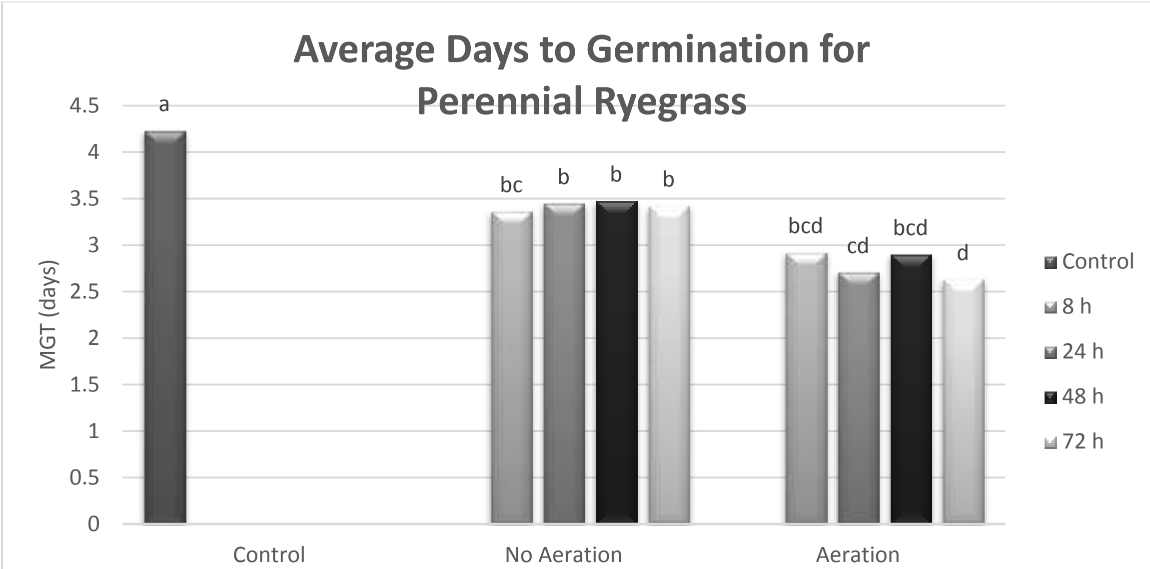

Figure 5. Effects of soaking duration and aeration on mean germination time for perennial ryegrass. (Columns with the same lettering are not significantly different from one another according to Fisher's Protected LSD (P<0.05).

EVALUATING ALTERNATIVE PESTICIDE-FREE ATHLETIC FIELD MANAGEMENT STRATEGIES FOR NEW ENGLAND

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INTRODUCTION

As of July 1, 2010, the state of Connecticut has banned the use of all lawn care pesticides on athletic fields at public and private schools that service pre-K through 8th grades. This legislation has caused great concern particularly for athletic field managers due to the nature of the traffic athletic fields endure and the liability associated with their use. However, very little research based information is available regarding managing athletic fields without the use of pesticides.

Athletic fields are in a constant state of re-establishment due to their high use and intensity of traffic. This persistent turfgrass wear and reduction in turfgrass cover creates a competitive environment. Turfgrass diseases and/or insects may turn a well-established turfgrass stand into an unstable playing surface. Biological controls for turfgrass diseases and insects have shown promise, but maintaining a sufficient population of the beneficial organisms to be effective has been challenging. This combined with the prohibitive cost of application has reduced the turfgrass managers' confidence in these types of pest control strategies.

The best turfgrass species for a cool-season athletic field has traditionally been a mixed stand of Kentucky bluegrass and perennial ryegrass. The rhizomatous growth habit of Kentucky bluegrass combined with the fast germination and development of perennial ryegrass has been considered ideal. However, excessive wear and subsequent weed competition during periods of low recuperative growth for cool-season grasses have negatively impacted athletic field quality. The genetic improvements of several turfgrass species merit revisiting the question of the best turfgrass species for cool-season athletic fields, most notably the use of bermudagrass. Bermudagrass spreads by both rhizomes and stolons and is extremely aggressive during its active growth period (i.e. summer).

Topdressing natural turfgrass playing surfaces with crumb rubber has been researched since the mid-1990's. Previous research has revealed significant advantages to adding crumb rubber to a turfgrass system such as improving traffic tolerance, soil physical properties, and surface playing characteristics. Benefits have included increased turfgrass density, faster spring greenup, greater root mass, lower surface hardness and lower soil bulk density values (Rogers et al., 1998, Baker et al., 2001, and Goddard et al., 2008). However, the potential synergistic effects of alternative athletic field turfgrass species and crumb rubber topdressing on turfgrass cover, weed population and playing surface characteristics have not been researched in New England. Crumb rubber located at the playing surface increases surface temperatures potentially extending the growing season for bermudagrass; warming soils sooner in the spring and keeping them warm later in the fall. Additionally, the stoloniferous growth habit of the bermudagrass will help form a dense contiguous community with the crumb rubber layer at the surface potentially suppressing competing weeds.

The objectives of this research are to determine the effect of turfgrass species and crumb rubber topdressing on; 1) turfgrass color, quality, cover and weed populations and, 2) playing surface characteristics for athletic fields subjected to simulated traffic.

MATERIALS AND METHODS

The research is separated into two separate studies (warm-season and cool-season grasses). A randomized complete block design arranged in a 4 x 2 x 2 factorial with three replications is being utilized for each study. The first factor in each study is turfgrass species. The warm-season study consists of three bermudagrass cultivars; 'Riviera', 'Yukon', and 'Latitude 36' (seeded/sprigged June 20, 2013) and one perennial ryegrass cultivar, 'Fiesta 4' perennial ryegrass (seeded on September 13, 2013). The cool-season study consists of 'Supranova', supina bluegrass, 'Granite' Kentucky bluegrass,' Mustang 4' tall fescue and 'Fiesta 4' (seeded on May 30, 2013.

Figure 1. a) 'Latitude 36' bermudagrass was established via sprigs while two other varieties, 'Yukon' and 'Rivera' were seeded. b) Sprigs were then cleated into the soil and topdressed with a fine layer of soil to assist with root development.

The second factor, crumb rubber topdressing has two levels; 1) yes, 2) none and is the same for both studies. In late September, 2013, crumb rubber (10/20 mesh) was applied to the cool-season study at a rate of 0.75 inch per plot and to the warm-season study at a rate of 0.5 inch per plot. The perennial ryegrass in the warm-season study was seeded at a later date than the bermudagrass and was therefore less established at the date of the crumb rubber application and only received half the application of rubber required in the fall of 2013.

The third factor, management has two levels; 1) minimal pesticides applied, and 2) no pesticides and is the same for both studies. The cool-season, minimal pesticide treatments received Tupersan 470 granules at a rate of 3lbs/1000ft^2 at seeding for pre-emergent crabgrass control. SpeedZone (5pts/acre) and Drive 75 DF (1lb/acre) were applied to the minimal pesticide plots of each study on 6 August for post-emergent control of crabgrass and broadleaf weeds. The cool-season study received an application of Compass 50WDG (0.25 oz/1000ft^2) on 15 June to all plots as a curative for pythium foliar blight. Heritage TL (1 fl oz/1000ft^2) and Daconil Ultrex (3.2 oz/1000ft^2) were applied on 19 September to the cool-season minimal pesticide plots to control gray leaf spot. The warm-season study required no fungicide or herbicide applications during the establishment phase. Acelepryn G (1.15lbs/1000ft^2) was applied on 19 August as a preventative insecticide treatment to the minimal pesticide plots to both the cool and warm-season studies.

Figure 2. In September 2013, crumb rubber was applied to cool-season turfgrasses at a rate of 0.75 inch per plot and to the warm-season bermudagrass plots at a rate of 0.5 inch per plot.

Both studies were maintained as an irrigated athletic field and mowed three days a week. The warm-season study was mowed at a height of 1.25 inches and the cool-season study was mowed at 2.5 inches. The warm and cool season study areas received a starter fertilizer (18-24-12 for a total of 0.72lbs of N) application when initially seeded/sprigged. Urea (45-0-0) was applied at a rate of 0.5lbs N 1000ft^{-2} per application every 14-30 days throughout the growing season (May-October) for a total of 4.22 lbs N 1000ft^{-2} for each study.

Digital image analysis was utilized in assessing turfgrass color and cover. Controlled light conditions were provided through the use of a light box. Images were scanned using Sigma Scan Software using the following threshold values; hue=55-125 and saturation=10-100. The Dark Green Color Index (DGCI) was calculated based on hue, saturation and brightness values. Color and quality data was collected on a biweekly basis

RESULTS AND DISCUSSION TO DATE

Results from the first year of this study are limited, since 2013 was an establishment year. Results to date are summarized below. Plots will be subjected to simulated athletic field traffic in spring 2014.

Warm-Season Study

All varieties of bermudagrass were extremely aggressive. Once seeded/sprigged, establishment was rapid and turfgrass cover became dense quickly.

Figure 3. Bermudagrass plots were completely covered within a few weeks of seeding/sprigging. This rapid growth rate competed well with crabgrass and broadleaf weed pressure.

However, the bermudagrass went into dormancy in mid-October (much quicker than the cool-season grasses). The plots with crumb rubber were delayed into dormancy by less than a week. The main concerns with the use of bermudagrass are its ability to survive the harsh winters of Connecticut and its ability to meet the needs of sports turf managers once dormancy occurs.

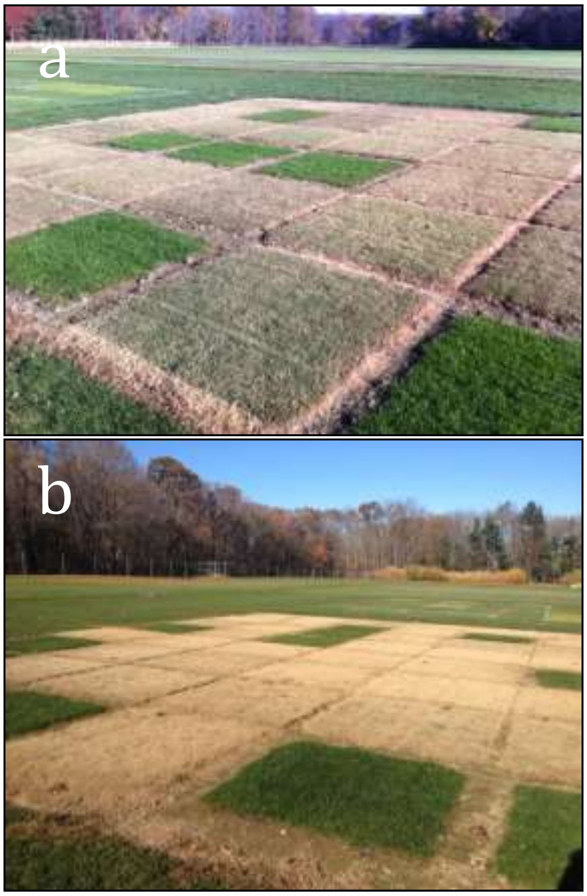

Figure 6. Bermudagrass goes dormant quite quickly once temperatures begin to drop. Crumb rubber applications delayed dormancy about one week a) October 28, b) November 4.

Cool-Season Study

Perennial ryegrass outperformed the other cool-season grasses during the spring establishment phase by achieving higher turfgrass density much faster than the other species. The cool-season plots required two curative fungicide applications and two post-emergent herbicide applications during the establishment phase. However, the warm-season plots required no fungicide or herbicide applications.

Figure 5. Supina bluegrass plots showed increased weed pressure and decreased color without applications of pesticides or crumb rubber.

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ILLINOIS SOIL N TEST (ISNT) AND PERMANGANATE-OXIDIZABLE SOIL CARBON (POXC) CONCENTRATIONS AS PREDICTORS OF LAWN TURF RESPONSE 2013

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INTRODUCTION

The Illinois Soil N Test (ISNT) and the permanganate-oxidizable soil carbon (POXC) test may be able to predict the responsiveness of turf sites to N fertilization. The ISNT and POXC are thought to detect the amount of potentially labile N and C in soils, which is correlated to N mineralization and supplying capacity of a soil. In studies with corn, the ISNT has been relatively effective in predicting site responsiveness to N fertilization, especially when organic matter is taken into account, and POXC has correlated well with soil microbial activity. If applicable to turf, these tests may help guide N fertilization of turf sites so that optimum amounts of N are applied that maximize quality and reduce the threat of N leaching and runoff losses due to excess. These tests may be especially beneficial in guiding N fertilization rates of turf areas that receive organic fertilizers, composts, and amendments.

MATERIALS & METHODS

In September 2007, Kentucky bluegrass (*Poa pratensis*) and turf-type tall fescue (*Festuca arundinacea*; *Lolium arundinaceum*) were established in separate field plot experiments on a fine sandy-loam soil that received varying rates of the organic fertilizer compost Suståne. The experiments were set out as randomized complete block designs with three replicates. Suståne (5-2-4, fine grade, all natural) was applied to 1 × 1 m plots at 23 rates ranging from 0 to 400 kg available N ha^{-1}, and incorporated to a depth of 15 cm on September 3, 2007.Turf was managed as a lawn in subsequent years. Plots were mowed to a 7.5-cm height as needed, and did not receive irrigation. In the late fall of 2008, 2009, 2010, and 2012 plots were solid-tined aerified and compost was applied again to the same plots using the same rates, and brushed into the aerification holes.

In the spring of 2013, soil samples were collected from each plot to a depth of 10 cm below the thatch layer, and analyzed for concentrations of ISNT-N (Khan et al., 2001) and POXC (0.02M $KMnO_4$; Weil et al., 2003). During the 2013 growing season, plots were mowed to a height of 7.5 cm twice a week, or as needed depending on growth. No supplemental irrigation was applied. At approximately two-week intervals after soil sampling, and continuing until the end of October, turf canopy reflectance was measured using Spectrum TCM 500 NDVI and CM 1000 chlorophyll meters (Spectrum Technologies, Inc., Aurora, IL). Nine measurements were taken per plot and averaged for each date. All measurements were taken on dry days between 1100hr and 1400hr. Clippings yield measurements were taken once a month from May through October. Clipping samples were collected from a random $0.05m^2$ area in each plot with hand shears during the same day after meter measurements or one day later, then dried at 65°C for at least 48 h. Monthly clippings dry yield was summed across the growing season for each plot.

Linear regression models were applied for mean NDVI, mean chlorophyll (CHL), and sum of the clippings yields as a function of the spring ISNT-N and POXC concentrations. The REG procedure of SAS 9.3 (SAS Institute, Cary, NC) was used for the statistical analyses.

RESULTS

As an indicator of turfgrass color, NDVI readings were significantly (p<0.001) associated with ISNT-N and soil POXC concentrations for both species in a positive linear relationship (Fig. 1 A, B, C, D), as were TCM 500 chlorophyll readings (Fig. 1 E, F, G, H). The growth response of Kentucky bluegrass and tall fescue lawns, as measured by clippings yield, was positively related in a linear trend (p<0.001 to <0.01) to ISNT-N and soil POXC concentrations (Fig. 1 I, J, K, L).

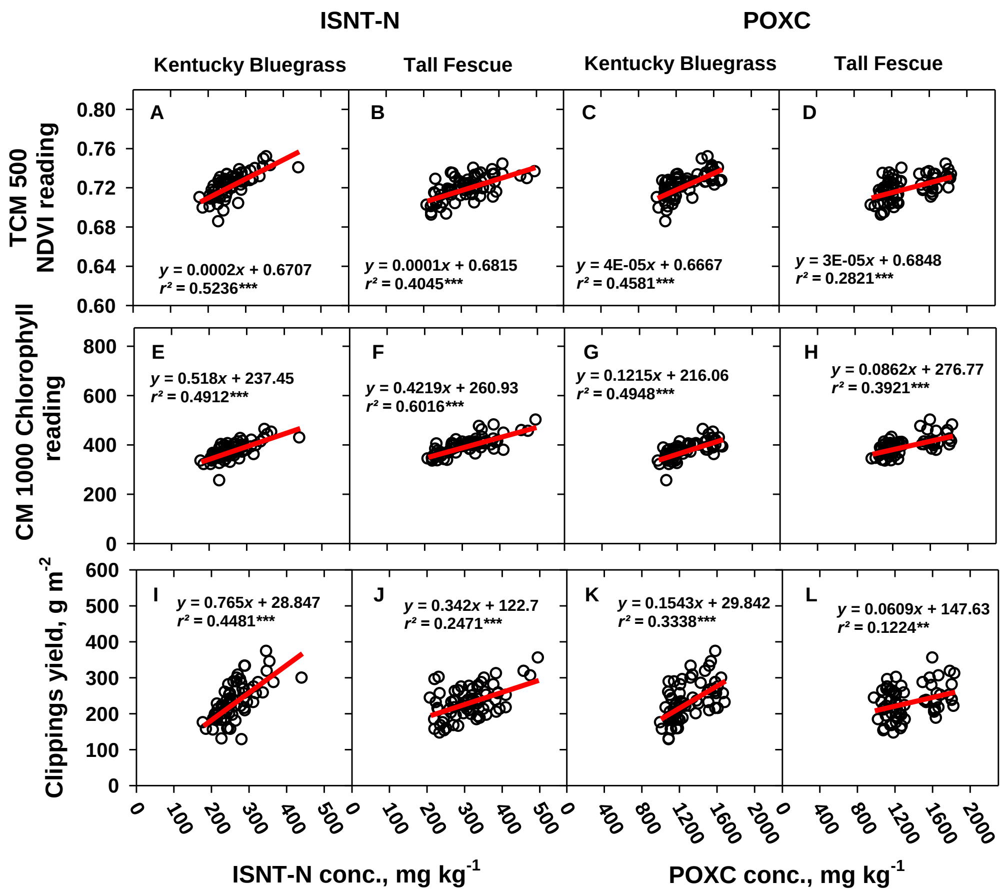

Fig. 1. Response of mean TCM 500 NDVI readings (panels A, B, C, D), mean CM 1000 chlorophyll readings (panels E, F, G, H), and sum of clippings yield (panels I, J, K, L), as a function of ISNT-N and POXC concentrations in 2012. Significance of coefficient of determination (r^2) for the linear response: ** (p<0.01), *** (p<0.001).

Fig. 2. Kentucky bluegrass response to varying rates of compost.

Fig. 3. Tall fescue response to varying rates of compost.

DISCUSSION

The sixth year's results of this study continue to show positive, relationships for Kentucky bluegrass and tall fescue quality and growth responses in response to a single spring measurement of ISNT-N and POXC concentrations. In 2013, the color measurements were more strongly correlated to ISNT-N and POXC than were clipping yields. There was more variation in monthly clipping yields than observed in the color biweekly color measurements.

These responses of Kentucky bluegrass and tall fescue lawns were estimated with reasonable confidence from a single spring soil sample measured for concentrations of ISNT-N (Khan et al., 2001) and POXC (0.02M $KMnO_4$; Weil et al., 2003). Guiding N fertilization based on ISNT-N and/or soil POXC concentrations should help to decrease excess N loading rates, resulting in reduced maintenance costs and lower chances of water quality impairment. Adoption and implementation of these tests to turfgrass systems should also result in better objective guidance for N fertilization than the current practices of historical, subjective practices of N management. Monitoring of the plots will continue through 2014.

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A detailed protocol for the updated POXC method of Weil et al. (2003) can be found at:
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(verified 14 March, 2014).

NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2012 NATIONAL TALL FESCUE TEST

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INTRODUCTION

Turf-type tall fescue has gained in popularity over the last decade. Characteristics that make turf-type tall fescue desirable are: it maintains a dense, dark green color, lower fertility requirements than conventional Kentucky bluegrass/ryegrass home lawns, and it has good traffic tolerance and shade tolerance. Turf-type tall fescue also exhibits excellent drought avoidance characteristics. When trying to reduce inputs such as fertilizer and water, turf-type tall fescue can be a good alternative.

The National Turfgrass Evaluation Program (NTEP) is sponsored by the Beltsville Agriculture Research Center and the National Turfgrass Federation Inc. NTEP works with breeders and testing sites throughout the United States in evaluating turfgrass species and cultivars. Results from turfgrass evaluations can aid professionals in their selection of turfgrass species/cultivars that best meet their needs. Results also aid breeders in selecting new cultivars that they may put into production, as well as helping in marketing their varieties. In 2012 NTEP selected fifteen standard testing sites and eleven ancillary test locations for their 2012 Turf-type Tall Fescue Test. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected as a standard site for the 2012 Turf-type Tall Fescue Test.

MATERIALS AND METHODS

One hundred and sixteen cultivars of Turf-type Tall fescue were seeded on September 11, 2012 in Storrs Connecticut. A complete randomized block design with 3 replicates of each cultivar was utilized for this study. Plot size is 5’ X 5’. Sponsors and entries are listed in Table 1.

Establishment and Management Practices

After seeding plots were covered to aid in germination and to reduce any chances of seed migration. All cultivars received the same management protocol during establishment and throughout the study. Management practices were as follows:

Mowing - Plots were maintained at a mowing height of 2.75 inches and mowed three times per week.
Irrigation - Plots were irrigated during establishment. In 2013 no irrigation was needed or applied.
Fertilizer and pesticide applications
9/11/12 - 0.5 lbs nitrogen /1,000ft^2
10/5/12 - 0.8 lbs nitrogen /1,000ft^2
4/19/13 - 0.42oz/1,000ft^{2}Prodiamine 65 WDG, pre-emergent
4/25/13 – 1.0 lb nitrogen /1,000ft^2.
5/14/13 – 2.9 oz./1,000ft^2 Q4® herbicide, broadleaf control
6/15/13 - 0.32 oz / 1,000ft^2 Acelepryn®, white grub control
7/12/13 - 0.5 lbs nitrogen /1,000ft^2
10/16/13 - 1.4 oz./1,000ft^2 Trimec® broadleaf herbicide
10/23/13 – 1.0 lbs nitrogen /1,000ft^2

Seedling Emergence Ratings

Seedling Emergence ratings were taken and recorded (Table 2) four weeks after planting on October 10, 2012. Emergence ratings were based on percent emergence and seedling vigor.

Gray Snow Mold Ratings

Gray snow mold (Typhula blight) occurrence was evaluated on April 4, 2013. Visual ratings were based on a scale of 1-9, with 9 equaling no disease (Table 2).

Quality Ratings

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2013 growing season. Overall turfgrass quality was determined using a visual rating system of 1-9. A score of 1 illustrates the poorest quality turf and 9 the highest quality. Monthly quality and mean quality ratings are provided in table 2.

Leaf Texture Ratings

While the preferable time to take leaf texture ratings would be in the late spring when the grass is not under stress, texture ratings for the first year were made in the fall of 2013. It was decided to wait until the fall because the plots were immature in the spring of 2013. Future ratings will take place in the late spring. Texture ratings were made using a visual scale with 1 equaling coarse turf and 9 equaling fine (Table 2).

Genetic Color Ratings

Genetic color ratings (Table 2) were evaluated in the fall of 2013. Ratings were based on visual color with 1 being light green and 9 being dark green. Genetic color ratings were taken in the fall due to the immaturity of the plots in the spring of 2013. Future genetic color ratings will be taken in the late spring.

RESULTS & DISCUSSION

Results for establishment ratings, monthly quality ratings, snow mold ratings, genetic color ratings, and leaf texture are provided in Table 2.

During the first full season of this NTEP trial the following general observations were noted. The overall appearance of the entire study illustrated less diversity in color or quality differences between plots than expected. This could be due to the immaturity of the grass combined with the growing conditions of 2013. In Storrs, we had a very wet start coming out of spring followed by a very hot summer.

Table 1- Sponsors and Entries			
SPONSOR	ENTRY	SPONSOR	ENTRY
Semillas Fito S.A.	Terrano	DLF International Seed	IS-TF-272
Standard Entry	Ky-31	Pennington Seed	ATF 1736
Landmark Turf and Native Seed	Regenerate	Brett-Young Seeds	ATF 1754
Semillas Fito S.A	Fesnova	Burlingham Seeds	Hemi
Z Seeds	ZW 44	Burlingham Seeds	Firebird 2
Turf Merchants Inc.	W45	Standard Entry	Bullseye
Turf Merchants Inc.	U43	Pure-Seed Testing, Inc	PST-5EV2
Turf Merchants Inc.	LSD	Pure-Seed Testing, Inc	PST-5GRB
Turf Merchants Inc.	Aquaduct	Pure-Seed Testing, Inc	PST-5SALT
Standard Entry	Catalyst	Pure-Seed Testing, Inc	PST-5SDT
Ledeboer Seed LLC	Marauder	Pure-Seed Testing, Inc	PST-5DZP
Ledeboer Seed LLC	Warhawk	Pure-Seed Testing, Inc	PST-5RO5
Ledeboer Seed LLC	Annihilator	Pure-Seed Testing, Inc	PST-5BPO
Ledeboer Seed LLC	Comp.Res. SST	Pure-Seed Testing, Inc	PST-5BRK
Ledeboer Seed LLC	204 Res.Blk4	John Deere Landscapes	DB1
Jacklin Seed by Simplot	JS 819	John Deere Landscapes	RZ2
Jacklin Seed by Simplot	JS 818	Columbia Seeds LLC	TD1
Jacklin Seed by Simplot	JS 809	Columbia Seeds LLC	DZ1
Jacklin Seed by Simplot	JS 916	Landmark Turf and Native Seed	T31
Jacklin Seed by Simplot	JS 825	Pickseed West Inc.	PSG-GSD
The Scotts Company	MET 1	Pickseed West Inc.	PSG-8BP2
The Scotts Company	F711	Pickseed West Inc.	PSG-TT4
DLF International Seed	IS-TF 291	Standard Entry	Faith
DLF International Seed	IS-TF 276 M2	The Scotts Company	K12-13
DLF International Seed	IS-TF 305 SEL	The Scotts Company	K12-05
DLF International Seed	IS-TF 269 SEL	Peak Plant Genetics	PPG-TF-156
DLF International Seed	IS-TF 282 M2	Columbia Seeds LLC	PPG-TF-157
DLF International Seed	IS-TF 284 M2	Columbia Seeds LLC	PPG-TF-169
Great Basin Seed	OR-21	Columbia Seeds LLC	PPG-TF-170
Great Basin Seed	TY 10	Lewis Seed Company	PPG-TF-137
Great Basin Seed	EXP TF-09	Ampac Seed Company	PPG-TF-135
Seed Research Oregon	SRX-TPC	Lewis seed Company	PPG-TF-115
Pickseed West Inc.	PSG-WEI	Lewis seed Company	PPG-TF-105
Pickseed West Inc.	Pick-W43	Peak Plant Genetics	PPG-TF-172
Pickseed West Inc.	Grade 3	Grassland Oregon	PPG-TF-151
Pickseed West Inc.	PSG-PO1	Peak Plant Genetics	PPG-TF-152
Landmark Turf and Native Seed	U45	Peak Plant Genetics	PPG-TF-148
Pennington Seed	B23	Columbia Seeds	PPG-TF-150
Pennington Seed	ATF 1612	Semillas Fito S.A.	Bizem
Peennington Seed	ATF 1704	Proseeds Marketing	CCR2
Burlingham Seed	Burl TF-2	Proseeds Marketing	Met-3
Burlingham Seed	Burl TF-136	The Scotts Company	W41
Lebanon Turf Products	LTP-FSD	Peak Plant Genetics	PPG-TF-145
Lebanon Turf Products	LTP-TWUU	.Ampac Seed Company	PPG-TF-138
Lebanon Turf Products	LTP-F5DPDR	Landmark Turf and Native Seed	PPG-TF-139
DLF International Seed	IS-TF-289	Landmark Turf and Native Seed	PPG-TF-142
DLF International Seed	MET 6 SEL	Columbia Seeds LLC	RAD-TF-89
Columbia Seeds LLC	IS-TF-330	Radix Reasearch	RAD-TF-92
Columbia Seeds LLC	TF-287	Grasslands Oregon	GO-DFR
Columbia Seeds LLC	IS-TF-307 SEL	The Scotts Company	K12-MCD
Columbia Seeds LLC	IS-TF 308 SEL	Pure-Seed Testing Inc.	PST-5EX2
Brett-Young Seeds	IS-TF-311	Pure-Seed Testing Inc.	PST-5MVD
Brett-Young Seeds	IS-TF-285	Oak Park Farms	RAD-TF-83
Brett-Young Seeds	IS-TLF 310 SEL	Grassland Oregon	RAD-TF 88

Table 1 (continued) - Sponsors and Entries			
SPONSOR	**ENTRY**	**SPONSOR**	**ENTRY**
Barenbrug USA	BAR Fa 120878	Pure-Seed testing Inc.	PST-R5NW
Barenbrug USA	BAR Fa 121089	Burlingham Seeds	Burl TF 69
Barenbrug USA	BAR Fa 121091	Standard Entry	Falcon IV
Barenbrug USA	BAR Fa 121095	Standard Entry	Falcon V

Figure 1. 2012Turf-Type Tall Fescue NTEP Trial, University of Connecticut (photo September 2013).

Table 2. Tall Fescue NTEP results 2013 for emergence (%), gray snow mold incidence (rating 1-9, where 9 equals no disease), turfgrass quality (rating 1-9, where 9 equals the highest turf quality), leaf texture (rating 1-9, where 9 equals the finest texture leaf blade), and genetic Color (rating 1-9, where 9 equals the darkest color).

	Emergence, %	Gray snow mold	Quality								Texture	Genetic color
Entry	10/10/13	04/04/13	04/23/13	05/24/13	06/19/13	07/22/13	08/22/13	09/24/13	10/30/13	mean	10/16/13	10/30/13
204 Res. Blk4	58.3	2.3	5.0	5.3	4.7	5.0	4.7	4.7	5.7	5.0	7.0	5.3
Annihilator	63.3	3.0	5.3	6.3	5.0	5.0	5.0	5.0	6.7	5.5	5.0	7.0
Aquaduct	58.3	4.7	6.0	5.7	5.3	6.0	5.7	4.3	5.0	5.4	4.0	6.0
ATF 1612	64.3	5.0	6.0	6.7	6.0	6.3	6.0	6.3	6.0	6.2	5.0	5.7
ATF 1704	56.7	5.7	7.3	7.3	7.0	6.3	6.7	6.3	6.3	6.7	5.3	6.0
ATF 1736	56.7	5.3	6.7	6.7	6.3	6.3	5.7	6.0	6.3	6.3	5.7	4.7
ATF 1754	53.3	5.7	6.0	6.3	6.3	6.0	6.3	6.0	6.0	6.2	6.0	5.3
B23	66.7	4.0	6.0	5.7	6.0	6.0	6.0	6.7	6.0	6.1	6.3	6.3
BAR Fa 120878	58.3	4.7	6.0	5.3	4.7	5.7	4.7	5.7	6.0	5.5	3.3	4.7
BAR Fa 121089	53.3	3.3	5.0	5.0	5.3	5.3	5.7	6.3	5.3	5.4	4.3	6.0
BAR Fa 121091	51.7	4.0	5.3	5.0	4.7	5.3	5.0	5.3	4.7	5.1	4.0	7.0
BAR Fa 121095	51.7	3.3	5.0	5.3	5.3	5.3	5.7	5.0	5.7	5.3	5.0	6.7
Bizem	56.7	6.0	6.0	6.0	6.3	5.3	6.3	6.3	6.7	6.1	5.7	5.3
Bullseye	61.7	4.7	6.3	5.7	6.3	5.7	5.7	5.7	6.0	5.9	5.3	6.0
Burl TF-136	62.7	5.3	5.7	6.3	5.7	7.0	6.3	6.3	5.7	6.1	6.0	5.3
Burl TF-2	55.0	6.3	6.0	5.7	5.7	6.0	6.0	6.7	6.3	6.1	6.0	6.0
Burl TF-69	53.3	3.7	6.0	5.3	5.7	5.0	6.0	6.0	7.0	5.9	6.3	6.7
Catalyst	63.3	5.0	6.3	5.7	5.3	5.7	5.7	6.0	6.0	5.8	5.7	6.3
CCR2	56.7	5.7	6.3	6.3	7.0	5.7	6.7	6.7	6.7	6.5	6.7	5.3
Comp. Res. SST	56.7	4.0	5.7	5.3	5.3	5.7	5.3	4.3	5.7	5.3	4.7	6.7
DB1	56.7	3.7	6.7	6.0	5.7	5.7	6.7	5.7	6.3	6.1	6.0	6.0
DZ1	51.7	5.7	6.0	6.3	6.0	7.0	6.7	6.0	6.3	6.4	5.7	6.0
Exp TF-09	56.7	4.3	6.0	5.0	4.3	4.7	5.0	5.0	5.7	5.1	4.7	7.3
F711	68.3	6.3	6.7	6.3	6.3	6.3	6.3	6.3	6.0	6.3	6.0	5.0
Faith	58.3	3.7	6.3	6.0	6.7	6.0	6.0	6.3	6.3	6.2	5.7	6.3
Falcon IV	65.0	4.3	6.0	6.7	6.0	6.0	6.0	6.3	6.0	6.1	5.0	6.3
Falcon V	53.3	5.7	5.7	6.0	6.3	6.0	6.3	6.7	6.3	6.2	5.3	6.3
Fesnova	58.3	4.7	6.7	6.7	6.3	6.0	6.3	6.7	7.0	6.5	5.7	6.3

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Firebird 4	53.3	6.0	6.0	6.0	6.0	6.0	5.3	6.0	5.3	5.8	5.0	5.7
GO-DFR	56.7	4.0	5.3	5.3	5.3	6.0	5.7	5.7	5.3	5.5	5.0	6.3
Grade 3	63.3	4.3	7.0	6.7	5.7	6.3	6.3	6.3	6.3	6.4	5.7	6.3
Hemi	60.0	5.7	6.7	6.0	6.7	6.3	6.3	7.0	7.0	6.6	6.3	5.7
IS-TF 269 SEL	58.3	4.3	6.0	5.7	6.0	5.7	5.7	6.0	6.3	5.9	6.0	6.0
IS-TF 272	51.7	5.0	5.7	5.7	5.7	5.3	5.0	6.0	6.3	5.7	5.7	7.0
IS-TF 276 M2	55.0	3.7	5.7	5.3	5.3	5.7	5.3	5.7	6.0	5.6	5.0	6.7
IS-TF 282 M2	55.0	6.3	6.0	6.0	6.0	5.3	5.3	5.7	6.0	5.8	4.7	6.7
IS-TF 284 M2	51.7	4.7	5.0	5.7	6.0	6.7	6.0	6.0	5.7	5.8	4.7	7.0
IS-TF 285	56.7	5.0	6.0	6.0	6.7	6.0	6.0	6.3	6.7	6.3	5.3	6.0
IS-TF 289	61.7	4.7	6.0	5.7	5.7	5.7	6.0	6.0	6.3	5.9	6.0	6.7
IS-TF 291	55.0	6.3	6.3	6.7	6.0	6.7	6.7	6.0	7.0	6.5	6.3	6.7
IS-TF 305 SEL	63.3	4.3	5.3	6.0	5.7	5.7	5.3	5.7	6.0	5.7	6.0	6.7
IS-TF 307 SEL	53.3	6.3	5.3	5.7	6.0	5.7	5.7	6.3	6.3	5.8	5.3	6.7
IS-TF 308 SEL	50.0	6.7	5.0	5.3	6.0	5.7	5.7	5.7	6.0	5.6	5.3	6.3
IS-TF 310 SEL	65.0	3.3	5.0	6.0	6.0	4.7	6.7	6.3	6.7	5.9	5.7	6.7
IS-TF 311	56.7	5.3	6.7	6.0	6.3	5.7	6.7	6.7	6.0	6.3	6.3	6.3
IS-TF 330	56.7	5.7	7.0	7.0	6.7	6.0	6.7	6.0	6.7	6.6	6.7	7.0
JS809	56.7	4.3	5.7	5.3	5.3	5.7	5.0	5.0	6.3	5.5	5.3	6.3
JS818	60.0	4.0	6.3	7.0	6.7	6.7	5.7	5.0	5.7	6.2	5.0	7.0
JS819	61.7	4.0	5.7	5.3	5.3	5.3	5.3	5.3	5.7	5.4	5.0	6.3
JS825	56.7	4.3	5.7	5.3	5.7	6.0	5.0	5.3	5.3	5.5	3.7	7.0
JS916	53.3	6.7	5.7	4.7	5.0	4.3	4.7	5.0	4.3	4.8	4.3	7.0
K12-05	60.0	3.3	5.3	5.0	5.7	6.3	6.0	6.0	5.7	5.7	5.3	6.7
K12-13	50.0	2.3	4.0	4.0	5.0	4.3	4.7	4.0	4.0	4.3	4.7	5.7
K12-MCD	61.7	4.3	6.3	7.0	6.3	6.3	7.0	6.3	6.7	6.6	5.3	6.3
Ky-31	73.3	5.3	7.0	5.0	3.0	3.7	2.0	2.7	2.7	3.7	2.7	2.0
LSD	60.0	4.3	6.7	6.3	6.3	7.0	6.3	6.3	6.3	6.5	5.7	5.7
LTP-F5DPDR	61.7	6.0	5.7	7.0	6.7	6.3	7.0	6.7	6.3	6.5	6.7	5.7
LTP-FSD	68.3	4.7	6.3	6.0	6.3	6.7	6.0	5.7	6.0	6.1	5.3	5.7
LTP-TWUU	55.0	5.3	7.0	6.0	6.3	6.3	7.0	6.7	6.0	6.5	6.3	5.7
Marauder	53.3	3.3	5.7	5.3	5.0	5.0	5.3	5.0	5.3	5.3	5.3	6.3
MET 1	66.7	5.0	6.0	6.0	5.7	6.0	6.0	6.0	6.7	6.0	5.3	5.7

MET 6 SEL	55.0	5.3	5.7	6.0	6.3	6.3	6.7	6.0	6.7	6.3	6.3	5.0
MET-3	56.7	6.7	6.7	6.3	6.7	6.3	6.0	6.7	6.0	6.4	6.3	5.3
OR-21	55.0	3.7	6.3	7.0	6.0	5.7	5.7	6.0	6.0	6.1	4.7	8.0
Pick-W43	61.7	4.3	5.7	7.3	6.7	6.3	7.0	7.3	6.3	6.7	6.0	6.3
PPG-TF-105	61.7	5.3	6.3	6.3	7.0	6.3	6.3	7.0	6.0	6.5	7.0	6.3
PPG-TF-115	58.3	5.0	6.0	5.3	6.0	5.7	6.3	6.3	6.0	6.0	5.7	6.0
PPG-TF-135	60.0	5.0	6.0	6.0	6.0	6.0	6.7	7.0	6.7	6.3	6.3	5.7
PPG-TF-137	60.0	6.0	6.0	6.3	6.0	5.7	6.0	6.7	6.0	6.1	6.7	6.0
PPG-TF-138	56.7	5.3	6.3	6.0	6.7	6.7	6.3	6.7	6.7	6.5	6.0	5.0
PPG-TF-139	53.3	4.7	5.0	5.3	4.7	5.3	5.0	5.0	5.0	5.1	4.7	5.3
PPG-TF-142	53.3	4.3	4.7	5.3	5.0	5.3	5.7	5.7	5.7	5.3	5.0	7.7
PPG-TF-145	43.3	5.3	5.0	5.3	6.0	5.3	5.0	6.0	5.7	5.5	5.3	6.7
PPG-TF-148	58.3	6.3	6.7	6.7	6.0	6.7	6.7	6.7	6.3	6.5	6.0	5.0
PPG-TF-150	65.0	5.0	6.7	7.0	7.0	6.7	6.7	7.0	6.7	6.8	6.0	6.0
PPG-TF-151	60.0	5.3	6.3	6.3	6.7	6.3	6.3	6.3	6.3	6.4	5.3	6.0
PPG-TF-152	65.0	6.0	6.3	6.7	6.7	5.7	6.0	7.0	6.3	6.4	6.0	6.3
PPG-TF-156	60.0	6.3	7.0	7.7	7.3	6.3	7.0	7.3	7.3	7.1	8.0	5.3
PPG-TF-157	60.0	4.7	6.3	7.7	6.7	7.0	7.3	7.3	7.3	7.1	6.3	7.3
PPG-TF-169	71.7	4.3	6.0	6.0	5.3	5.7	6.0	6.0	6.0	5.9	5.3	5.7
PPG-TF-170	68.3	5.3	7.0	7.0	6.0	6.3	6.7	7.0	6.7	6.7	7.3	6.7
PPG-TF-172	56.7	4.7	6.0	7.0	6.3	6.0	6.3	6.3	6.3	6.3	6.3	5.3
PSG-8BP2	56.7	5.3	6.0	6.3	6.3	6.7	6.0	7.0	6.7	6.4	5.0	6.3
PSG-GSD	58.3	4.3	6.7	6.7	6.3	7.3	6.3	5.7	6.7	6.5	5.3	5.3
PSG-PO1	58.3	5.0	6.3	6.3	7.0	7.0	6.7	7.3	7.3	6.8	6.0	6.3
PSG-TT4	58.3	4.7	5.7	6.3	5.7	5.0	5.7	6.0	5.7	5.7	5.3	6.7
PSG-WE1	58.3	5.3	6.7	6.7	5.7	6.3	6.0	6.3	7.0	6.4	7.0	6.3
PST-57DT	63.3	3.7	6.7	5.7	5.3	6.3	5.3	5.3	5.7	5.8	5.0	4.3
PST-5BPO	55.0	4.7	6.0	6.7	5.0	5.7	6.7	6.7	6.3	6.2	5.3	5.3
PST-5BRK	68.3	4.3	6.7	6.7	7.3	6.3	6.7	6.0	6.7	6.6	6.3	5.0
PST-5DZP	53.3	5.0	5.0	5.0	5.7	5.3	6.0	5.7	6.3	5.6	5.0	5.7
PST-5EV2	55.0	5.7	5.7	5.7	5.7	5.7	6.3	6.0	6.0	5.9	5.0	5.0
PST-5EX2	65.0	4.7	5.0	6.0	5.3	6.0	6.7	6.3	6.0	5.9	5.3	6.0
PST-5GRB	70.0	5.7	7.0	7.0	6.0	5.7	5.7	5.3	5.7	6.0	7.3	5.7

PST-5MVD	60.0	4.0	5.7	6.0	6.0	5.7	5.7	5.7	6.7	5.9	5.0	5.7
PST-5R05	56.7	5.3	6.0	6.0	5.7	5.7	5.7	5.7	6.0	5.8	5.3	6.0
PST-5SALT	63.3	3.7	6.0	5.7	5.3	5.7	6.0	6.0	5.3	5.7	4.7	5.3
PST-R5NW	56.7	5.0	6.0	6.0	5.7	5.7	5.7	5.7	5.7	5.8	4.3	5.3
RAD-TF-83	55.0	3.7	5.0	5.3	5.3	4.3	4.7	5.7	5.7	5.2	5.0	7.0
RAD-TF-88	63.3	3.7	5.7	5.7	5.3	5.3	5.7	6.3	7.0	5.9	6.3	6.7
RAD-TF-89	63.3	3.3	5.3	5.0	5.0	4.3	4.7	5.7	7.0	5.3	5.3	7.0
RAD-TF-92	58.3	4.0	4.7	4.7	4.3	4.0	4.0	5.3	4.7	4.5	5.3	6.7
Regenerate	61.7	5.3	6.7	6.7	6.0	5.7	5.7	6.3	6.3	6.2	6.7	5.3
RZ2	60.0	5.7	6.3	6.0	6.3	6.7	6.7	6.0	6.3	6.4	6.0	5.0
SRX-TPC	60.0	5.3	5.7	5.7	6.0	6.3	6.3	6.3	6.3	6.1	5.0	6.0
T31	56.7	5.3	5.7	5.7	5.7	6.0	6.0	6.3	6.3	5.9	5.3	5.7
TD1	56.7	4.3	5.7	5.3	5.3	6.0	5.3	5.7	5.7	5.6	5.7	6.0
Terrano	53.3	5.0	6.3	5.7	6.3	5.7	5.3	5.3	5.7	5.8	4.7	6.0
TF-287	63.3	5.7	7.0	6.7	6.3	5.7	6.3	6.3	7.3	6.5	6.3	6.0
TY 10	53.3	4.0	5.7	5.7	5.3	4.7	5.3	5.3	6.0	5.4	4.7	7.7
U43	65.0	5.0	7.3	6.7	7.3	6.7	6.7	7.0	7.0	7.0	6.3	6.0
U45	53.3	6.0	5.3	5.7	6.3	5.3	5.7	5.7	6.7	5.8	5.7	6.0
W41	63.3	4.7	5.3	6.0	6.0	6.0	6.0	6.7	6.7	6.1	6.0	6.0
W45	61.7	5.0	5.3	6.0	6.0	4.7	5.7	5.3	6.0	5.6	6.0	5.0
Warhawk	61.7	2.3	5.0	6.0	4.3	5.3	5.3	4.3	5.3	5.1	5.7	7.7
ZW44	61.7	6.0	7.0	6.7	7.3	6.0	6.7	7.3	5.7	6.7	6.3	5.3
$LSD_{0.05}$	8.94	1.60	1.19	1.36	1.33	1.43	1.42	1.20	1.40	0.89	1.33	1.15
CV%	9.5	20.6	12.3	14.1	14.0	15.3	14.9	12.4	14.3	9.3	14.9	11.9

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COOPERATIVE TURFGRASS BREEDERS FIELD EVALUATION OF FINE FESCUE CULTIVARS, 2012-2013

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INTRODUCTION

The 'Cooperative Turfgrass Breeders' Test (CTBT) is a variety evaluation trial program initiated by turfgrass breeders of commercial seed companies to support additional data on experimental cultivars considered for commercial production. Six plant breeding groups contribute to the CTBT program: DLF International Seeds, Peak Genetics, The Pickseed Group, Pure Seed Testing, NexGen Turf Research, and Rutgers' University. The 2011 Fine Fescue Cooperator Trial has 10 locations throughout the United States. The University of Connecticut is one of the chosen locations (figure 1). Site cooperators collect data on turf quality, color and density. Turfgrass injury as related to insect, disease, drought, wear, and shade is also noted. Cultivars are evaluated for two years from the date of establishment.

MATERIALS AND METHODS

Ninety-nine cultivars of fine fescues were established on September 15, 2011 in Storrs Connecticut. A complete randomized block design with 3 replicates of each cultivar was utilized for this study. Plot size is 3' X 5'. Cultivars, species, and sponsors are listed in Table 1.

Establishment & Management Practices

All Cultivars received the same management protocol during establishment and throughout the study. Plots were planted on September 15, 2011 and were fertilized at the time of seeding at the rate of 1 pound of nitrogen per 1,000 ft^2. Plots were maintained at a mowing height of 2 ¾" height of cut and were mowed approximately 2 times per week. No supplemental irrigation was applied during the growing season.

Fertilizer and Pest Management Applications

Plots were treated in April 2013 with a pre-emergent crabgrass control (prodiamine)/fertilizer combination product. Trimec® broadleaf herbicide control was applied May 2013. Plots were treated with imidacloprid for white grub control June 2013. (2012 management practices can be viewed in the UConn CANR 2012 Annual Turfgrass Research Report).

Quality ratings

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2013 growing season. Overall turfgrass quality was determined using a visual rating system of 1-9. A score of 1 illustrates the poorest quality turf and 9 the highest quality.

RESULTS & DISCUSSION

Mean overall turfgrass quality results are provided in Table 2. During the 2013 season the following observations were noted: Early in the season, the hard fescues consistently rated higher in overall turfgrass quality when compared to the Chewings fescue and creeping red fescue cultivars. However, during the prolonged wet June, followed by intense summer heat early in July, the hard fescues suddenly experienced extreme and rapid dieback. Examination for the cause of the decline was attributed to a physiological decline in the species and many of the cultivars were unable to re-establish for the remainder of the season, leaving open space for weeds to establish.

Figure 1. Commercial Turfgrass Breeders Fine Fescue Test University of Connecticut.

Table 1- Sponsors and Cultivars			
SPONSOR	**CULTIVAR**	**SPONSOR**	**CULTIVAR**
Hard Fescues (Sheep)		***Strong Creeping Red Fescue***	
NexGen	AHF203	Peak Genetics	PPG-FRR106
Peak Genetics	Blue Ray	DLF	IS-FRR65
Peak Genetics	Beacon	Peak Genetics	PPG-FRR105
PSG	3J2927	Peak Genetics	PPG-FRR102
NexGen	AHF181	NexGen	Lustrous
PSG	SR 3150	PSG	5J51-15
DLF	IS-FL47	NexGen	ASC332
PSG	AZB (Sheep)	NexGen	ASC295
PSG	Azay Blue (sheep)	PSG	5RJ1L
DLF	IS-FL48	NexGen	ASC313
PSG	3TH3	PSG	ORC 126
NexGen	AHF204	NexGen	ASC321
DLF	IS-FL50	DLF	IS-FRR68C
PST	Big Horn GT (Sheep)	DLF	IS-FRR62
PSG	Spartan II	NexGen	ASC320
PST	4BIL	PSG	5RJ1E
PSG	S2SE	NexGEN	ASC323
PST	4HES	DLF	Cindy Lou
NexGen	AHF177	DLF	IS-FRR61
NexGen	AHF188	NexGen	ASC319
Rutgers	Firefly	Peak Genetics	PPG-FRR103
DLF	Eureka II	NexGen	ASC333
DLF	IS-FL46	PSG	OS2
PST	Soil Guard	PST	4GRY
PST	4NY	Peak Genetics	PPG-FRR104
Chewings Fescue		PST	4CRD-8
NexGen	ACF277	PST	4RED
PST	Enchantment	PST	4CR10-08
NexGen	ACF278	PST	4CRD-U
Peak Genetics	Radar	PST	4CRD-P
Peak Genetics	PPG-FRC103	PST	Shademaster III
DLF	Wrigley 2	PSG	SO
NexGen	ACF 261	PSG	SDT
PSG	FC 09-2	PSG	Gamet
PST	4CHY	PSG	SHST
PSG	50C3	PSG	SDHT
DLF	IS-FRC36	PSG	SG
DLF	IS-FRC37	PSG	SHSM
NexGen	ACF256	PSG	Boreal
NexGen	ACF283	***Slender Creeping Red Fescue***	
Peak Genetics	Koket	NexGen	ASR184
DLF	Longfellow II	PST	4SEA
PST	R4TC	NexGen	ASR176
DLF	Longfellow lll	NexGen	ASR181
PST	4CHT	NexGen	ASR172
Rutgers	Intrigue ll	Peak Genetics	Navigator II
PST	PST-4C30D	PSG	PSG 5RM
PST	4SHR-CH	PST	Seabreeze GT
PSG	PSG SPRS	PSG	Oracle
NexGen	Culumbra ll	PSG	07-1FF
NexGen	Survivor (ACF 266)		

Table 2- Turfgrass Quality Ratings

CULTIVAR *Hard Fescues (Sheep)*	Average Quality Rating 2012	Average Quality Rating 2013	Average Quality Rating 2012-2013	CULTIVAR *Strong Creeping Red Fescue*	Average Quality Rating 2012	Average Quality Rating 2013	Average Quality Rating 2012-2013
AHF203	6.25	5.09	5.67	PPG-FRR106	5.63	4.96	5.29
Blue Ray	6.17	5.75	5.96	IS-FRR65	5.29	5.00	5.15
Beacon	6.17	5.67	5.92	PPG-FRR105	5.29	5.38	5.34
3J2927	6.13	5.38	5.75	PPG-FRR102	5.25	5.13	5.19
AHF181	6.04	4.88	5.46	Lustrous	5.25	4.80	5.02
SR 3150	6.00	5.92	5.96	5J51-15	5.13	5.13	5.13
IS-FL47	6.00	5.71	5.86	ASC332	5.04	5.21	5.13
AZB (Sheep)	6.00	4.46	5.23	ASC295	5.00	5.17	5.09
Azay Blue (sheep)	6.00	4.71	5.36	5RJ1L	4.96	4.50	4.73
IS-FL48	5.92	5.67	5.79	ASC313	4.96	5.09	5.02
3TH3	5.79	5.21	5.50	ORC 126	4.92	5.13	5.02
AHF204	5.71	3.67	4.69	ASC321	4.92	4.67	4.79
IS-FL50	5.71	5.34	5.52	IS-FRR68C	4.92	4.79	4.86
Big Horn GT Sheep)	5.54	5.13	5.33	IS-FRR62	4.88	4.34	4.60
Spartan II	5.54	5.13	5.34	ASC320	4.88	5.09	4.98
4BIL	5.50	5.59	5.54	5RJ1E	4.84	4.75	4.79
S2SE	5.50	4.67	5.09	ASC323	4.80	4.96	4.88
4HES	5.46	4.54	5.00	Cindy Lou	4.79	4.17	4.48
AHF177	5.46	4.08	4.77	IS-FRR61	4.79	4.50	4.65
AHF188	5.46	4.25	4.86	ASC319	4.79	4.67	4.73
Firefly	5.34	5.17	5.25	PPG-FRR103	4.79	4.88	4.84
Eureka II	5.34	4.75	5.04	ASC333	4.71	4.75	4.73
IS-FL46	5.29	3.84	4.56	OS2	4.67	4.67	4.67
Soil Guard	5.13	4.50	4.81	4GRY	4.63	5.00	4.81
4NY	4.96	4.17	4.57	PPG-RR104	4.59	4.17	4.38
	Chewings Fescue			4CRD-8	4.54	4.04	4.29
ACF277	5.42	5.04	5.23	4RED	4.46	4.42	4.44
Enchantment	5.42	5.25	5.33	4CR10-08	4.46	4.50	4.48
ACF278	5.38	5.33	5.36	4CRD-U	4.42	4.34	4.38
Radar	5.34	5.42	5.38	4CRD-P	4.42	4.17	4.29
PPG-FRC103	5.25	5.63	5.44	Shademaster III	4.34	4.13	4.23
Wrigley 2	5.21	5.42	5.31	SO	4.34	4.46	4.39
ACF 261	5.21	5.42	5.31	SDT	4.21	4.04	4.13
FC 09-2	5.17	5.04	5.11	Gamet	4.13	4.38	4.25
4CHY	5.13	4.96	5.05	SHST	4.04	4.00	4.02
50C3	5.13	5.38	5.25	SDHT	4.00	4.38	4.19
IS-FRC36	5.09	5.29	5.19	SG	3.96	3.96	3.96
IS-FRC37	5.04	5.34	5.19	SHSM	3.88	4.17	4.02
ACF256	5.04	5.34	5.19	Boreal	3.63	4.29	3.96
ACF283	5.04	5.59	5.31	***Slender Creeping Red Fescue***			
Koket	5.00	4.46	4.73	ASR184	5.29	5.63	5.46
Longfellow II	5.00	5.04	5.02	4SEA	5.21	4.59	4.90
R4TC	4.96	5.42	5.19	ASR176	5.21	4.34	4.77
Longfellow lll	4.92	5.21	5.06	ASR181	4.96	5.38	5.17
4CHT	4.92	5.25	5.09	ASR172	4.88	5.09	4.98
Intrigue ll	4.83	5.25	5.04	Navigator II	4.75	4.17	4.46
PST-4C30D	4.71	5.13	4.92	PSG 5RM	4.46	4.63	4.54
4SHR-CH	4.71	5.08	4.90	Seabreeze GT	4.34	4.21	4.27
PSG SPRS	4.50	4.79	4.65	Oracle	3.88	3.96	3.92
Culumbra ll	4.50	5.09	4.79	07-1FF	3.29	3.63	3.46
Survivor (ACF 266)	4.46	5.17	4.81	***LSD (0.05)***	0.51	0.94	0.61

TOLERANCE OF PERENNIAL RYEGRASS VARIETIES AND BLENDS TO GRAY LEAF SPOT IN CONNECTICTUT, 2013

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INTRODUCTION

Gray leaf spot (GLS) is the most devastating disease of perennial ryegrass (*Lolium perenne* L.) turf. The disease is caused by the fungus *Magnaporthe oryzae,* and periodically affects perennial and annual ryegrass during August and September in the Northeast. Initially, symptoms may appear similar to drought stress, with dried, twisted leaf tips. However, symptoms can rapidly progress to thinning of the turf stand and complete collapse of affected areas. In the past 2-3 years, an increase of this disease has been observed in the region wherever ryegrass is grown (e.g., athletic fields, golf courses, residential and commercial lawns).

Perennial ryegrass breeding programs have greatly improved our ability to manage GLS through the development of new tolerant varieties. However, the degree of GLS tolerance of new varieties can vary. The objective of this trial was to evaluate GLS tolerance of several new commercially available varieties and developmental accessions seeded individually or as blends.

MATERIALS & METHODS

A field study was established as lawn turf on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT in 2013. New commercially available cultivars or developmental accessions of perennial ryegrass were seeded individually or as blends. All plots were seeded on 15 July at 8.0 lbs 1000-ft^{-2} unless otherwise noted in Table 1. Treatments overseeded during the gray leaf spot epidemic received an additional 4.0 lbs 1000ft^{-2} on 5 and 11 September for a total overseeding rate of 8.0 lbs 1000ft^{-2}.

Nitrogen was applied at 1.0 lb 1000-ft^{-2} at seeding and on 6 August as 18-9-18 (14% water soluble N). An additional 1.0 lb N 1000-ft^{-2} was applied as urea over the duration of the trial. Segway was applied on 10 August to prevent pythium blight, and ProStar was applied on 10 and 19 August for brown patch control. Speedzone was applied for control of broadleaf weeds on 19 August. Once the turf was mature, the field was mowed at 2.75 inches once per week. The trial area was irrigated 3 times per day to maintain leaf wetness and encourage disease development.

The study was inoculated the evening of 7 August with a solution containing three isolates of *Magnaporthe oryzae* at a total concentration of 16,292 conidia mL^{-1} applied in a carrier volume of 2 gal 1000-ft^{-2} using a backpack sprayer. Following inoculation, the trial area was covered overnight with a plastic tarp to increase relative humidity and temperatures to promote infection.

Gray leaf spot severity was visually assessed on a 1-9 scale from 26 August to 8 October; where 9 represented disease-free turf and 5 was the minimum acceptable level. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Turf color was measured on 14 August with a Spectrum TCM500 NDVI Turf Color Meter (Spectrum Technologies Inc., Plainfield, IL). All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS & DISCUSSION

Gray leaf spot symptoms initially developed in the trial area on 15 August, 8 days after inoculation. Disease progressed slowly until 26 August (Table 1) as overnight temperatures and humidity increased. The epidemic continued to develop during late-August and early-September, reaching a peak on 5 September. Disease progress slowed by mid- to late-September and recovery began to occur by 8 October.

Single Varieties

All single variety entries contained obvious GLS symptoms by 26 August, except Karma which had almost no disease. Several varieties or accessions tolerated the disease to a limited extent early on, providing an acceptable level of disease control on this date. These included: Bargamma, Barorlando, Pirouette II, Double Time, Express II, BAR Lp 10970, 12-(11-LPS109), 12-(11-LPS117), and 12-Lp(4x) 129. However, 10 days later, during the peak of the epidemic, all single variety entries, except Karma, contained unacceptable levels of GLS (Fig. 1). Karma remained nearly disease free from this time through the end of September. Conditions were less favorable for GLS in late September and October, permitting disease recovery to occur in most plots. Express II and 12-(11-LPS117) recovered to an acceptable level of damage by 8 October.

Blends

Perennial ryegrass blends incorporating Karma (GLS tolerant) with moderately GLS susceptible varieties such as Double Time or Express II improved tolerance of the turfgrass stands to GLS. Double Time and Express II failed to provide acceptable disease control during the height of the epidemic when seeded individually (Table 1). However, adding as little as 1/3rd of Karma (1:3) to a seed blend containing Double Time or Express II improved stand performance compared to either of the latter varieties seeded individually, resulting in an acceptable level of disease control, albeit poor (Table 1). Better results were achieved, when equal parts (1:1) of Karma and Double Time or Express II were blended and seeded together. Under reduced disease pressure, in late-August and late-September, equal parts of a tolerant and susceptible variety (1:1) were just as effective in suppressing disease as a blend containing a majority of Karma (3:1). However, during high disease pressure (5 – 13 September) blends with a majority of Karma did provide better disease control compared to equal blends (1:1).

Overseeding

Ryegrass seedlings and young plants, even of tolerant varieties, are purported to be more susceptible to GLS than established plants. Therefore, overseeding an area with active GLS disease with ryegrass is often discouraged until environmental conditions are no longer favorable for disease. However, in the current trial overseeding GLS blighted turf (Susceptible Blend 1:1:1) with Karma during the epidemic helped promote recovery by 8 October (Table 1). Moreover, little change in disease severity was observed in Karma plots overseeded during the epidemic with Express II or Karma.

CONCLUSIONS

Perennial ryegrass cultivars vary greatly in their tolerance to GLS. Blends incorporating even a small portion (1/3rd) of a tolerant variety can improve the overall perennial ryegrass stand resilience to GLS. However, areas routinely affected with GLS (i.e., favorable disease conditions) or areas with little tolerance for turf decline should select a blend containing 50% or more of a tolerant variety. Further research evaluating the impact of overseeding during GLS epidemics is needed. However, in the meantime turf managers should continue to follow current recommendations to delay overseeding of GLS affected areas with ryegrass until conditions become less favorable for disease.

Table 1. Gray leaf spot severity on various newly seeded perennial ryegrass varieties at the Plant Science Research and Education Facility in Storrs, CT during 2013.

Entry[z]	Rate per 1000ft^2	Gray Leaf Spot Severity[w] 26 Aug	5 Sept	13 Sept	24 Sept	8 Oct
		------------1-9; 5=min acceptable, 9=no disease -------------				
Baralpha	8.0 lbs	4.8 efg[v]	2.3 ghi	2.3 hi	1.5 mn	3.0 mn
Barbeta	8.0 lbs	3.0 i	1.0 l	1.0 k	1.0 n	2.3 o
Bargamma	8.0 lbs	5.0 efg	2.5 gh	2.3 hi	2.3 kl	4.0 jk
Barlibro	8.0 lbs	4.0 ghi	1.5 jkl	1.5 jk	1.3 n	3.3 lm
Barorlando	8.0 lbs	5.8 de	4.0 e	4.0 f	4.3 gh	5.0 hi
BAR Lp 10970	8.0 lbs	5.0 efg	2.8 fg	2.8 gh	3.3 ij	4.5 ij
12-(11-LpS109)	5.0 lbs	5.5 ef	2.8 fg	3.3 g	2.8 jk	3.8 kl
12-(11-LpS117)	8.0 lbs	6.8 cd	4.0 e	4.3 f	4.8 g	5.5 gh
12-Lp(4x) 129	6.0 lbs	5.5 ef	1.3 kl	1.0 k	1.0 n	2.5 no
LpS2 E+	8.0 lbs	3.5 hi	1.8 ijk	2.0 ij	2.0 lm	3.0 mn
Pinnacle II	8.0 lbs	4.5 fgh	2.8 fg	2.8 gh	3.3 ij	4.0 jk
Pirourette II	8.0 lbs	5.0 efg	3.3 f	3.3 g	3.8 hi	4.5 ij
Double Time	8.0 lbs	6.8 cd	2.8 fg	2.5 hi	2.5 kl	3.8 kl
Cutter II	8.0 lbs	4.5 fgh	2.0 hij	2.8 gh	2.8 jk	3.8 kl
Express II	8.0 lbs	5.8 de	3.3 f	4.0 f	4.8 g	6.0 fg
Karma	8.0 lbs	8.8 ab	8.8 a	8.8 a	8.3 ab	7.8 abc
Double Time Blend (3:1)		7.8 bc	5.3 d	5.0 e	6.0 f	6.3 f
-Double Time	6.0 lbs					
-Karma	2.0 lbs					
Double Time Blend (1:1)		8.5 ab	6.8 c	6.8 c	7.0 de	6.5 ef
-Double Time	4.0 lbs					
-Karma	4.0 lbs					
Double Time Blend (1:3)		9.0 a	8.0 b	7.8 b	7.5 cd	7.3 cd
-Double Time	2.0 lbs					
-Karma	6.0 lbs					
Express II Blend (3:1)		7.0 c	5.8 d	5.8 d	6.5 ef	6.5 ef
-Express II	6.0 lbs					
-Karma	2.0 lbs					
Express II Blend (1:1)		8.5 ab	7.0 c	7.3 bc	7.3 cd	7.0 de
-Express II	4.0 lbs					
-Karma	4.0 lbs					
Express II Blend (1:3)		8.5 ab	7.8 b	8.5 a	7.8 bc	7.5 bcd
-Express II	2.0 lbs					
-Karma	6.0 lbs					
Susceptible Blend (1:1:1)		4.5 fgh	2.8 fg	3.3 g	3.8 hi	5.3 h
-Double Time	2.7 lbs					
-Cutter II	2.7 lbs					
-Express II	2.7 lbs					
+Overseed Karma[y]	8.0 lbs					
Karma	8.0 lbs	9.0 a	9.0 a	9.0 a	8.3 ab	8.3 a
+Overseed Karma[y]	8.0 lbs					
Karma	8.0 lbs	9.0 a	8.8 a	8.5 a	8.5 a	8.0 ab
+Overseed Express II[x]	8.0 lbs					
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001

[z] All entries were seeded on 15 July.

[y] Overseeded with Karma during the gray leaf spot epidemic at 4 lbs/1000ft^{-2} on 5 and 11 Sept for a total of 8.0 lbs/1000ft^{-2}

[x] Overseeded with Express II during the gray leaf spot epidemic at 4 lbs/1000ft^{-2} on 5 and 11 Sept for a total of 8.0 lbs/1000ft^{-2}

[w] Treatments were inoculated with 3 isolates of *Magnaporthe oryzae* at a total concentration of 16,292 conidia mL^{-1} in a carrier volume of 2 gal/1000ft^{-2}. The trial was irrigated prior to inoculation and covered overnight with plastic sheets.

[v] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

ISOLATION OF SHORT-GROWTH PERENNIAL RYEGRASS MUTANTS AND EVALUATION OF THEIR SHADE TOLERANCE

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INTRODUCTION

Perennial ryegrass (PRG; *Lolium perenne* L.) is an important cool-season grass widely used for lawns, athletic fields, and golf courses. PRG is often maintained under different kinds of shade due to the presence of trees in the lawns or golf course buildings, which negatively affects growth (Christians, 2004). Under shady conditions, fast shoot growth occurs which results in longer internodes. Tiller formation becomes inhibited and turfgrass color may be negatively affected due to lack light (Okeyo et al. 2011).

PRG grown in shade is more vertical because of an inactivation of phytochrome, resulting in an increase in gibberellic acid (GA) (Rood et al., 1986). GAs are phytohormones that induce the expression of genes involved in cell elongation and division (Davies, 2007). Trinexapac-ethyl (TE) is a plant growth regulator (PGR) which inhibits the formation of physiologically active GA1. TE has been widely used to prevent the increase of GA in turfgrass, especially under a shade environment (Hedden et al., 1991). Previous studies have shown that applying 3.72 g AI /1000ft^2 TE to a mixed lawn of *Agrostis* spp., *Festuca* spp., and PRG reduced fresh clipping mass by 41% during a 3 year period in England (Daniels and Sugden, 1996). Additionally, the application of TE could cause increased tiller density on perennial ryegrass (Ervin et al, 1998), and it has been shown to increase tiller density of creeping bentgrass under 80% shade (Goss et al., 2002).

Even though turf quality under a shady condition can be improved by TE treatment, this benefit cannot be inherited. Developing shade tolerant PRG cultivars could prove to be an effective approach to optimizing turf quality while reducing maintenance costs. Aneta et al. (2012) used transgenic method to overexpress GA2-oxidases in order to inactivate bioactive gibberellins, which improved turfgrass quality under reduced light conditions. Transgenic methods often lead to public skepticism (Zapiola et al., 2008), but traditional hybridization breeding is not possible since there is no equivalent natural trait. Some researchers have used mutation breeding to create artificial variation to help develop new cultivars (Ahloowalia and Maluszynski, 2001).

By utilizing a similar approach, we developed dwarf perennial ryegrass mutants which exhibit a greater tiller number and wide leaf extension in normal light conditions. However, it was unknown how the plants would perform in shady conditions.

In this study we found that several dwarf mutants could maintain short-growth characteristics under both neutral shade (produced by polyfiber black cloth in a greenhouse) and natural shade (produced by trees) conditions.

MATERIALS & METHODS

Plant material. Three perennial ryegrass dwarf mutants: FNA3, GA3, A1, and wild-type ‘Fiesta 4’ were used in this experiment. Dwarf mutants were developed previously using gamma irradiation as described by Thammina, 2013.

Evaluation in a greenhouse under full sun condition. A greenhouse experiment was conducted for three dwarf lines and wild-type ‘Fiesta 4’ (WT) as a control. The plants were propagated in a 6 ½" x 5" x 2 ¾" pot from single tillers, each pot containing 12 tillers. The plants were fertilized with 0.1lbsN/1000ft^2 applied as 20-20-20 every week and irrigated as per requirement in a greenhouse maintained at 68℉Photos were taken after 2 months of growth.

Evaluation in a field trial under full sun conditions. A field trial was conducted for three dwarf lines. Wild-type ‘Fiesta 4’ (WT) was used as a control. Transplanting of 3-inch plugs (with 8-10 tillers) was done in September, 2012. The field test employed a randomized design with three replicates. There was a 10 inches space between plants in a row and between rows. All the plants were watered as required until they were established in the field. In June 2013 internode length measurements were taken from ten randomly selected mature tillers within each replicate. The highest three internodes on each tiller was measured and mean values were calculated for each replicate. Canopy height, root length, and dry root: shoot biomass ratios were also measured for the three replicates. Data were reported as a mean of three replicates for each plant line.

Evaluation under a greenhouse shade environment. Three mutant lines (FNA3, GA3, A1) and wild-type were propagated in cell trays from a single tiller (October 15th, 2012). When the plants had developed ten to twelve tillers, they were moved to two of light environments (January 29th, 2013): a control (non-shaded, ambient light conditions in a greenhouse) or 90% neutral shade created by a polyfiber black cloth. Plants were fertilized with 49gN/100m^2 applied as 20-20-20 every week and irrigated as required in a greenhouse maintained at 20±2℃. All the plants were cut at 3 inches every two weeks. Photos were taken every two weeks until the wild-type died.

Evaluation under a field shade environments. Three inch plugs (with 8-10 tillers) of three mutant lines and wild-type plants were transplanted to 96% and 80% tree shade in September, 2012. The test employed a randomized design with three replicates. The space between two plants in a row and between rows for the 96% and 80% light reduction environments were 6" and 3" respectively. All the plants were watered as required until they were established in the field. All the plants were cut at 3 inches every two weeks. Photos were taken in the 2013 spring and summer every two weeks until wild-type died.

Statistical analysis. Analysis of variance was performed on the data collected from the field-grown plants, using IBM SPSS software (Version 19.0; IBM Corporation, Somers, NY). When sufficient differences (P = 0.05) were observed, the least significant difference (LSD, Steel et al., 1996) test was performed to detect differences between treatments.

RESULTS & DISCUSSION

FNA3, GA3, and A1 mutants of perennial ryegrass showed short-growth characteristics in greenhouse and field conditions.

Fig 1 shows the leaf lengths of FNA3 and GA3 plants were much shorter than wild-type plants (WT) under a greenhouse condition (A1 data not show). As shown in Table 1 and Fig 2, FNA3 and GA3 had significantly lower canopy heights (32% and 13% reduction respectively, compared to WT) and significantly shorter internodes (54% and 80% of WT respectively) in a field trial (A1 data not show). Because of their short-growth characteristics, these two mutant lines might need less mowing frequency, and their requirements for water might be reduced due to the less transpiration caused by less leaf surface. Table 1 shows FNA3 and GA3 also displayed significantly higher ratio of dry root and shoot biomass (41.52% and 28.47% higher than WT), suggesting they might be more resistant to drought.

FNA3, GA3, and A1 mutants were shade tolerant under a greenhouse shade environment.

Fig 3a, 4a, 5a, show, FNA3, GA3, and A1 plants all exhibited greener color after two months in a 90% greenhouse shade environment, compared to the wild-type plants. And some wild-type started to show leaf necrosis, while the mutants appeared healthy. Fig 3b, 4b, 5b show, after three months, the three mutants were greener and healthier than the wild-type. Fig 5c shows, after four months in the same conditions, the wild-type, GA3 and A1 died (data not show), while the FNA3 survived.

FNA3, GA3, and A1 mutants were shade tolerant under a field shade environment.

Fig 6 shows both GA3 and FNA3 plants appeared healthier under a 96% tree shade environment, compared to wild-type plants (A1 data not show). When the wild-type died after three months in the shade environment, both GA3 and FNA3 survived. The GA3 was much healthier than FNA3 due to more tillers and a better root system. When light was increased in an 80% shade environment, GA3 and A1 maintained healthy through one year, while the wild-type died (FNA3 data not show) (Fig. 7), suggesting these two lines can be used on shady lawns under both greenhouse and field conditions.

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Table 1: Morphological characteristics of short-growth mutants in comparison to the wild-type ‘Fiesta 4’ perennial ryegrass grown under full sun in the greenhouse.

Genotype	Canopy height[z] (cm ± SE[z])	Root length[z] (cm ± SE[z])	Internode length[z] (cm ± SE[z])	Root:Shoot Biomass[z]
Wild-type	67.00 ± 1.15 a[y]	32.33 ± 1.20 a[y]	8.06 ± 0.07 a[y]	0.1233 ± 0.01 a[y]
FNA3	45.67 ± 0.44 c	19.00 ± 0.29 c	4.38 ± 0.23 c	0.1745 ± 0.02 c
GA3	58.50 ± 0.76 b	22.50 ± 0.50 b	6.44 ± 0.07 b	0.1584 ± 0.01 b

SE = standard error

z Each value represents the mean of three replicates. Measurements were taken in June 2013 (at maturity stage), on ten randomly picked tillers from each replicate for internode length.

y Values followed by the same letter were not significantly different from each other according to the LSD (P=0.05).

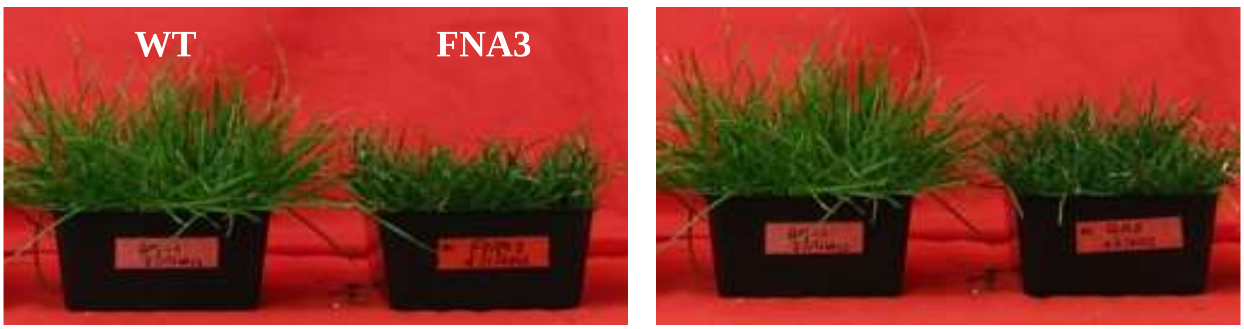

Fig. 1. Comparison of wild-type ‘Fiesta 4’ perennial ryegrass (left) and FNA3, GA3 mutant lines (right) in a greenhouse under full sun.

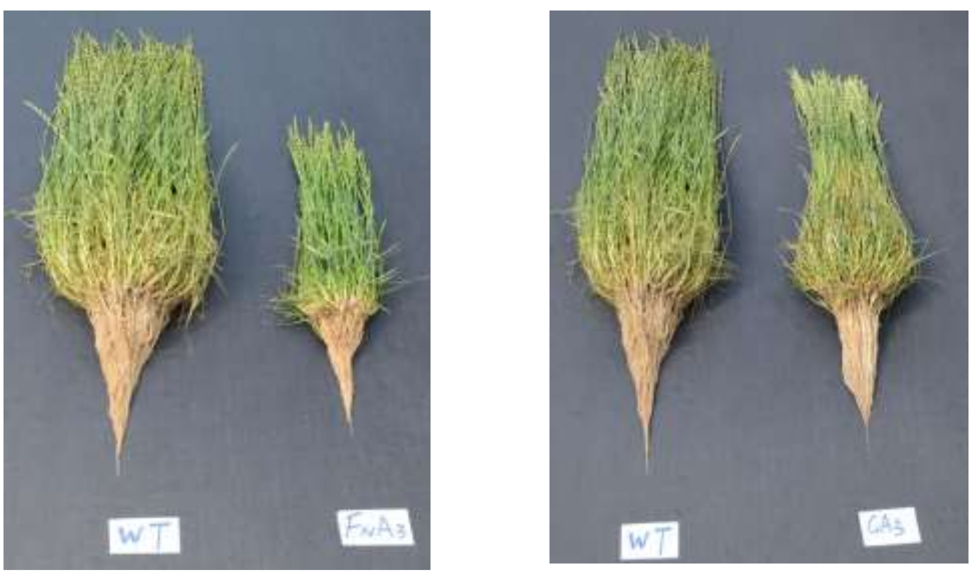

Fig. 2. Comparison of canopy height and root length of wild-type ‘Fiesta 4’ perennial ryegrass (left) and FNA3, GA3 mutants (right) grown under full sun in the field.

Fig. 3. Comparison of shade tolerance of wild-type (left) and GA3 mutant (right). (a) GA3 exhibited greener color after two months of shade treatment, compared to the wild-type. (b) After 3 months of shade treatment in a greenhouse, GA3 maintained much greener than the wild-type

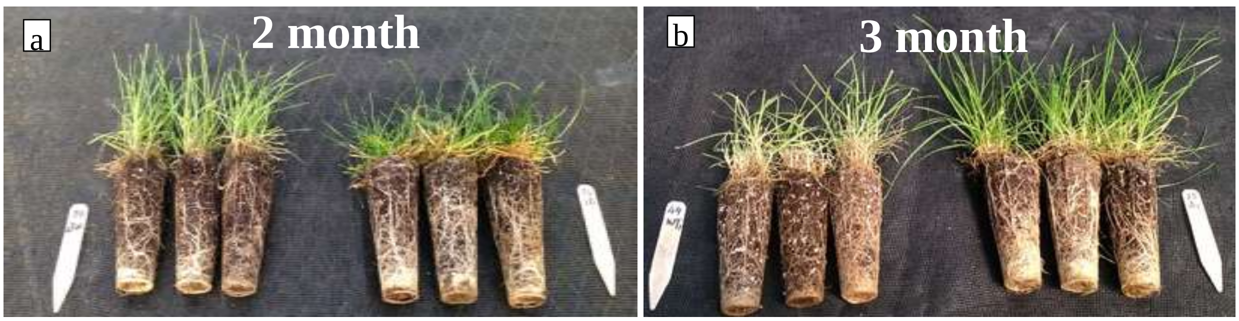

Fig. 4. Comparison of shade tolerance of wild-type (left) and A1 mutant (right). (a) A1 exhibited greener color after two months of shade treatment, compared to the wild-type. (b) After 3 months of shade treatment in a greenhouse, A1 maintained much greener than the wild-type.

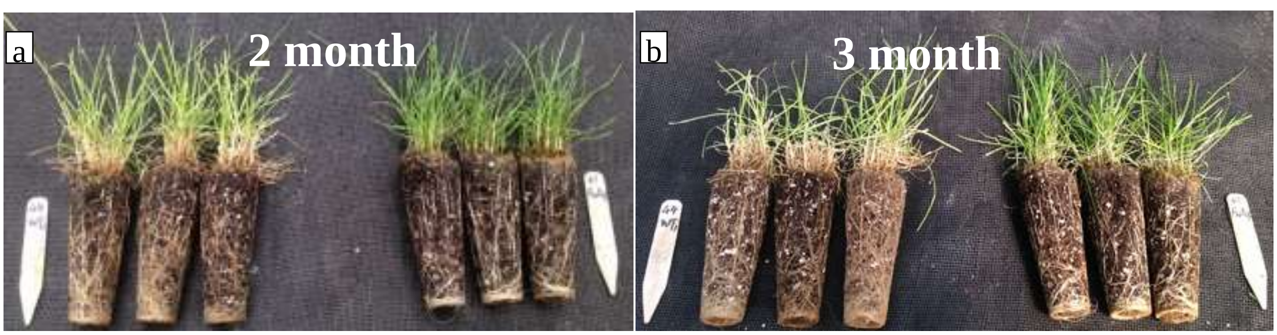

Fig. 5. Comparison of shade tolerance of wild-type (left) and FNA3 mutant (right). (a) FNA3 exhibited greener color after two months of shade treatment, compared to the wild-type. (b) After 3 months of shade treatment in a greenhouse, FNA3 maintained much greener than the wild-type. (c) After 4 months of shade treatment in the greenhouse, FNA3 survived, while wild-type plants died

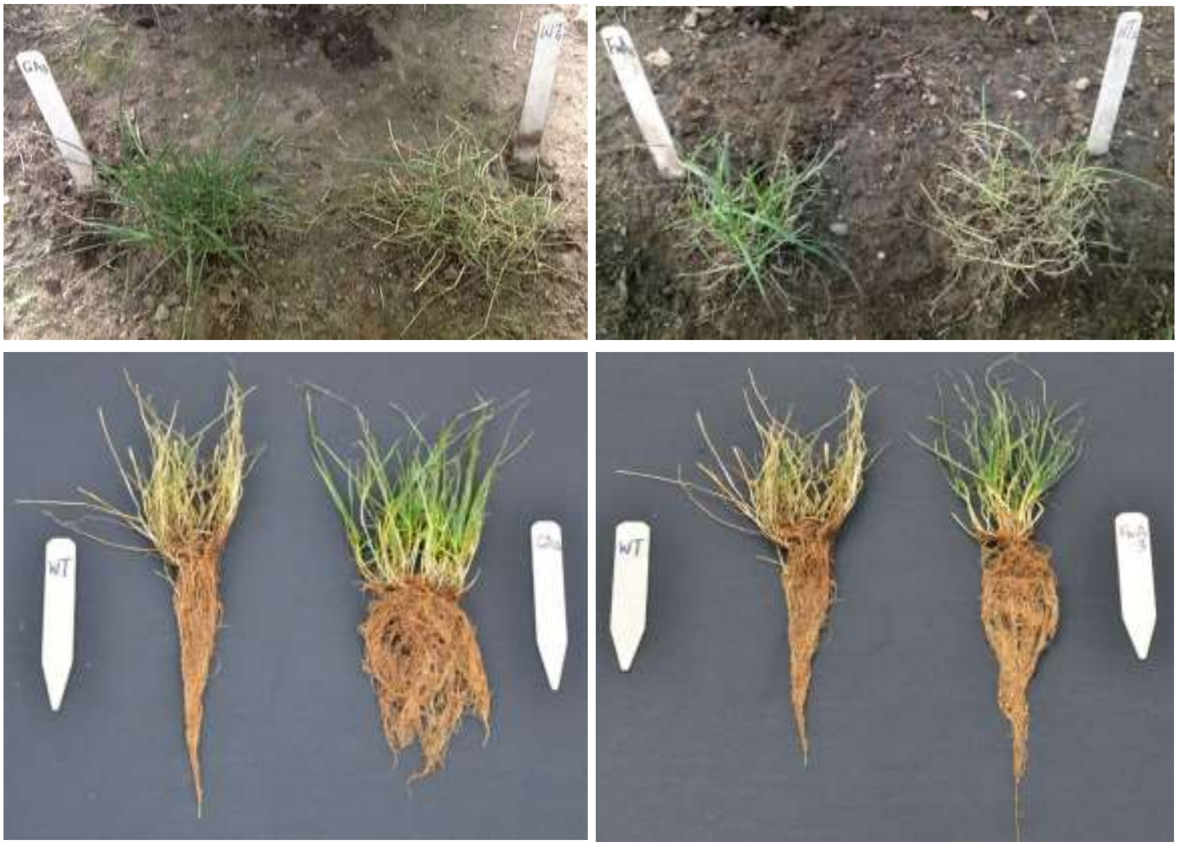

Fig. 6. Comparison of shade tolerance of wild-type and GA3, FNA3 mutants in a 96% tree shade environment. After 3 months of shade treatment, GA3 and FNA3 maintained much greener than the wild-type.

Fig. 7. Comparison of shade tolerance of wild-type, GA3, and A1 mutants in an 80% tree shade environment. The GA3 and A1 lines kept alive until winter came in November, 2013 (right), while the wild-type already died.

TOPDRESSING SAND PARTICLE SHAPE AND INCORPORATION EFFECTS ON ANTHRACNOSE SEVERITY OF AN ANNUAL BLUEGRASS PUTTING GREEN

Inguagiato, J. C., J. A. Murphy, and B. B. Clarke. 2013. Topdressing sand particle shape and incorporation effects on anthracnose severity of an annual bluegrass putting green. Int. Turfgrass Soc. Res. J. 12:127-133.

Sand topdressing is a common practice on putting green turf and has been suspected to enhance anthracnose disease caused by the fungus *Colletotrichum cereale* sensu lato Crouch, Clarke, and Hillman. A field trial was conducted to evaluate topdressing incorporation method (none, vibratory rolling, soft bristled brush and stiff bristled brush) and sand shape (none, round and sub-angular) effects on anthracnose severity of a *Poa annua* L. f. *reptans* (Hausskn) T. Koyama turf in 2006 and 2007. The trial was conducted as a split-plot design arranged in a 4 x 3 factorial with incorporation method as the main plot factor and sand shape as the subplot factor on a *P. annua* turf mowed at 3.2 mm. Topdressing was applied at 0.3 L m^{-2} every 14 d from 27 June to 13 Sept. 2006 and 14 May to 27 Sept. 2007. Sand shape was the only significant source of variation in both years. None of the topdressing incorporation methods affected anthracnose severity. Both sand shapes initially increased disease severity 4 to 14% compared to non-topdressed turf in July 2006; however, continued topdressing with sub-angular and round sand reduced anthracnose 8 to 29% and 7 to 29%, respectively, during August and September of 2006 and 2007 compared to the non-sand treatment. Anthracnose was less severe in plots topdressed with sub-angular sand than round sand in July 2006 and July through September 2007. This trial supports the findings of previous topdressing and verticutting trials which indicate that subtle wounding or bruising associated with routine cultural practices is not a significant factor affecting anthracnose severity.

A METHOD TO EVENLY APPLY FOOT TRAFFIC TO TURF PLOTS

Roberts, J. A., J. C. Inguagiato, and J. A. Murphy. 2013. A method to evenly apply foot traffic to turf plots. Int. Turfgrass Soc. Res. J. 12:743-746.

Foot traffic can cause both wear of turf and compaction of the soil, which are often significant management challenges on a golf course resulting from the playing of the game. Traffic tolerance has been previously examined using a variety of methods including both human foot traffic as well as custom machinery; however, a methodology for producing uniform foot traffic does not exist. The objectives were to: 1) devise a foot traffic methodology that applies a controlled number of footsteps per unit area, 2) compare the color and quality of trafficked turfgrass using this methodology to an untrafficked control, and 3) evaluate the traffic methodology effects on soil bulk density. Three people walking in soft-spiked golf shoes were evaluated for stride and foot lengths. This information was used to develop a walking procedure of 16 passess that evenly distributed 76 total footsteps over a 0.25 by 3.7 m traffic lane. These sixteen walking passes produced a foot traffic intensity that was similar to the number of footsteps occurring near the hole of a putting green during approximately 50 rounds of golf. A trial to compare trafficked and non-trafficked plots indicated that the damage from foot traffic applied using this walking procedure was realistic and uniform. This method would be useful to scientists interested in replicating the effects of walking foot traffic on turf.

RELATIONSHIP OF CANOPY REFLECTANCE AND FOLIAR NO^-_3-N TO ANTHRACNOSE SEVERITY ON AN ANNUAL BLUEGRASS PUTTING GREEN

Inguagiato, J. 2013. Relationship of canopy reflectance and foliar NO^-_3-N to anthracnose severity on an annual bluegrass putting green. Phytopath.103(6S):S2.65.

Anthracnose of *Poa annua* L., caused by *Colletotrichum cereale* Manns sensu lato Crouch, Clarke and Hillman, continues to be a challenging disease on putting greens throughout the United States. Nitrogen fertility is known to influence anthracnose, although optimum rates to suppress the disease may vary annually and are often based on subjective assessments of color. A field study was conducted on a *P. annua* putting green turf in Storrs, CT during 2011 to evaluate the relationship between anthracnose severity and foliar NO^-_3-N, chlorophyll index (CHL), and normalized difference vegetative index (NDVI). Nitrogen treatments were applied at 0.0, 2.4, 4.9, 9.8, 14.7, 19.5, 24.4, and 36.7 kg ha^{-1} every 14 days from 30 May to 11 August. Anthracnose developed in late-June and severity declined from 76 to 4% with increasing N rate during July. No consistent relationship was observed between NO^-_3-N measured in sap extracted from clippings and anthracnose severity. CHL and NDVI values were lower in plots where anthracnose was more severe; plots with values greater than 250 or 0.780 generally were <= 10% blighted, respectively. These data suggest that it may be possible to use reflectance meters to guide N fertility practices to minimize anthracnose incidence on putting green turf.

CULTIVATION AND MANGANESE APPLICATION EFFECTS ON SUMMER PATH SEVERITY IN COMPACTED AND NON-COMPACTED KENTUCKY BLUEGRASS TURF

Inguagiato, J. C., J. J. Henderson, and X. Chen. 2013. Cultivation and manganese application effects on summer path severity in compacted and non-compacted Kentucky bluegrass turf. ASA, CSSA, and SSSA International Annual Meetings. https://scisoc.confex.com/scisoc/2013am/webprogram/Paper80377.html

Summer patch, caused by *Magnaporthe poae*, is a common disease of annual bluegrass and Kentucky bluegrass turf areas. The disease is often most problematic in areas with poor drainage. Supplemental manganese fertility has been purported to reduce summer patch severity although the effect of this practice on disease is unknown. A two year field study was initiated on a Kentucky bluegrass (*Poa pratensis*) turf maintained at 3.8 cm in June 2011 to determine the effects of soil compaction, cultivation and manganese fertilization on the incidence and severity of summer patch. The study was established as a split plot design arranged in a 2 x 3 x 2 factorial with four blocks. The main plot factor was compaction, the subplot factors were cultivation and manganese fertilization. Compaction treatments received 64 or 32 passes with a 1361 kg sheepsfoot roller in 2011 and 2012, respectively to create soil bulk density differences throughout the study. Cultivation treatments were conducted using a Toro ProCore aerifier with 1.9 cm tines spaced on 2.54 cm centers on 29 June. Manganese was applied as a manganese sulfate ($MnSO_4$) solution containing 293 kg ha^{-1} on 3 August. Compacted plots consistently had lower soil water content (5.7 - 7.0%) and higher soil temps compared to non-compacted turf. Hollow and solid tine aerification reduced soil water content. Hollow tine aerification increased soil temperatures compared to other cultivation treatments. Summer patch initiated in late-August, although disease development was not uniform, and no differences were observed at that time. Results from this study will improve recommendations for cultivation and fertilization to reduce the incidence and severity of summer patch on turfgrass surfaces.

RESEARCH TOOLS AND TECHNOLOGIES FOR TURFGRASS ESTABLISHMENT

Li, D., J. Henderson, J. T. Vanini, and J. N. III Rogers. 2013. Research tools and technologies for turfgrass establishment. In Stier, J. C., B.P. Horgan, and S.A. Bonos (eds.) Turfgrass: Biology, Use, and Management. Madison, Wisconsin: American Society of Agronomy: p. 1189-1240.
doi:10.2134/agronmonogr56.c31

Turfgrass performance will continue to advance as researchers and industry professionals work to improve turfgrass management strategies to meet the needs of the end user. Researchers are constantly looking for better ways to quantify turfgrass responses to various cultural practices and environmental stresses to gain a better understanding of the turfgrass system. Ideas to make jobs simpler, more efficient, and less costly are always a consideration of many practitioners. Those ideas have been realized by improved and expanded technology.

ORGANIC MANAGEMENT PRACTICES ON ATHLETIC FIELDS: PART 2: THE EFFECTS ON PLAYING SURFACE CHARACTERISTICS AND SOIL PHYSICAL PROPERTIES

Miller, N. A., and J. J. Henderson. 2013. Organic management practices on athletic fields: Part 2: The effects on playing surface characteristics and soil physical properties. Crop Sci. 53(2):p. 637-646.
doi:10.2135/cropsci2012.03.0195

Many organic products have been used effectively in turfgrass management programs, but their exclusive use in athletic field maintenance and effect on playing surface characteristics and soil physical properties have not been extensively researched. The objectives were to determine the effects of management regimes and overseeding perennial ryegrass (*Lolium perenne* L.) into an existing Kentucky bluegrass (*Poa pratensis* L.) stand during simulated traffic on (i) rotational traction and surface hardness and (ii) soil physical properties. Treatments were arranged as a 2 × 6 factorial in a randomized complete block design with two overseeding levels (overseeded and not overseeded) of a perennial ryegrass blend during traffic and six management regimes (fertility and pest management): (i) conventional, (ii) organic manure (OMan), (iii) organic protein (OPro), (iv) organic manure plus compost tea (OMan+CT), (v) organic protein plus compost tea (OPro+CT), and (vi) a control. This research was conducted over 2 yr on a mature stand of 'Langara' Kentucky bluegrass on a Paxton fine sandy loam. Fall traffic was simulated with a Cady Traffic Simulator. There were no consistent effects on rotational traction or surface hardness as a result of management regimes or overseeding. Management regimes did not affect soil physical properties, but overseeding increased total porosity by 2.2% and increased aeration porosity by 12.4% in 2008. In 2009, overseeding increased capillary porosity by 2.2% but had no affect on total and aeration porosity values. Overseeding minimally decreased particle and bulk density values during both years. Overseeding also increased soil organic matter by 5.7% in 2009 when accompanied by organic fertilizers but not with compost tea applications. Using organic fertilizers or compost tea showed no enhancement or deterioration of soil physical properties over this two year study.

HOST PLANT FEEDING PREFERENCES OF THE ASIATIC GARDEN BEETLE

Eckman, L., and A. Legrand. 2013. Host plant feeding preferences of the Asiatic garden beetle. ESA EB Annual Meeting. Lancaster, PA. March 17th, 2013.

The Asiatic garden beetle (AGB), *Maladera castanea*, is an invasive scarab pest of turfgrass, crops, and ornamentals. The beetle has been minimally studied, and is resistant to many traditional controls. A better understanding of adult habits, which influence larval location and adult damage, could suggest better management strategies, for example selecting plants less palatable to adult AGBs. Field and laboratory experiments were conducted to investigate AGB feeding preferences. The field experiments used beetle counts to indicate comparative preference for three cultivars each of nine edible plants: basil, beet, carrot, eggplant, kohlrabi, parsnip, hot pepper, sweet pepper, and turnip. AGBs were counted in a common garden with a randomized complete block design in 2011 and 2012. The laboratory experiments estimated concrete feeding preferences, using a no-choice format where change in mass and area of leaf pieces represented willingness to feed. These tests included the basil, beet, and kohlrabi varieties used in the field experiments, and, in 2012, also included six ornamental landscape plants: elderberry, viburnum, green ash, red maple, sugar maple, and American sweetgum. The 2011 and 2012 field experiments indicated a strong preference for basil over other crop plants. This was supported by the 2012 lab leaf area change data. Statistically significant differences were not discernable among other edible plant varieties. The 2012 laboratory no-choice tests indicated that sugar maple was significantly less likely to be eaten than the other landscape plants tested, which were not significantly different from one another in terms of AGB feeding.

DEVELOPMENT OF SHORT-GROWTH CULTIVARS OF PERENNIAL RYEGRASS THROUGH MUTATION BREEDING TECHNIQUES

Thammina C., J. Chen, W. Li, H. Yu, H. Yer, K. Cao, J. Inguagiato, and Y. Li. 2013. Development of short-growth cultivars of perennial ryegrass through mutation breeding techniques. 77th Annual Meeting of the Northeast Section American Society of Plant Biologists. 20-21 April. Univ. Mass., Amherst, MA.

Perennial ryegrass (PRG; *Lolium perenne* L.) is an important cool-season grass grown in lawns, athletic fields and golf courses. PRG is commonly used in residential and commercial lawns and maintained at an optimum mowing height of 5 to 9 cm. Short-growth PRG mutants can reduce mowing frequency and may also be useful in fairways and tees where low mowing heights are desirable. We have used mutation breeding techniques to generate short-growth mutants of 'Fiesta 4' perennial ryegrass. A number of mutant lines including GAD-1, GAD-2 and FN-5, exhibiting short-growth characteristics were selected from M2 generation. Mutant lines and the wild-type (WT) were vegetatively propagated and evaluated under greenhouse and field conditions. The data from greenhouse studies show that the GAD-1 and GAD-2 mutants had significantly lower leaf extension rates (29%, 27%) and leaf blade lengths (38%, 31%), respectively, when compared to the WT. Similarly, under field conditions at maturity stage, GAD-1, GAD-2 mutants had significantly lower canopy heights (27%, 31%) and shorter leaf blades (39%, 49%), respectively, when compared with the WT. Also, FN-5 mutant evaluated under field conditions had extremely shorter canopy (72% shorter than the WT), shorter internodes (74% shorter than the WT) and shorter leaf blades (56% shorter than the WT). Because of their short-growth characteristics, all the 3 mutants need mowing less frequently, their requirements for water and fertilizer should also be reduced. Further evaluation is in progress to characterize the performance of these plants under drought, low fertilizer and other conditions.

EVALUATION OF SHORT-GROWTH MUTANTS OF PERENNIAL RYEGRASS FOR THEIR SHADE TOLERANCE

Li, W., C. Thammina, J. Chen, H. Yu, K. Cao, J. Inguagiato, and Y. Li. .2013. Evaluation of short-growth mutants of perennial ryegrass for their shade tolerance. 77th Annual Meeting of the Northeast Section American Society of Plant Biologists. 20-21 April. Univ. Mass., Amherst, MA.

Shade tolerance is an important trait for perennial ryegrass (PRG; Lolium perenne L.). Under shade environment, typical symptoms of PRG include thin, narrow and elongated leaf blades, reduced leaf appearance and tiller number, poor wearing ability, and weak root system. We have used mutagenesis techniques to breed short-growth (dwarf) mutant PRG varieties. A number of M2 generation plant lines were selected based on height, tiller number and leaf width. One line, named EMS18, displayed lower leaf extension rate (shorter leaf blade), better leaf appearance (greener color) and longer root when compared to the wild-type controls under greenhouse conditions. FN4, another line, also showed reduced elongation in leaf blade and internodes length when grown in the field. We have further evaluated their responses to shade under field conditions. EMS18 and FN4 were planted in woods and mowed at a height of 3 inches regularly. After 1.5 months of totally shaded (no direct sunlight) environments, these two mutant lines were green in color and healthy in general, while the wild-type controls became yellow and some leaves were dying. The root systems, particularly the root lengths of both EMS18 and FN4, were similar to that of the wild-type controls. After two months, the wild-type controls totally died but EMS18 survived and appeared to be healthy. Additional characterization and field evaluation will be done in 2013.

DEVELOPMENT OF NEW CULTIVARS OF PERENNIAL RYEGRASS FOR BETTER LAWNS USING MUTATION BREEDING TECHNIQUES

H. Yu, C. Thammina, J. Chen, W. Li, H. Yer, K. Cao, J. Inguagiato, and Yi Li. 2013. Development of new cultivars of perennial ryegrass for better lawns using mutation breeding techniques. Annual Meeting of the American Society of Plant Biologists. 20-24 July. Providence, RI.

Perennial ryegrass (PRG; Lolium perenne L.) is an important cool-season grass grown in lawns, athletic fields and golf courses. PRG is commonly used in residential and commercial lawns and maintained at an optimum mowing height of 5 to 9 cm. It is poorly adapted to low mowing heights (i.e. < 3 cm). Short-growth PRG mutants can reduce mowing frequency and may also be useful in fairways and tees where low mowing heights are desirable. Water requirement of PRG is also quite high. Therefore there is an increasing demand for short-growth turf with reduced mowing, irrigation and fertilizer requirements. We have used mutation breeding techniques to generate short-growth mutants of 'Fiesta 4' Perennial ryegrass. A number of mutant lines including GAD-1, GAD-2 and FN-5, exhibiting short-growth characteristics were selected from M2 generation. Mutant lines and the wild-type (WT) were vegetatively propagated and evaluated under greenhouse and field conditions. The data from greenhouse studies show that the GAD-1 and GAD-2 mutants had significantly lower leaf extension rates (29%, 27%) and leaf lengths (38%, 31%), respectively when compared to the WT. Similarly, under field conditions at maturity stage, GAD-1 and GAD-2 mutants had significantly lower canopy heights (27%, 31% reduction compared to WT), shorter internodes (45%, 40% shorter than WT) and shorter leaves (39%, 49% shorter than WT). Also, FN-5 mutant evaluated under field conditions had extremely shorter canopy (72% shorter than WT), shorter internodes (74% shorter than WT) and shorter leaves (56% shorter than WT). Because of their short-growth characteristics, all the 3 mutants need mowing less frequently, their requirements for water and fertilizer should also be reduced. Some of the short-growth mutants we have isolated may be commercially useful upon further characterization.