University of Connecticut

College of Agriculture, Health and Natural Resources

2014 Annual Turfgrass Research Report

UConn Turfgrass Science Team at the start of the 2014 Turfgrass Field Day

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PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

Cover photo: Members of the UConn Turfgrass Science Team at the start of the 4th Biennial UConn Turfgrass Field Day, July 15, 2014. From left to right: Kevin Miele, G. Scott Vose, Steven Rackliffe, Victoria Wallace (front), Jason Henderson (back), Karl Guillard, John Inguagiato, and Stephen Olsen. (Photo credits: Kim Bova, Kim Bova Photography, www.kimbova.com)

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PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

2014 Annual Turfgrass Research Report Summary

University of Connecticut
College of Agriculture, Health 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 and entomology), athletic field and golf turf maintenance, fertility and nutrient management, and cultivar evaluation and improvement. Additionally, abstracts and citations of scientific publications and presentations published in 2014 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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2014 Financial Support

The University of Connecticut Turfgrass Science 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 Turfgrass Science Program

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SCIENTIFIC PUBLICATIONS (ABSTRACTS & CITATIONS)

PREVENTIVE ANTHRACNOSE CONTROL ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2014

J. Inguagiato, K. Miele, X. Chen, K. Hyatt, S. Kalinowski and S. Vose

Department of Plant Science and Landscape Architecture
University of Connecticut, Storrs

INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. An integrated disease control program including cultural management and fungicides is required to minimize turf loss due to this disease. Rotational fungicide programs utilizing different chemical modes of action and multi-site fungicides have been found to be most effective in providing season-long anthracnose control. Identifying new fungicides with unique modes of action effective against anthracnose is important to continued control of this disease and resistance management. The objective of this study was to examine the efficacy of PCNB and a developmental fungicide applied alone or in combination with other commonly used fungicides 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 1.7 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through 15 August. 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 13 May for dollar spot control; ProStar (1.5 oz) was also applied every 14 days from 14 June throughout the trial to prevent brown patch development. Subdue MAXX (1.0 fl.oz.) was applied for downy mildew on 29 April. Scimitar GC (0.23 fl.oz.) and Dylox 80 (3.75 oz.) were applied on 21 and 31 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 and rotational programs. Initial applications were made on 20 May prior to disease developing in the trial area. Subsequent applications were made every 7 or 14-d through 5 August. 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 $1000\text{-}ft^{-2}$ 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 27 June through 15 August. 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 on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Anthracnose severity data were arcsine square root transformed for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS

Anthracnose Severity

Disease pressure was low throughout the trial due to mild summer temperatures and humidity. Anthracnose symptoms were first observed uniformly throughout the trial on 27 June, developing from a natural infestation (Table 1). Disease progressed in untreated control plots reaching ~30% plot area blighted by mid-July and ~40% by early-August. All treatments provided near complete anthracnose control through the study. Turf treated with UC14-1 and UC14-2 had a slight increase in disease compared to other treatments, albeit infrequent and still good anthracnose control. Plant Food Program 2, an exclusively nutritional and biostimulant based program, provided good anthracnose control though mid-July; although became unacceptable during more favorable disease conditions in late-July and early-August.

Turf Quality and Phytotoxicity

Turf quality was generally good in all treatments throughout the trial due to limited disease severity (Table 2). However, a temporary decrease in turf quality was apparent in all treatments on 6 June, when turf density and uniformity declined as seedheads were waning. Turf treated with Syngenta Program 2, QP Fosetyl-Al + QP Chlorothalonil + Foursome, or Plant Food Program 1 had the highest quality ratings over a majority of observation dates (i.e., ≥ 5 out of 9 dates) in this trial. Turf quality of QP Enclave and the tank mix of QP Chlorothalonil + Ipro 2SE + TM Flowable + and Tebuconazole plots was reduced on 3 July during a period when temperatures (°F) were in the upper 80s. Unacceptable phytotoxicity was observed in the tank mix treatment on that date (Table 3). Phytotoxicity was less severe as temperatures became cooler in early August. Interestingly, the tank mix of QP Chlorothalonil + Ipro 2SE + TM Flowable + and Tebuconazole consistently increased phytotoxicity compared to the pre-mixed product QP Enclave which contains the same active ingredients and amounts during July and August.

CONCLUSION

All fungicide treatments evaluated in this trial provided excellent or good anthracnose control given the moderate environmental conditions and low disease pressure. Despite limited disease development, results from this trial still support previous research demonstrating that rotational programs and/or tank mixes typically provide the most effective control of anthracnose. In the current trial, UC14-1 and UC14-2 applied individually were slightly less effective than tank mixes or programs. However, both of these treatments still provided good disease control. UC14-3 provided slightly better anthracnose control than the aforementioned treatments. Few consistent differences in turf quality or phytotoxicity were observed; although, UC14-3 did have ~4 times the amount of foam in agitated solutions compared to UC14-1 or UC14-2 (Fig. 1).

In recent years, pre-mix formulations of two or more active ingredients have become commonplace. All fungicides contain inert ingredients such as surfactants or stickers that help improve efficacy. During development of pre-mix formulations inert ingredients are selected to optimize efficacy of active ingredients and mix compatibility. In this trial the 4-way pre-mix, QP Enclave, was compared to a treatment containing the same 4 active ingredients and ratios of each as the pre-mix formulation. In this trial, the pre-mix formulation appeared to cause less phytotoxicity than individual components applied as a tank-mix at the same rates and timings. While pre-mix formulations may reduce user selectivity of application rates, it does appear based on this year's data that in some cases pre-mix formulations may minimize phytotoxicity compared to tank mixes. This may be due to the optimization of inert ingredients in pre-mix formulations versus individual components tank mixed.

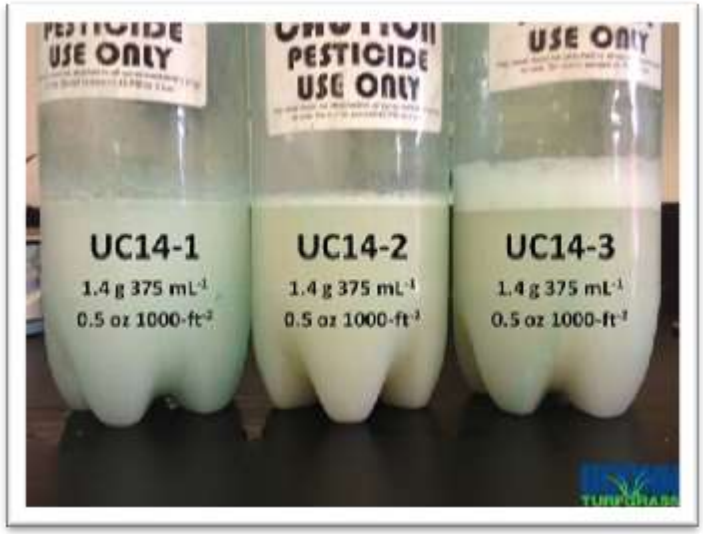

Figure 1. Foam produced following agitation of three developmental fungicides.

Table 1. Anthracnose severity influenced by various fungicides applied preventatively to annual bluegrass putting green turf at the Plant Science Research Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[u]	Anthracnose Severity					
			27 Jun	3 Jul	11 Jul	17 Jul	1 Aug	15 Aug
			----------------------------% plot area blighted-----------------------					
UC14-1	0.5 oz.	14-d	0.3 b[t]	0.1[s]b	0.3[s]cd	0.1[s]d	0.9[s] d	1.3[s] cd
UC14-2	0.5 oz.	14-d	0.1 b	0.4 b	1.4 bc	0.3 d	0.3 d	0.2 de
UC14-3	0.5oz.	14-d	0.1 b	0.2 b	0.3 cd	0.0 d	0.0 d	0.0 e
Daconil Action	3.5 fl.oz.	14-d	0.0 b	0.1 b	0.0 d	0.1 d	0.1 d	0.0 e
+Velista	0.5 oz.							
+Primo MAXX	0.125 fl.oz.[z]							
Secure	0.5 fl.oz.	14-d	0.0 b	0.0 b	0.3 cd	0.0 d	0.0 d	0.0 e
+Velista	0.5 oz.							
+Primo MAXX	0.125 fl.oz.[z]							
Daconil Action	3.5 fl.oz.	14-d	0.3 b	0.2 b	0.1 cd	0.2 d	0.5 d	0.0 e
+Primo MAXX	0.125 fl.oz.[z]							
Velista	0.5 oz.	14-d	0.1 b	0.0 b	0.5 bcd	0.0 d	0.0 d	0.0 e
+Primo MAXX	0.125 fl.oz.[z]							
Syngenta Program 1	pgm[y]	14-d	0.0 b	0.0 b	0.0 d	0.0 d	0.0 d	0.0 e
Syngenta Program 2	pgm[x]	14-d	0.0 b	0.0 b	0.0 d	0.0 d	0.0 d	0.1 de
QP Fosetyl-Al	4.0 oz.	14-d	0.0 b	0.0 b	0.0 d	0.0 d	0.0 d	0.0 e
+QP Chlorothalonil DF	3.23 oz.							
+Foursome	0.4 fl.oz.							
Chipco Signature	0.4 fl.oz.	14-d	0.0 b	0.0 b	0.0 d	0.0 d	0.0 d	0.0 e
+Daconil Ultrex	3.23 oz.							
QP Chlorothalonil 720 SFT	1.47 fl.oz.	14-d	0.0 b	0.0 b	0.1 d	0.0 d	0.1 d	0.0 e
+QP Ipro 2SE	1.47 fl.oz.							
+QP TM Flowable	0.65 fl.oz.							
+QP Tebuconazole	0.244 fl.oz.							
QP Enclave	3.0 fl.oz.	14-d	0.0 b	0.0 b	0.0 d	0.0 d	0.2 d	0.0 e
Plant Food Program 1	pgm[w]	7-d	0.0 b	0.0 b	0.0 d	0.0 d	0.1 d	0.2 de
Plant Food Program 2	pgm[v]	7-d	0.0 b	0.2 b	2.4 b	5.7 c	8.5 c	4.1 c
Untreated			0.8 a	5.8 a	28.5 a	38.7 a	53.9 a	39.9 a
Untreated			0.3 b	5.0 a	25.9 a	30.4 b	31.0 b	29.7 b
Untreated			0.9 a	7.4 a	32.8 a	37.6 a	39.0 a	37.2 ab
ANOVA: Treatment (P > F)			0.0006	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	3	2	3	1	2	3
		14-d	11	2	10	1	2	3

[z]Primo MAXX was applied at 0.1 fl.oz. until 16 June, after which it was applied at 0.125 fl.oz.

[y]Daconil Action (3.5 fl.oz.), Velista (0.5 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Briskway (0.49 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

[x]Daconil Action (3.5 fl.oz.), Secure (0.5 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Medallion (1.5 fl.oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

[w]16-2-7 (6.0 fl.oz.), Phosphite 30 (3.0 fl.oz.), Adams Earth (3.0 fl.oz.), 6 Iron (3.0 fl.oz.), Flo Thru (1.5 fl.oz.), and Daconil Weather Stik (0.9 fl.oz.) were tank-mixed and applied on 20 May, 2 and 16 June, 1, 16, and 29 July, and 12 August. Harrell's pH Buffer (0.44 fl.oz.), Cal Nitrate (6.0 fl.oz.), Sugar Cal (3.0 fl.oz.), Impulse (3.0 fl.oz.), Omega (0.35 fl.oz.), and Daconil Weather Stik were tank-mixed and applied on 27 May, 10 and 24 June, 8 and 22 July, and 5 August.

[v]16-2-7 (6.0 fl.oz.), Phosphite 30 (3.0 fl.oz.), Adams Earth (3.0 fl.oz.), 6 Iron (3.0 fl.oz.), and Flo Thru (1.5 fl.oz.) were tank-mixed and applied on 20 May, 2 and 16 June, 1, 16, and 29 July, and 12 August. Harrell's pH Buffer (0.44 fl.oz.), Cal Nitrate (6.0 fl.oz.), Sugar Cal (3.0 fl.oz.), Impulse (3.0 fl.oz.), and Omega (0.35 fl.oz.) were tank-mixed and applied on 27 May, 10 and 24 June, 8 and 22 July, and 5 August.

[u]Treatments were initiated on 20 May, prior to disease development. Subsequent 7-d treatments were applied on 27 May, 2, 10, 16, and 24 June, 1, 8, 16, 22, and 29 July, and 5 and 12 August. Subsequent 14-d treatments were applied on 2 and 16 June, 1, 16, and 29 July, and 12 August.

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

[s]Data were arc-sin square-root transformed, means presented are back-calculated.

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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 2014.

Treatment	Rate per 1000ft^2	Int[u]	26 May	30 May	6 Jun	20 Jun	27 Jun
			Turf Quality				
			-------------------- 1-9, 6=min acceptable ----------------------				
UC14-1	0.5 oz.	14-d	6.8 cde[t]	7.3 ab	6.3 bc	7.3 bcd	7.3 de
UC14-2	0.5 oz.	14-d	6.5 de	6.5 cd	6.0 bcd	6.5 def	6.8 efg
UC14-3	0.5oz.	14-d	6.8 cde	6.8 bcd	6.3 bc	7.0 cde	6.8 efg
Daconil Action	3.5 fl.oz.	14-d	6.5 de	6.5 cd	5.3 de	6.3 ef	7.0 def
+Velista	0.5 oz.						
+Primo MAXX	0.125 fl.oz.[z]						
Secure	0.5 fl.oz.	14-d	6.8 cde	6.8 bcd	5.8 bcd	6.8 de	7.3 de
+Velista	0.5 oz.						
+Primo MAXX	0.125 fl.oz.[z]						
Daconil Action	3.5 fl.oz.	14-d	6.5 de	6.5 cd	4.8 e	6.3 ef	6.5 fg
+Primo MAXX	0.125 fl.oz.[z]						
Velista	0.5 oz.	14-d	6.8 cde	7.0 bc	5.8 bcd	7.0 cde	6.5 fg
+Primo MAXX	0.125 fl.oz.[z]						
Syngenta Program 1	pgm[y]	14-d	7.0 bcd	6.3 d	6.3 bc	7.0 cde	7.3 de
Syngenta Program 2	pgm[x]	14-d	7.5 ab	7.8 a	5.5 cde	7.8 abc	8.0 bc
QP Fosetyl-Al	4.0 oz.	14-d	8.0 a	7.8 a	7.8 a	8.3 a	8.0 bc
+QP Chlorothalonil DF	3.23 oz.						
+Foursome	0.4 fl.oz.						
Chipco Signature	0.4 fl.oz.	14-d	7.0 bcd	7.3 ab	6.5 b	7.8 abc	7.5 cd
+Daconil Ultrex	3.23 oz.						
QP Chlorothalonil 720 SFT	1.47 fl.oz.	14-d	6.3 e	6.8 bcd	5.3 de	5.8 f	6.3 g
+QP Ipro 2SE	1.47 fl.oz.						
+QP TM Flowable	0.65 fl.oz.						
+QP Tebuconazole	0.244 fl.oz.						
QP Enclave	3.0 fl.oz.	14-d	7.0 bcd	6.8 bcd	6.0 bcd	6.5 def	6.5 fg
Plant Food Program 1	pgm[w]	7-d	7.3 bc	7.3 ab	7.5 a	8.0 ab	9.0 a
Plant Food Program 2	pgm[v]	7-d	7.0 bcd	7.8 a	7.5 a	8.0 ab	8.3 b
Untreated			7.0 bcd	7.0 bc	6.5 bc	6.5 def	6.3 g
Untreated			6.8 cde	6.8 bcd	6.5 bcd	7.0 cde	6.8 efg
Untreated			6.8 cde	6.8 bcd	5.8 bcd	6.5 def	6.3 g
ANOVA: Treatment (P > F)			0.0046	0.0014	0.0001	0.0001	0.0001
Days after treatment		7-d	6	3	4	10	3
		14-d	6	9	4	14	11

[z]Primo MAXX was applied at a rate of 0.1 fl.oz. until 16 June, after which it was applied at 0.125 fl.oz.

[y]Daconil Action (3.5 fl.oz.), Velista (0.5 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Briskway (0.49 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

[x]Daconil Action (3.5 fl.oz.), Secure (0.5 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Medallion (1.5 fl.oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

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[t]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 2 (cont). Turf quality influenced by various fungicides on annual bluegrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[u]	Turf Quality 3 Jul	17 Jul	1 Aug	15 Aug
			-------------- 1-9, 6=min acceptable ------------------			
UC14-1	0.5 oz.	14-d	7.0 bcd[t]	7.0 de	6.8 ef	7.0 c
UC14-2	0.5 oz.	14-d	6.8 cde	7.0 de	7.0 def	7.8 bc
UC14-3	0.5oz.	14-d	7.0 bcd	7.3 cde	8.3 abc	8.8 ab
Daconil Action	3.5 fl.oz.	14-d	6.0 efg	7.5 bcd	7.0 def	8.5 ab
+Velista	0.5 oz.					
+Primo MAXX	0.125 fl.oz.[z]					
Secure	0.5 fl.oz.	14-d	6.5 def	8.0 abc	7.8 b-e	8.8 ab
+Velista	0.5 oz.					
+Primo MAXX	0.125 fl.oz.[z]					
Daconil Action	3.5 fl.oz.	14-d	6.3 d-g	7.8 a-d	7.0 def	7.0 c
+Primo MAXX	0.125 fl.oz.[z]					
Velista	0.5 oz.	14-d	6.8 cde	7.0 de	7.8 b-e	8.8 ab
+Primo MAXX	0.125 fl.oz.[z]					
Syngenta Program 1	pgm[y]	14-d	7.8 ab	7.8 a-d	9.0 a	9.0 a
Syngenta Program 2	pgm[x]	14-d	7.0 bcd	8.3 ab	7.3 c-f	8.0 abc
QP Fosetyl-Al	4.0 oz.	14-d	8.3 a	8.5 a	8.5 ab	8.8 ab
+QP Chlorothalonil DF	3.23 oz.					
+Foursome	0.4 fl.oz.					
Chipco Signature	0.4 fl.oz.	14-d	7.5 abc	8.3 ab	7.0 def	7.8 bc
+Daconil Ultrex	3.23 oz.					
QP Chlorothalonil 720 SFT	1.47 fl.oz.	14-d	5.5 g	7.3 cde	6.5 fg	7.0 c
+QP Ipro 2SE	1.47 fl.oz.					
+QP TM Flowable	0.65 fl.oz.					
+QP Tebuconazole	0.244 fl.oz.					
QP Enclave	3.0 fl.oz.	14-d	5.8 fg	7.0 de	6.8 ef	7.0 c
Plant Food Program 1	pgm[w]	7-d	8.3 a	8.3 ab	8.0 a-d	8.0 abc
Plant Food Program 2	pgm[v]	7-d	7.5 abc	6.5 e	5.5 g	5.8 d
Untreated			5.5 g	4.8 f	3.0 h	4.0 e
Untreated			5.8 fg	4.8 f	3.5 h	4.3 e
Untreated			5.5 g	4.5 f	3.3 h	4.3 e
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	2	1	2	3
		14-d	2	1	2	3

[z]Primo MAXX was applied at a rate of 0.1 fl.oz. until 16 June, after which it was applied at 0.125 fl.oz.

[y]Daconil Action (3.5 fl.oz.), Velista (0.5 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Briskway (0.49 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

[x]Daconil Action (3.5 fl.oz.), Secure (0.5 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Medallion (1.5 fl.oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

[w]16-2-7 (6.0 fl.oz.), Phosphite 30 (3.0 fl.oz.), Adams Earth (3.0 fl.oz.), 6 Iron (3.0 fl.oz.), Flo Thru (1.5 fl.oz.), and Daconil Weather Stik (0.9 fl.oz.) were tank-mixed and applied on 20 May, 2 and 16 June, 1, 16, and 29 July, and 12 August. Harrell's pH Buffer (0.44 fl.oz.), Cal Nitrate (6.0 fl.oz.), Sugar Cal (3.0 fl.oz.), Impulse (3.0 fl.oz.), Omega (0.35 fl.oz.), and Daconil Weather Stik were tank-mixed and applied on 27 May, 10 and 24 June, 8 and 22 July, and 5 August.

[v]16-2-7 (6.0 fl.oz.), Phosphite 30 (3.0 fl.oz.), Adams Earth (3.0 fl.oz.), 6 Iron (3.0 fl.oz.), and Flo Thru (1.5 fl.oz.) were tank-mixed and applied on 20 May, 2 and 16 June, 1, 16, and 29 July, and 12 August. Harrell's pH Buffer (0.44 fl.oz.), Cal Nitrate (6.0 fl.oz.), Sugar Cal (3.0 fl.oz.), Impulse (3.0 fl.oz.), and Omega (0.35 fl.oz.) were tank-mixed and applied on 27 May, 10 and 24 June, 8 and 22 July, and 5 August.

[u]Treatments were initiated on 20 May, prior to disease development. Subsequent 7-d treatments were applied on 27 May, 2, 10, 16, and 24 June, 1, 8, 16, 22, and 29 July, and 5 and 12 August. Subsequent 14-d treatments were applied on 2 and 16 June, 1, 16, and 29 July, and 12 August.

[t]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 3. Phytotoxicity affected by various fungicides on annual bluegrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[u]	Phytotoxicity					
			26 May	6 Jun	20 Jun	3 Jul	1 Aug	15 Aug
			0-5, 2=max acceptable					
UC14-1	0.5 oz.	14-d	0.0 c[t]	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
UC14-2	0.5 oz.	14-d	0.0 c	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
UC14-3	0.5oz.	14-d	0.0 c	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
Daconil Action	3.5 fl.oz.	14-d	0.0 c	0.5 ab	0.0 c	0.5 bcd	0.0 c	0.0 c
+Velista	0.5 oz.							
+Primo MAXX	0.125 fl.oz.[z]							
Secure	0.5 fl.oz.	14-d	0.0 c	0.3 b	0.0 c	0.0 d	0.0 c	0.0 c
+Velista	0.5 oz.							
+Primo MAXX	0.125 fl.oz.[z]							
Daconil Action	3.5 fl.oz.	14-d	0.0 c	1.0 a	1.3 a	0.5 bcd	0.0 c	0.0 c
+Primo MAXX	0.125 fl.oz.[z]							
Velista	0.5 oz.	14-d	0.0 c	0.3 b	0.0 c	0.0 d	0.0 c	0.0 c
+Primo MAXX	0.125 fl.oz.[z]							
Syngenta Program 1	pgm[y]	14-d	0.3 bc	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
Syngenta Program 2	pgm[x]	14-d	0.0 c	0.5 ab	0.0 c	0.3 cd	0.0 c	0.0 c
QP Fosetyl-Al	4.0 oz.	14-d	0.0 c	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
+QP Chlorothalonil DF	3.23 oz.							
+Foursome	0.4 fl.oz.							
Chipco Signature	0.4 fl.oz.	14-d	0.0 c	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
+Daconil Ultrex	3.23 oz.							
QP Chlorothalonil 720 SFT	1.47 fl.oz.	14-d	0.0 c	0.4 b	0.8 ab	2.3 a	1.3 a	1.0 a
+QP Ipro 2SE	1.47 fl.oz.							
+QP TM Flowable	0.65 fl.oz.							
+QP Tebuconazole	0.244 fl.oz.							
QP Enclave	3.0 fl.oz.	14-d	0.0 c	0.0 b	0.5 bc	1.0 b	0.5 b	0.5 b
Plant Food Program 1	pgm[w]	7-d	0.5 ab	0.0 b	0.3 bc	0.5 bcd	0.5 b	0.0 c
Plant Food Program 2	pgm[v]	7-d	0.8 a	0.3 b	0.5 bc	0.8 bc	1.0 a	0.0 c
Untreated			0.0 c	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
Untreated			0.0 c	0.0 b	0.0 c	0.3 cd	0.0 c	0.0 c
Untreated			0.0 c	0.0 b	0.0 c	0.0 d	0.0 c	0.0 c
ANOVA: Treatment ($P > F$)			0.0002	0.0208	0.0002	0.0001	0.0001	0.0001
Days after treatment		7-d	6	4	10	2	2	3
		14-d	6	4	14	2	2	3

[z]Primo MAXX was applied at a rate of 0.1 fl.oz. until 16 June, after which it was applied at 0.125 fl.oz.

[y]Daconil Action (3.5 fl.oz.), Velista (0.5 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Briskway (0.49 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

[x]Daconil Action (3.5 fl.oz.), Secure (0.5 fl.oz.), Signature (4.0 oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 20 May, 16 June, 16 July, and 12 August. Daconil Action (3.5 fl.oz.), Medallion (1.5 fl.oz.), and Primo MAXX (0.125 fl.oz.[z]) were tank-mixed and applied on 2 June, and 1 and 29 July.

[w]16-2-7 (6.0 fl.oz.), Phosphite 30 (3.0 fl.oz.), Adams Earth (3.0 fl.oz.), 6 Iron (3.0 fl.oz.), Flo Thru (1.5 fl.oz.), and Daconil Weather Stik (0.9 fl.oz.) were tank-mixed and applied on 20 May, 2 and 16 June, 1, 16, and 29 July, and 12 August. Harrell's pH Buffer (0.44 fl.oz.), Cal Nitrate (6.0 fl.oz.), Sugar Cal (3.0 fl.oz.), Impulse (3.0 fl.oz.), Omega (0.35 fl.oz.), and Daconil Weather Stik were tank-mixed and applied on 27 May, 10 and 24 June, 8 and 22 July, and 5 August.

[v]16-2-7 (6.0 fl.oz.), Phosphite 30 (3.0 fl.oz.), Adams Earth (3.0 fl.oz.), 6 Iron (3.0 fl.oz.), and Flo Thru (1.5 fl.oz.) were tank-mixed and applied on 20 May, 2 and 16 June, 1, 16, and 29 July, and 12 August. Harrell's pH Buffer (0.44 fl.oz.), Cal Nitrate (6.0 fl.oz.), Sugar Cal (3.0 fl.oz.), Impulse (3.0 fl.oz.), and Omega (0.35 fl.oz.) were tank-mixed and applied on 27 May, 10 and 24 June, 8 and 22 July, and 5 August.

[u]Treatments were initiated on 20 May, prior to disease development. Subsequent 7-d treatments were applied on 27 May, 2, 10, 16, and 24 June, 1, 8, 16, 22, and 29 July, and 5 and 12 August. Subsequent 14-d treatments were applied on 2 and 16 June, 1, 16, and 29 July, and 12 August.

[t]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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PREVENTIVE ANTHRACNOSE CONTROL WITH PCNB AND OTHER FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2014

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INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. An integrated disease control program including cultural management and fungicides is required to minimize turf loss due to this disease. Rotational fungicide programs utilizing different chemical modes of action and multi-site fungicides have been found to be most effective in providing season-long anthracnose control. Identifying new fungicides with unique modes of action effective against anthracnose is important to continued control of this disease and resistance management. The objective of this study was to examine the efficacy of PCNB and a developmental fungicide applied alone or in combination with other commonly used fungicides 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 1.7 lb N $1000\text{-}ft^{-2}$ 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 13 May for dollar spot control; ProStar (1.5 oz) was also applied every 14 days from 14 June throughout the trial to prevent brown patch development. Subdue MAXX (1.0 fl.oz.) was applied for downy mildew on 29 April. Scimitar GC (0.23 fl.oz.) and Dylox 80 (3.75 oz.) were applied on 21 and 31 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 and rotational programs. Initial applications were made on 21 May prior to disease developing in the trial area. Subsequent applications were made every 14-d through 12 August. 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 $1000\text{-}ft^{-2}$ 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 27 June through 15 August. 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 on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Anthracnose severity data were arcsine square root transformed for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS & DISCUSSION

Anthracnose Severity

Anthracnose symptoms were first observed uniformly throughout the trial on 27 June, developing from a natural infestation (Table 1). Disease progressed quickly in untreated control plots reaching ~50% plot area blighted by mid-July and 76% by early-August. However, mild summer temperatures during July and August kept overall disease pressure low throughout the trial. All treatments provided near complete or acceptable anthracnose control through July. However, breakthrough in control started to become evident in some treatments by August.

Turfcide and UC14-7 provided acceptable anthracnose control throughout the trial (Table 1). Both provided similar levels of control whether they were applied with Par only, or tank mixed with Torque and Par, regardless of application rate. Turfcide or UC14-7 applied at 4.0 fl.oz. with Par were not significantly different than increased rates of each of these fungicides, although lower rates also were not different than less effective treatments in this study (e.g., Torque 0.3 fl.oz.). Rotational programs including Turfcide or UC14-7 provided excellent disease control. Torque applied at the standard rate (0.6 fl.oz.) and Velista at 0.5 oz provided excellent to good anthracnose control throughout the trial. Reduced rates of Torque (0.3 or 0.45 fl.oz.) applied alone provided good disease control during most of the trial, although they were less effective than the standard rate by 15 August. Similarly, the low rate of Velista (0.3 oz.) failed to provide season-long anthracnose control. Heritage TL applied alone did not control anthracnose in the current trial. Resistance to QoI fungicides, such as Heritage TL, is well documented among *C. cereale* isolates. Based on these data and previous years observations, the population of *C. cereale* at the Storrs site is likely resistant to all QoI fungicides. However, at locations with *C. cereale* populations susceptible to QoI's this group of fungicides can be very effective for anthracnose control.

Turf Quality and Phytotoxicity

Turf quality in the trial was predominantly influenced by anthracnose incidence and phytotoxicity. Most treatments provided good turf quality in May (Table 2), prior to significant anthracnose development. However, by June and

July, repeat applications of Torque every 14-d began to reduce turf quality. Turf quality differences were most apparent on 3 July. Highest quality turf on this date was observed in Turfcide + Par, UC14-7 + Par, UC14-7 + Par + Velista, and UC14-7 + Par + Heritage TL. Torque applied alone reduced turf quality to unacceptable levels regardless of application rate. Moreover, the addition of Torque to tank mixes of Turfcide + Par or UC14-7 + Par slightly reduced turf quality. This was most evident in treatments containing the high rate of Torque (0.6 fl.oz.), Turfcide (6.0 fl.oz.) or UC14-7 (6.0 – 8.0 fl.oz.). Rotational programs containing Torque had a similar response. Turf treated with repeat applications of UC14-9 + Par also had reduced, albeit acceptable, turf quality compared to UC14-7. The addition of Par to Torque appeared to help reduce the severity of phytotoxicity associated with this treatment (Table 3).

CONCLUSION

Turfcide and UC14-7 provided good to excellent control of anthracnose under low disease pressure during this trial. Increased rates (i.e., 6.0 – 8.0 fl.oz.) of UC14-7 appeared to be more effective than reduced rates (4.0 fl.oz.), but were not statistically different. No phytotoxicity was observed in Turfcide + Par or UC14-7 + Par treated turf regardless of rate. Phytotoxicity in creeping bentgrass has been observed with Turfcide and AMV4820; however based on these data annual bluegrass appears to be less susceptible to this injury, or potential detrimental effects may have been masked by Par, a green pigment.

Tank mixes containing Torque + Par with Turfcide or UC14-7 provided similar disease control as the later two fungicides applied alone. However, under higher disease pressure the addition of Torque would likely provide better anthracnose control than Turfcide or UC14-7 alone. Velista or Heritage TL tank mixed with Turfcide and UC14-7 also provided excellent anthracnose control. Moreover, Velista and Heritage TL did not reduce turf quality like repeat applications of Torque tank mixes. Repeat applications of Torque with Turfcide or UC14-7 should be avoided to minimize reductions in turf quality commonly associated with frequent applications of DMI fungicides. In the current trial, Torque (0.6 fl.oz.) + UC14-7 (4.0 fl.oz.) + Par provided excellent anthracnose control with minimal reduction in turf quality.

Turfcide is not currently labeled for anthracnose control. Preliminary results with this fungicide appear promising for anthracnose control. However, further research is needed to validate the efficacy of this material against anthracnose and its safety on annual bluegrass putting greens under more stressful environmental conditions.

Table 1. Anthracnose severity influenced by various fungicides and a green pigment applied preventatively to annual bluegrass putting green turf at the Plant Science Research Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[x]	Anthracnose Severity					
			27 Jun	3 Jul	11 Jul	17 Jul	1 Aug	15 Aug
			% plot area blighted					
Turfcide...................................... +Harrell's Par.........................	4.0 fl oz 0.37 fl oz	14-d	0.0[w] e[v]	0.0 d	0.3 cd	0.5 cd	0.1 ef	5.5 cde
Turfcide...................................... +Harrell's Par.........................	8.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.1 d	0.3 c-f	1.2 c-g
UC14-7....................................... +Harrell's Par.........................	4.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.6 cd	2.5 cd	5.8 bcd
UC14-7....................................... +Harrell's Par.........................	6.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.7 c-f	0.6 d-g
UC14-7....................................... +Harrell's Par.........................	8.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.0 f	0.9 d-g
Torque..	0.3 fl oz	14-d	0.5 cd	0.3 c	2.3 bc	2.8 bc	3.0 c	9.4 bc
Torque......................................	0.45 fl oz	14-d	0.3 d	0.0 d	0.3 cd	0.3 d	1.1 c-f	5.4 cde
Torque..	0.6 fl oz	14-d	0.0 e	0.0 d	0.3 cd	0.2 d	0.1 ef	0.1 fg
Velista	0.3 oz	14-d	0.8 bc	1.7 b	3.7 b	6.3 b	10.7 b	18.6 b
Velista	0.5 oz	14-d	0.0 e	0.1 cd	0.3 cd	0.3 d	1.8 cde	3.5 c-g
Heritage TL................................	1.0 fl oz	14-d	2.0 a	11.9 a	47.5 a	67.9 a	76.5 a	55.1 a
Torque.. +Turfcide.................................. +Harrell's Par.........................	0.6 fl oz 4.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.0 f	3.1 c-g
Torque.. +Turfcide.................................. +Harrell's Par.........................	0.6 fl oz 8.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.1 d	0.0 f	5.0 c-f
Torque.. +UC14-7 .... +Harrell's Par.........................	0.3 fl oz 4.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.0 f	2.6 c-g
Torque...................................... +UC14-7 .... +Harrell's Par.........................	0.45 fl oz 6.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.5 c-f	0.6 d-g
Torque.. +UC14-7 .... +Harrell's Par.........................	0.6 fl oz 4.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.0 f	0.0 g
Torque.. +UC14-7 .... +Harrell's Par.........................	0.6 fl oz 6.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.0 f	0.1 fg
Torque.. +UC14-7 .... +Harrell's Par.........................	0.6 fl oz 8.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.2 cd	0.1 d	0.6 c-f	0.7 d-g
UC14-9..................................... +Harrell's Par.........................	7.41 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.1 d	0.1 d	0.2 def	3.2 c-g
Velista .... +UC14-7 .... +Harrell's Par.........................	0.3 oz 8.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.1 d	0.1 ef	0.5 d-g
Heritage TL................................ +UC14-7 .... +Harrell's Par.........................	1.0 fl oz 8.0 fl oz 0.37 fl oz	14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.0 f	0.4 d-g
AMVAC Program 1[z]		14-d	0.0 e	0.0 d	0.0 d	0.1 d	0.3 c-f	0.5 d-g
AMVAC Program 2[y]		14-d	0.0 e	0.0 d	0.0 d	0.0 d	0.0 f	0.0 g
Untreated			1.5 ab	10.9 a	50.1a	66.2 a	76.2 a	62.2 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment			8	1	9	15	2	3

[z]Torque (0.6 fl oz), UC14-7 (8.0 fl oz) and Harrell's Par (0.37 fl oz) were tank-mixed and applied on 21 May and 30 July. Daconil Ultrex (3.25 oz) was applied on 3 June and 2 July. Signature (4.0 oz) and Velista (0.5 oz) were applied on 19 June and 17 July. Endorse (4.0 oz) was applied on 2 July. Signature (4.0 oz) and Medallion (0.33 oz) were applied on 12 August.

[y]Torque (0.6 fl oz), Turfcide (8.0 fl oz) and Harrell's Par (0.37 fl oz) were tank-mixed and applied on 21 May and 30 July. Daconil Ultrex (3.25 oz) was applied on 3 June and 2 July. Signature (4.0 oz) and Velista (0.5 oz) were applied on 19 June and 17 July. Endorse (4.0 oz) was applied on 2 July. Signature (4.0 oz) and Medallion (0.33 oz) were applied on 12 August.

[x]Treatments were initiated on 21 May, prior to disease development. Subsequent applications of 14-d treatments were made on 21 May, 3 and 19 June, 2, 17, and 30 July, and 12 August.

[w] Data were arcsine square-root transformed; means presented are de-transformed.

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

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Table 2 Turf quality influenced by various fungicides and a green pigment on annual bluegrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

			Turf Quality							
Treatment	Rate per 1000ft^2	Int[x]	26 May	30 May	6 Jun	20 Jun	3 Jul	17 Jul	1 Aug	15 Aug
			---- 1-9; 6=min acceptable ----							
Turfcide	4.0 fl oz	14-d	7.5 abc[w]	7.3 a-d	6.8 a-d	7.8 ab	8.3 a	7.0 b-e	6.8 a-d	7.5 abc
+Harrell's Par	0.37 fl oz									
Turfcide	8.0 fl oz	14-d	7.0 cd	7.5 abc	7.3 ab	7.8 ab	8.5 a	7.5 abc	7.0 abc	8.0 ab
+Harrell's Par	0.37 fl oz									
UC14-7	4.0 fl oz	14-d	8.0 a	7.8 ab	7.0 abc	8.0 a	8.8 a	7.0 b-e	6.0 c-f	6.5 c-f
+Harrell's Par	0.37 fl oz									
UC14-7	6.0 fl oz	14-d	7.8 ab	8.0 a	7.3 ab	7.3 bcd	8.0 ab	7.8 ab	6.5 b-e	8.5 a
+Harrell's Par	0.37 fl oz									
UC14-7	8.0 fl oz	14-d	7.3 bc	7.3 a-d	6.3 c-f	7.0 cd	8.0 ab	8.0 a	7.5 ab	8.3 ab
+Harrell's Par	0.37 fl oz									
Torque	0.3 fl oz	14-d	6.0 ef	6.5 de	5.8 e-h	6.0 fg	5.5 fg	5.8 g	5.3 ef	5.8 ef
Torque	0.45 fl oz	14-d	5.5 f	6.3 e	4.8 i	5.5 g	5.0 gh	6.0 fg	5.5 def	6.0 def
Torque	0.6 fl oz	14-d	6.3 e	6.5 de	5.0 hi	6.3 ef	5.0 gh	5.8 g	6.0 c-f	7.0 b-e
Velista	0.3 oz	14-d	6.3 e	6.3 e	5.3 ghi	5.8 fg	5.8 efg	6.0 fg	5.0 f	5.3 f
Velista	0.5 oz	14-d	6.5 de	7.0 b-e	6.5 b-e	6.3 ef	6.5 cde	6.3 efg	6.0 c-f	7.3 a-d
Heritage TL	1.0 fl oz	14-d	6.0 ef	6.5 de	5.5 f-i	5.5 g	4.3 h	3.5 h	2.5 g	3.5 g
Torque	0.6 fl oz	14-d	7.5 abc	7.5 abc	6.8 a-d	7.3 bde	6.5 cde	6.5 d-g	6.5 b-e	7.8 abc
+Turfcide	4.0 fl oz									
+Harrell's Par	0.37 fl oz									
Torque	0.6 fl oz	14-d	6.0 ef	6.8 cde	6.0 d-g	6.8 de	6.3 def	6.8 c-f	6.5 b-e	7.5 abc
+Turfcide	8.0 fl oz									
+Harrell's Par	0.37 fl oz									
Torque	0.3 fl oz	14-d	7.0 cd	7.0 b-e	6.5 b-e	6.8 de	7.3 bc	7.3 a-d	6.8 a-d	7.5 abc
+UC14-7	4.0 fl oz									
+Harrell's Par	0.37 fl oz									
Torque	0.45 fl oz	14-d	7.3 bc	7.5 abc	6.5 b-e	7.3 bcd	7.3 bc	7.0 b-e	7.0 abc	7.5 abc
+UC14-7	6.0 fl oz									
+Harrell's Par	0.37 fl oz									
Torque	0.6 fl oz	14-d	7.3 bc	7.3 a-d	6.0 d-g	7.0 cd	7.3 bc	7.0 b-e	7.0 abc	8.3 ab
+UC14-7	4.0 fl oz									
+Harrell's Par	0.37 fl oz									
Torque	0.6 fl oz	14-d	6.5 de	6.5 de	6.5 b-e	7.0 cd	7.0 cd	6.8 c-f	6.8 a-d	8.3 ab
+UC14-7	6.0 fl oz									
+Harrell's Par	0.37 fl oz									
Torque	0.6 fl oz	14-d	7.5 abc	7.3 a-d	6.8 a-d	7.0 cd	6.3 def	7.5 abc	6.5 b-e	7.8 a-d
+UC14-7	8.0 fl oz									
+Harrell's Par	0.37 fl oz									
UC14-9	7.41 fl oz	14-d	7.0 cd	7.0 b-e	6.3 c-f	7.3 bcd	6.8 cd	6.8 c-f	6.5 b-e	7.3 a-d
+Harrell's Par	0.37 fl oz									
Velista	0.3 oz	14-d	7.5 abc	7.5 abc	7.5 a	7.5 abc	8.3 a	7.8 ab	7.8 ab	8.3 ab
+UC14-7	8.0 fl oz									
+Harrell's Par	0.37 fl oz									
Heritage TL	1.0 fl oz	14-d	7.0 cd	7.8 ab	6.8 a-d	7.0 cd	8.0 ab	7.8 ab	7.0 abc	8.3 ab
+UC14-7	8.0 fl oz									
+Harrell's Par	0.37 fl oz									
AMVAC Program 1[z]		14-d	7.3 bc	7.3 a-d	5.8 e-h	6.8 de	6.3 def	7.3 a-d	7.3 abc	7.8 abc
AMVAC Program 2[y]		14-d	7.5 abc	7.3 a-d	6.0 d-g	6.8 de	6.8 cd	7.8 ab	8.0 a	8.0 ab
Untreated			6.5 de	6.8 cde	5.3 ghi	5.8 fg	4.5 h	3.3 h	2.0 g	3.0 g
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment			5	9	3	1	1	15	2	3

[z]Torque (0.6 fl oz), UC14-7 (8.0 fl oz) and Harrell's Par (0.37 fl oz) were tank-mixed and applied on 21 May and 30 July. Daconil Ultrex (3.25 oz) was applied on 3 June and 2 July. Signature (4.0 oz) and Velista (0.5 oz) were applied on 19 June and 17 July. Endorse (4.0 oz) was applied on 2 July. Signature (4.0 oz) and Medallion (0.33 oz) were applied on 12 August.

[y]Torque (0.6 fl oz), Turfcide (8.0 fl oz) and Harrell's Par (0.37 fl oz) were tank-mixed and applied on 21 May and 30 July. Daconil Ultrex (3.25 oz) was applied on 3 June and 2 July. Signature (4.0 oz) and Velista (0.5 oz) were applied on 19 June and 17 July. Endorse (4.0 oz) was applied on 2 July. Signature (4.0 oz) and Medallion (0.33 oz) were applied on 12 August.

[x]Treatments were initiated on 21 May, prior to disease development. Subsequent applications of 14-d treatments were made on 21 May, 3 and 19 June, 2, 17, and 30 July, and 12 August.

[w] 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 3. Phytotoxicity affected by various fungicides and a green pigment on annual bluegrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[x]	Phytotoxicity 26 May	6 Jun	20 Jun	3 Jul	17 Jul	1 Aug	15 Aug
			------------------------------ 0-5; 2=max acceptable ------------------------------						
Turfcide	4.0 fl oz	14-d	0.0	0.0	0.0 b[w]	0.0 d	0.0	0.0 d	0.0 b
+Harrell's Par	0.37 fl oz								
Turfcide	8.0 fl oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
+Harrell's Par	0.37 fl oz								
UC14-7	4.0 fl oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
+Harrell's Par	0.37 fl oz								
UC14-7	6.0 fl oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
+Harrell's Par	0.37 fl oz								
UC14-7	8.0 fl oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
+Harrell's Par	0.37 fl oz								
Torque	0.3 fl oz	14-d	0.3	0.0	0.3 b	1.0 b	0.0	1.5 b	1.0 a
Torque	0.45 fl oz	14-d	0.5	0.0	1.0 a	2.5 a	0.0	2.3 a	1.0 a
Torque	0.6 fl oz	14-d	0.0	0.0	0.3 b	3.0 a	0.0	1.8 ab	1.3 a
Velista	0.3 oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
Velista	0.5 oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
Heritage TL	1.0 fl oz	14-d	0.3	0.0	0.3 b	0.0 d	0.0	0.0 d	0.0 b
Torque	0.6 fl oz	14-d	0.0	0.0	0.0 b	0.3 cd	0.0	0.5 cd	0.0 b
+Turfcide	4.0 fl oz								
+Harrell's Par	0.37 fl oz								
Torque	0.6 fl oz	14-d	0.0	0.0	0.0 b	0.3 cd	0.0	0.3 cd	0.0 b
+Turfcide	8.0 fl oz								
+Harrell's Par	0.37 fl oz								
Torque	0.3 fl oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
+UC14-7	4.0 fl oz								
+Harrell's Par	0.37 fl oz								
Torque	0.45 fl oz	14-d	0.3	0.0	0.0 b	0.3 cd	0.0	0.0 d	0.0 b
+UC14-7	6.0 fl oz								
+Harrell's Par	0.37 fl oz								
Torque	0.6 fl oz	14-d	0.0	0.0	0.0 b	0.3 cd	0.0	0.0 d	0.0 b
+UC14-7	4.0 fl oz								
+Harrell's Par	0.37 fl oz								
Torque	0.6 fl oz	14-d	0.0	0.0	0.0 b	0.3 cd	0.0	0.8 c	0.0 b
+UC14-7	6.0 fl oz								
+Harrell's Par	0.37 fl oz								
Torque	0.6 fl oz	14-d	0.0	0.0	0.0 b	0.3 cd	0.0	0.5 cd	0.0 b
+UC14-7	8.0 fl oz								
+Harrell's Par	0.37 fl oz								
UC14-9	7.41 fl oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.3 cd	0.3 b
+Harrell's Par	0.37 fl oz								
Velista	0.3 oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
+UC14-7	8.0 fl oz								
+Harrell's Par	0.37 fl oz								
Heritage TL	1.0 fl oz	14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
+UC14-7	8.0 fl oz								
+Harrell's Par	0.37 fl oz								
AMVAC Program 1[z]		14-d	0.0	0.0	0.0 b	0.0 d	0.0	0.0 d	0.0 b
AMVAC Program 2[y]		14-d	0.0	0.0	0.0 b	0.3 cd	0.0	0.3 cd	0.0 b
Untreated			0.0	0.0	0.0 b	0.8 bc	0.0	0.0 d	0.0 b
ANOVA: Treatment (P > F)			0.1492	1.0000	0.0002	0.0001	1.000	0.0001	0.0001
Days after treatment			5	3	1	1	15	2	3

[z]Torque (0.6 fl oz), UC14-7 (8.0 fl oz) and Harrell's Par (0.37 fl oz) were tank-mixed and applied on 21 May and 30 July. Daconil Ultrex (3.25 oz) was applied on 3 June and 2 July. Signature (4.0 oz) and Velista (0.5 oz) were applied on 19 June and 17 July. Endorse (4.0 oz) was applied on 2 July. Signature (4.0 oz) and Medallion (0.33 oz) were applied on 12 August.

[y]Torque (0.6 fl oz), Turfcide (8.0 fl oz) and Harrell's Par (0.37 fl oz) were tank-mixed and applied on 21 May and 30 July. Daconil Ultrex (3.25 oz) was applied on 3 June and 2 July. Signature (4.0 oz) and Velista (0.5 oz) were applied on 19 June and 17 July. Endorse (4.0 oz) was applied on 2 July. Signature (4.0 oz) and Medallion (0.33 oz) were applied on 12 August.

[x]Treatments were initiated on 21 May, prior to disease development. Subsequent applications of 14-d treatments were made on 21 May, 3 and 19 June, 2, 17, and 30 July, and 12 August.

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

ANTHRACNOSE SEVERITY INFLUENCED BY SEAWEED EXTRACTS WITH AND WITHOUT PHOSPHITE AND FUNGICIDES, 2014

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INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. Factors which enhance turf stress such as heat, drought stress, low fertility, etc. are known to predispose turf to the disease. Practices and products which minimize turf stress can reduce the disease. Seaweed extracts are commonly used in turf to improve abiotic stress tolerance. These products contain phytohormones such as cytokinins which have been shown to enhance heat tolerance and other abiotic stresses. Phosphites are also commonly applied to putting greens to minimize abiotic stress. Moreover, phosphite fertilizers have been demonstrated to help suppress anthracnose. The objectives of this trial were: 1.) to compare Sea Green Organic seaweed extract to a commercially available product for suppression of anthracnose; 2.) assess any potential synergistic benefits of tank-mixes of seaweed extracts and a phosphite fertilizer; 3.) determine if seaweed extract and phosphite tank-mixes could improve efficacy of chlorothalonil for anthracnose control.

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 1.7 lb N 1000-ft^{-2} was applied as water soluble sources from April through 15 August. 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 13 May for dollar spot control; ProStar (1.5 oz) was also applied every 14 days from 14 June throughout the trial to prevent brown patch development. Subdue MAXX (1.0 fl.oz.) was applied for downy mildew on 29 April. Scimitar GC (0.23 fl.oz.) and Dylox 80 (3.75 oz.) were applied on 21 and 31 May for control of annual bluegrass weevil adults and larvae, respectively.

Initial applications were made on 20 May prior to disease developing in the trial area. Subsequent applications were made every 7 or 14-d through 5 August. 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 27 June through 15 August. 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 on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Anthracnose severity data were arcsine square root transformed for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS

Anthracnose Severity

Disease pressure was low throughout the trial due to mild summer temperatures and humidity. Anthracnose symptoms were first observed uniformly throughout the trial on 27 June, developing from a natural infestation (Table 1). Disease progressed in untreated control plots reaching ~30% plot area blighted by mid-July and ~40% by early-August.

In the absence of phosphite or chlorothalonil, Sea Green seaweed extract (SG-SWE) provided a slight reduction of anthracnose symptoms compared to untreated turf during early- and mid-July as the epidemic began to increase. Disease suppression observed at this time was not commercially acceptable. As disease continued to increase in late-July and August turf treated with SG-SWE alone was no different than untreated. Guarantee Organic (GO-SWE) alone did not reduce anthracnose at anytime during this trial. However, SG-SWE provided statistically better anthracnose than GO-SWE on only one observation date (17 Jul). In general, SWE applied alone had little effect on anthracnose.

The phosphite fertilizer, P-K Plus, provided a significant reduction of anthracnose throughout the trial. However, disease severity in these plots would not be considered commercially acceptable. Combinations of P-K Plus with either SWE did not improve disease control compared to P-K Plus alone. No differences between SWE products were observed when applied with P-K Plus. The only treatments to provide acceptable disease control throughout this trial were those containing the fungicide Daconil Weather Stik. This fungicide and the application rate were selected based on previous observations that this material and rate are unlikely to provide season-long anthracnose control. Less than optimal fungicidal disease control may have provided an opportunity to observe potential benefits of tank-mixes including SWE and phosphites. However, disease pressure was relatively low in this trial due to mild summer conditions, and Daconil Weather Stik provided good disease control regardless of SWE or phosphite.

Turf Quality, NDVI, and Phytotoxicity

No turf quality differences were observed among any of the treatments prior to the onset of disease symptoms (Table 2). By 3 July disease had developed throughout the study and differences in turf quality were largely based on the presence or absence of anthracnose. Results from NDVI measurements were similarly affected by anthracnose, however treatment differences were observed on one date prior to the onset of disease. On that date (9 June) turf treated with P-K Plus generally had the highest NDVI readings (Table 3). This is likely due to nitrogen or micronutrients contained in P-K Plus. No phytotoxicity was observed in any of the treatments evaluated in this trial (Table 4).

DISCUSSION

In this trial, Sea Green seaweed extract provided a slight reduction of anthracnose severity during the onset of disease. Disease was reduced more consistently, and to a greater extent with the phosphite P-K Plus. However, neither of these products provided acceptable disease control applied alone or together. It is important to note that neither product is a registered pesticide, and does not claim to provide disease control. Rather, the objective of this trial was to see if they had any suppressive effects and if the combination of these products was more effective than either applied individually. In this trial, the addition of SWE to a phosphite did not improve disease suppression compared to the phosphite alone. Fungicide efficacy of a moderate rate of chlorothalonil was not improved when applied with SWE and phosphite, however this may be due to the good control achieved with chlorothalonil under low disease pressure.

Table 1. Anthracnose severity influenced by seaweed extracts and a phosphite with and without chlorothalonil applied preventatively to annual bluegrass putting green turf at the Plant Science Research Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[z]	Anthracnose Severity						
			27 Jun	3 Jul	11 Jul	17 Jul	27 Jul	1 Aug	15 Aug
			% plot area blighted						
Sea Green Organic	6.0 fl oz	14-d	0.0	1.0[y] bcd[x]	14.9 bc	26.5 b	27.4 ab	33.1 ab	39.7 ab
Guarantee Organic	6.0 fl oz	14-d	0.3	2.6 ab	24.6 ab	42.4 a	34.3 a	46.4 a	43.6 a
P-K Plus	6.0 fl oz	14-d	0.4	1.2 bc	7.0 cd	11.0 c	17.7 b	18.7 b	27.2 b
Sea Green Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	0.0	0.2 cd	5.8 d	11.4 c	15.5 b	19.2 b	29.5 ab
Guarantee Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	0.3	0.6 bcd	6.5 d	14.8 bc	15.6 b	24.2 b	28.7 b
Daconil Weather Stik	3.0 fl oz	14-d	0.1	0.0 d	0.0 e	0.1 d	2.0 c	0.9 c	3.4 c
Sea Green Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	0.0	0.0 d	0.0 e	0.1 d	0.9 c	0.4 c	1.4 c
Guarantee Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	0.3	0.3 cd	0.3 e	0.7 d	2.2 c	1.8 c	2.4 c
Untreated			0.0	4.2 a	27.1 a	44.7 a	41.1 a	45.6 a	43.6 a
ANOVA: Treatment (P > F)			0.2790	0.0017	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	10	2	10	16	10	3	3

[z]Treatments were initiated on 20 May, prior to disease development. Subsequent 14-d treatments were applied on 2 June, 17 June, 1 July, 17 July, 29 July, and 12 August.

[y]Data were arc-sin 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 ($\alpha = 0.05$).

Table 2. Turf quality influenced by seaweed extracts and a phosphite with and without chlorothalonil applied preventatively to annual bluegrass putting green turf at the Plant Science Research Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[z]	Turf Quality				
			26 May	6 Jun	20 Jun	3 Jul	1 Aug
			1-9; 6=min acceptable				
Sea Green Organic	6.0 fl oz	14-d	7.0	6.5	7.8	6.3 bcd[y]	3.0 cde
Guarantee Organic	6.0 fl oz	14-d	7.0	6.3	7.0	5.8 cd	2.5 e
P-K Plus	6.0 fl oz	14-d	7.0	6.5	7.8	6.3 bcd	3.8 bcd
Sea Green Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	7.0	6.3	8.0	6.5 abc	4.0 bc
Guarantee Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	7.3	6.5	7.5	6.5 abc	4.3 b
Daconil Weather Stik	3.0 fl oz	14-d	7.0	6.5	7.3	7.3 a	7.0 a
Sea Green Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	7.3	6.5	7.3	7.0 ab	7.3 a
Guarantee Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	7.0	6.3	7.8	6.8 ab	6.3 a
Untreated			7.0	6.0	7.5	5.5 d	2.8 de
ANOVA: Treatment (P > F)			0.5774	0.7363	0.1320	0.0048	0.0001
Days after treatment		14-d	6	4	3	2	3

[z]Treatments were initiated on 20 May, prior to disease development. Subsequent 14-d treatments were applied on 2 June, 17 June, 1 July, 17 July, 29 July, and 12 August.

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

Table 3. NDVI affected by seaweed extracts and a phosphite with and without chlorothalonil applied preventatively to annual bluegrass putting green turf at the Plant Science Research Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[z]	NDVI 9 Jun	16 Jun	23 Jun	9 Jul	17 Jul	1 Aug	11 Aug
			index value						
Sea Green Organic	6.0 fl oz	14-d	0.770 cd[y]	0.746	0.720	0.705 bc	0.701 cde	0.670 cd	0.689 b
Guarantee Organic	6.0 fl oz	14-d	0.770 cd	0.735	0.726	0.688 d	0.695 de	0.656 cd	0.690 b
P-K Plus	6.0 fl oz	14-d	0.780 ab	0.739	0.730	0.711 abc	0.706 cd	0.685 abc	0.696 b
Sea Green Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	0.783 a	0.748	0.722	0.712 abc	0.715 bc	0.678 bc	0.687 b
Guarantee Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	0.778 abc	0.748	0.714	0.715 ab	0.704 cd	0.681 bc	0.693 b
Daconil Weather Stik	3.0 fl oz	14-d	0.767 d	0.738	0.716	0.717 ab	0.728 ab	0.710 ab	0.726 a
Sea Green Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	0.780 ab	0.749	0.720	0.719 ab	0.730 a	0.706 ab	0.730 a
Guarantee Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	0.772 bcd	0.743	0.724	0.720 a	0.723 ab	0.714 a	0.736 a
Untreated			0.773 bcd	0.745	0.724	0.699 cd	0.690 e	0.645 d	0.680 b
ANOVA: Treatment (P > F)			0.0190	0.5077	0.5528	0.0014	0.0001	0.0015	0.0005
Days after treatment		14-d	7	14	6	8	16	3	13

[z]Treatments were initiated on 20 May, prior to disease development. Subsequent 14-d treatments were applied on 2 June, 17 June, 1 July, 17 July, 29 July, and 12 August.

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

Table 4. Phytotoxicity affected by seaweed extracts and a phosphite with and without chlorothalonil applied preventatively to annual bluegrass putting green turf at the Plant Science Research Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[z]	Phytotoxcity 26 May	6 Jun	20 Jun	3 Jul
			0-5; 2=max acceptable			
Sea Green Organic	6.0 fl oz	14-d	0.0	0.0	0.0	0.0
Guarantee Organic	6.0 fl oz	14-d	0.0	0.0	0.0	0.0
P-K Plus	6.0 fl oz	14-d	0.0	0.0	0.0	0.0
Sea Green Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	0.0	0.0	0.0	0.0
Guarantee Organic +P-K Plus	6.0 fl oz 6.0 fl oz	14-d	0.0	0.0	0.0	0.0
Daconil Weather Stik	3.0 fl oz	14-d	0.0	0.0	0.0	0.0
Sea Green Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	0.0	0.0	0.0	0.0
Guarantee Organic +P-K Plus +Daconil Weather Stik	6.0 fl oz 6.0 fl oz 3.0 fl oz	14-d	0.0	0.0	0.0	0.0
Untreated			0.0	0.0	0.0	0.0
ANOVA: Treatment (P > F)			1.0000	1.0000	1.0000	1.0000
Days after treatment		14-d	6	4	3	2

[z]Treatments were initiated on 20 May, prior to disease development. Subsequent 14-d treatments were applied on 2 June, 17 June, 1 July, 17 July, 29 July, and 12 August.

PREVENTIVE BROWN PATCH CONTROL WITH FUNGICIDES AND BIORATIONALS ON A COLONIAL BENTGRASS FAIRWAY TURF, 2014

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INTRODUCTION

Brown patch of turfgrass, caused by *Rhizoctonia solani* is characterized by round patches of diffusely-blighted, thinned turf. It is a summer disease that is most active under warm (nighttime temps ≥ 65° F) and humid conditions. On golf course fairways it is commonly controlled using cultural practices such as avoiding excess nitrogen and improving air movement, as well as through the use of preventative fungicides. The objective of this study was to evaluate the effectiveness of new and existing fungicides and biorational materials at controlling brown patch in a colonial bentgrass fairway turf.

MATERIALS AND 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 1.85 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through July. Daconil Ultrex was applied on 13 May to prevent brown patch development before initiation of treatments. Emerald was applied on 31 May to prevent dollar spot development. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of fungicides and biorationals applied individually, or as tank mixes. Initial applications were made on 10 June prior to disease developing in the trial area. Subsequent applications were made at specified treatment intervals through 30 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 1.0 gal $1000\text{-}ft^{-2}$ at 40 psi, except Turfshield Plus G. Turfshield Plus G was applied by hand using a shaker jar and watered-in immediately afterward with a watering can to deliver 0.1 inch of irrigation. Quantum Growth treatments were applied once the turf canopy had dried.

Brown patch was assessed visually as a percentage of the plot area blighted by *Rhizoctonia solani*. 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 arc-sin square root transformed for ANOVA and mean separation tests, although means presented are de-transformed values.

RESULTS AND DISCUSSION

Brown Patch

Disease pressure was inconsistent throughout the trial area for the duration of the trial. All fungicide treatments provided excellent levels of control at all dates, however it is worth noting that even untreated plots had acceptable levels of disease until 25 July (Table 1). It is unlikely that this season's brown patch infestation provided a rigorous and conclusive assessment of these treatments.

By 16 July, unacceptable levels of disease had developed in plots treated with Sugar Cal + Omega + Green Blade, with plots averaging 30.1% blighted turf. Individual plots of this treatment, however, had up to 70% blighted turf.

Disease increased by 25 July, resulting in unacceptable levels of brown patch in Turfshield Plus G + Quantum Grown VSC + Quantum growth, Regalia PTO, and Omega (regardless of rate) treated plots. Regalia + Daconil Weather Stik (2.0 fl oz) and Omega + Daconil Weather Stik both had acceptable levels of disease.

Turf Quality and Phytotoxicity

There was no phytotoxicity observed at any point throughout the trial (Table 3). Turf quality (Table 2) was therefore primarily influenced by brown patch severity. Fungicide treatments resulted in good to excellent turf quality at all dates. For other treatments, brown patch resulted in poor to unacceptable turf quality.

Due to variable amounts of disease, even within replications of the same treatment, the reliability of the means of these turf quality ratings is questionable. Individual untreated plots on 18 July, for example, ranged in quality ratings from 6.0 (minimally acceptable) to 9.0 (excellent) and on 11 August, they ranged from 4.0 (unacceptable) to 8.0 (good).

Table 1. Brown patch severity influenced by various fungicides and biorationals applied preventatively to a colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[x]	Brown Patch Severity							
			20 Jun	2 Jul	11 Jul	16 Jul	18 Jul	25 Jul	1 Aug	11 Aug
			% plot area blighted							
UC14-1	0.5 oz.	21-d	0.0	0.0	0.0[w] c[v]	0.0 f	0.0 d	0.0 b	0.3 c	0.0 f
UC14-2	0.5 oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.2 ef
UC14-3	0.5 oz.	21-d	0.0	0.0	0.0 c	0.1 ef	0.0 d	0.0 b	0.0 c	0.0 f
UC14-4	0.236 fl.oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.2 c	3.9 cde
UC14-5	0.21 fl.oz.	21-d	0.0	0.0	0.0 c	0.1 ef	0.0 d	0.0 b	0.0 c	1.3 def
UC14-1	0.5 oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.0 f
+ Secure	0.5 fl.oz.	21-d								
UC14-2	0.5 oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.1 ef
+ Secure	0.5 fl.oz.	21-d								
UC14-3	0.5 oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.1 ef
+ Secure	0.5 fl.oz.	21-d								
UC14-4	0.236 fl.oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.5 def
+ Secure	0.5 fl.oz.	21-d								
Secure	0.5 fl.oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.3 cd	1.6 b	1.3 c	1.0 def
QP Strobe 50 WG	0.4 oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.0 f
Heritage 50 WG	0.4 oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.0 f
Heritage TL	2.0 fl.oz.	21-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.0 f
Disarm T	0.66 fl.oz.	14-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.0 f
Disarm M	1.0 fl.oz.	14-d	0.0	0.0	0.0 c	0.0 f	0.0 d	0.0 b	0.0 c	0.3 def
Daconil Weather Stik	2.0 fl.oz.	14-d	0.0	0.0	0.0 c	0.6 def	0.5 cd	0.0 b	3.7 bc	1.5 def
+ Regalia PTO	3.0 fl.oz.	14-d								
Regalia PTO	3.0 fl.oz.	14-d	0.0	0.0	1.3 bc	5.7 b-e	4.4 bcd	21.4 a	21.6 a	16.7 ab
Sugar Cal	3.0 fl.oz.	14-d	0.0	0.0	3.5 ab	30.1 a	21.6 a	26.8 a	14.2 ab	22.5 a
+ Omega	0.35 fl.oz.	14-d								
+ Green Blade	0.35 fl.oz.	14-d								
Turfshield Plus G	2.0 lb[z]	28-d	0.0	0.0	1.9 bc	8.3 bcd	8.8 ab	14.9 a	15.1 ab	6.3 bcd
+ Quantum Growth VSC	2.0 fl.oz.	14-d								
+ Quantum Growth light	2.0 fl.oz.	14-d								
Omega	0.367 fl.oz.[y]	14-d	0.0	1.3	5.5 ab	15.5 ab	10.7 ab	27.4 a	16.5 ab	5.2 b-e
Omega	0.734 fl.oz.	14-d	0.0	1.3	1.5 bc	3.6 b-f	6.9 bc	16.2 a	16.5 ab	1.9 def
Omega	1.46 fl.oz.	14-d	0.0	1.5	9.9 a	14.1 abc	15.1 ab	23.4 a	29.1 a	12.0 abc
Omega	1.46 fl.oz.	14-d	0.0	0.0	0.0 c	2.9 c-f	3.5 bcd	0.0 b	4.0 bc	0.6 def
+ Daconil Weather Stik	2.0 fl.oz.	14-d								
Untreated			0.0	0.0	0.0 c	3.7 b-f	5.5 bc	19.2 a	20.2 a	11.5 abc
ANOVA: Treatment (P > F)			1.0000	0.1042	0.0011	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	10	21	9	14	1	8	2	12
		21-d	10	21	9	14	16	2	9	19
		28-d	10	21	28	33	1	8	15	25

[z]Plots treated with Turfshield Plus G received 0.1 inch of irrigation immediately following treatment application. Plots were allowed to dry before Quantum Growth treatments were applied.

[y]Water carrier was adjusted to a pH of 5.5 with Harrell's pH Buffer prior to addition of Omega.

[x]Treatments were initiated on 10 June, prior to disease development. Subsequent 14-d treatments were applied 21-d later on 2 July. Thereafter they were applied every 14-d on 17 and 30 July. Subsequent 21-d treatments were made on 2 and 23 July. Subsequent 28-d treatments were made on 17 July.

[w]Data were arc-sin square-root transformed; means are de-transformed for presentation.

[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 2. Turf quality influenced by various fungicides and biorationals applied preventatively to a colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[x]	Turf Quality 20 Jun	2 Jul	11 Jul	18 Jul	1 Aug	11 Aug
			1-9; 6=min acceptable					
UC14-1	0.5 oz.	21-d	9.0 a[w]	9.0	9.0 a	9.0 a	8.8 ab	8.3 ab
UC14-2	0.5 oz.	21-d	9.0 a	9.0	9.0 a	9.0 a	9.0 a	8.5 a
UC14-3	0.5 oz.	21-d	9.0 a	9.0	8.8 ab	9.0 a	9.0 a	8.8 a
UC14-4	0.236 fl.oz.	21-d	9.0 a	9.0	9.0 a	8.8 ab	8.8 ab	8.3 ab
UC14-5	0.21 fl.oz.	21-d	8.8 ab	8.5	9.0 a	8.8 ab	8.8 ab	8.0 abc
UC14-1	0.5 oz.	21-d	8.0 c	8.8	9.0 a	9.0 a	8.8 ab	8.0 abc
+ Secure	0.5 fl.oz.	21-d						
UC14-2	0.5 oz.	21-d	9.0 a	8.3	9.0 a	9.0 a	9.0 a	8.3 ab
+ Secure	0.5 fl.oz.	21-d						
UC14-3	0.5 oz.	21-d	9.0 a	8.5	9.0 a	9.0 a	9.0 a	7.8 a-d
+ Secure	0.5 fl.oz.	21-d						
UC14-4	0.236 fl.oz.	21-d	9.0 a	8.5	9.0 a	9.0 a	8.5 ab	8.0 abc
+ Secure	0.5 fl.oz.	21-d						
Secure	0.5 fl.oz.	21-d	8.8 ab	8.8	9.0 a	8.8 ab	7.8 bc	7.8 a-d
QP Strobe 50 WG	0.4 oz.	21-d	8.8 ab	8.8	9.0 a	9.0 a	9.0 a	8.8 a
Heritage 50 WG	0.4 oz.	21-d	9.0 a	8.8	9.0 a	9.0 a	9.0 a	8.8 a
Heritage TL	2.0 fl.oz.	21-d	9.0 a	8.3	9.0 a	9.0 a	9.0 a	7.8 a-d
Disarm T	0.66 fl.oz.	14-d	9.0 a	8.8	9.0 a	9.0 a	8.5 ab	8.5 a
Disarm M	1.0 fl.oz.	14-d	8.8 ab	8.5	8.8 ab	9.0 a	8.8 ab	7.8 a-d
Daconil Weather Stik	2.0 fl.oz.	14-d	8.8 ab	8.5	9.0 a	8.3 abc	7.8 bc	7.8 a-d
+ Regalia PTO	3.0 fl.oz.	14-d						
Regalia PTO	3.0 fl.oz.	14-d	9.0 a	8.8	8.3 a-d	7.5 b-f	6.0 de	6.5 e
Sugar Cal	3.0 fl.oz.	14-d	8.8 ab	8.8	8.0 bcd	5.8 g	6.0 de	6.3 e
+ Omega	0.35 fl.oz.	14-d						
+ Green Blade	0.35 fl.oz.	14-d						
Turfshield Plus G	2.0 lb[z]	28-d	8.8 ab	8.5	8.5 abc	6.8 d-g	6.3 de	7.0 cde
+ Quantum Growth VSC	2.0 fl.oz.	14-d						
+ Quantum Growth light	2.0 fl.oz.	14-d						
Omega	0.367 fl.oz.[y]	14-d	8.5 b	8.0	7.8 cd	6.3 fg	5.8 e	6.8 de
Omega	0.734 fl.oz.	14-d	9.0 a	8.3	8.5 abc	7.3 c-f	6.5 de	7.0 cde
Omega	1.46 fl.oz.	14-d	9.0 a	7.8	7.5 d	6.5 efg	6.0 de	7.3 b-e
Omega	1.46 fl.oz.	14-d	8.8 ab	8.3	9.0 a	8.0 a-d	7.0 cd	8.0 abc
+ Daconil Weather Stik	2.0 fl.oz.	14-d						
Untreated			9.0 a	9.0	9.0 a	7.8 a-e	5.5 e	6.3 e
ANOVA: Treatment (P > F)			0.0074	0.3445	0.0419	0.0001	0.0001	0.0001
Days after treatment		14-d	10	21	9	1	2	12
		21-d	10	21	9	16	9	19
		28-d	10	21	28	1	15	25

[z]Plots treated with Turfshield Plus G received 0.1 inch of irrigation immediately following treatment application. Plots were allowed to dry before Quantum Growth treatments were applied.

[y]Water carrier was adjusted to a pH of 5.5 with Harrell's pH Buffer prior to addition of Omega.

[x]Treatments were initiated on 10 June, prior to disease development. Subsequent 14-d treatments were applied 21-d later on 2 July. Thereafter they were applied every 14-d on 17 and 30 July. Subsequent 21-d treatments were made on 2 and 23 July. Subsequent 28-d treatments were made on 17 July.

[w]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. Phytotoxicity affected by various fungicides and biorationals applied preventatively to a colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[x]	Phytotoxicity 2 Jul	18 Jul	11 Aug
			-- 0-5; 2=max acceptable --		
UC14-1	0.5 oz.	21-d	0.0	0.0	0.0
UC14-2	0.5 oz.	21-d	0.0	0.0	0.0
UC14-3	0.5 oz.	21-d	0.0	0.0	0.0
UC14-4	0.236 fl.oz.	21-d	0.0	0.0	0.0
UC14-5	0.21 fl.oz.	21-d	0.0	0.0	0.0
UC14-1	0.5 oz.	21-d	0.0	0.0	0.0
+ Secure	0.5 fl.oz.	21-d			
UC14-2	0.5 oz.	21-d	0.0	0.0	0.0
+ Secure	0.5 fl.oz.	21-d			
UC14-3	0.5 oz.	21-d	0.0	0.0	0.0
+ Secure	0.5 fl.oz.	21-d			
UC14-4	0.236 fl.oz.	21-d	0.0	0.0	0.0
+ Secure	0.5 fl.oz.	21-d			
Secure	0.5 fl.oz.	21-d	0.0	0.0	0.0
QP Strobe 50 WG	0.4 oz.	21-d	0.0	0.0	0.0
Heritage 50 WG	0.4 oz.	21-d	0.0	0.0	0.0
Heritage TL	2.0 fl.oz.	21-d	0.0	0.0	0.0
Disarm T	0.66 fl.oz.	14-d	0.0	0.0	0.0
Disarm M	1.0 fl.oz.	14-d	0.0	0.0	0.0
Daconil Weather Stik	2.0 fl.oz.	14-d	0.0	0.0	0.0
+ Regalia PTO	3.0 fl.oz.	14-d			
Regalia PTO	3.0 fl.oz.	14-d	0.0	0.0	0.0
Sugar Cal	3.0 fl.oz.	14-d	0.0	0.0	0.0
+ Omega	0.35 fl.oz.	14-d			
+ Green Blade	0.35 fl.oz.	14-d			
Turfshield Plus G	2.0 lb[z]	28-d	0.0	0.0	0.0
+ Quantum Growth VSC	2.0 fl.oz.	14-d			
+ Quantum Growth light	2.0 fl.oz.	14-d			
Omega	0.367 fl.oz.[y]	14-d	0.0	0.0	0.0
Omega	0.734 fl.oz.	14-d	0.0	0.0	0.0
Omega	1.46 fl.oz.	14-d	0.0	0.0	0.0
Omega	1.46 fl.oz.	14-d	0.0	0.0	0.0
+ Daconil Weather Stik	2.0 fl.oz.	14-d			
Untreated			0.0	0.0	0.0
ANOVA: Treatment (P > F)			1.0000	1.0000	1.0000
Days after treatment		14-d	21	1	12
		21-d	21	16	19
		28-d	21	1	25

[z]Plots treated with Turfshield Plus G received 0.1 inch of irrigation immediately following treatment application. Plots were allowed to dry before Quantum Growth treatments were applied.

[y]Water carrier was adjusted to a pH of 5.5 with Harrell's pH Buffer prior to addition of Omega.

[x]Treatments were initiated on 10 June, prior to disease development. Subsequent 14-d treatments were applied 21-d later on 2 July. Thereafter they were applied every 14-d on 17 and 30 July. Subsequent 21-d treatments were made on 2 and 23 July. Subsequent 28-d treatments were made on 17 July.

EFFICACY OF BIOFUNGICIDES, BIORATIONALS, AND FUNGICICDES FOR PREVENTIVE BROWN PATCH CONTROL IN A MIXED PERENNIAL RYEGRASS / FINE FESCUE TURF, 2014

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INTRODUCTION

Brown patch commonly affects commercial, residential, and athletic field turf resulting in diffusely blighted, thin areas. The disease is favored by hot, humid temperatures common in Connecticut between June and August. Severity of the disease is often enhanced by increased nitrogen fertility, excess irrigation, poor drainage and poor air movement. The disease is easily controlled through proper cultural management and properly timed fungicide applications. However, recent restrictions on pesticide use on K-8 school grounds and consumer interest in pesticide free turf management limit the options available for control of this disease. The objective of this trial was to assess the efficacy of commercially available biofungicides, soil inoculants, and bioratoinal materials for brown patch control in a mixed perennial ryegrass and fine fescue lawn.

MATERIALS AND METHODS

A field study was conducted on a mixed stand of perennial ryegrass (*Lolium perenne*) and fine fescue (*Festuca spp.*) established in fall 2012 on a Woodbridge loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed two days wk^{-1} at 2.75-inches. A total of 2.25 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from June through July to encourage brown patch development. Overhead irrigation was only applied to remove fertilizer off of leaf surfaces.

Treatments were initiated on 6 June prior to disease developing in the trial area. Subsequent applications were made every 14- or 28-d through 18 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 1.0 gal $1000\text{-}ft^{-2}$ at 40 psi.

Brown patch was assessed visually as a percentage of the plot area blighted by *Rhizoctonia solani*. 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 de-transformed values.

RESULTS AND DISCUSSION

Brown patch developed throughout the trial from a natural infestation in mid-July during a period of daytime temperatures in the mid-80's°F and nighttime temperatures in the mid-60's°F. During the onset of disease, conventional fungicides QP Strobe 50 and Heritage 50WG were the only treatments to reduce brown patch severity compared to untreated (Table 1). As the epidemic progressed, Omega (1.64 fl.oz.) and More (2.2 fl.oz.) each applied every 28-d provided a slight reduction of disease compared to the untreated, although were not as effective as the conventional fungicides. By the last rating date (27 July) only QP Strobe and Heritage 50WG provided acceptable disease control.

In this trial, conventional fungicides provided acceptable brown patch control, although alternative disease control products failed to provide commercially acceptable control. It should be noted that cultural practices known to enhance brown patch severity (i.e., excessive N fertility) were used to promote disease in this study for a rigorous assessment of product efficacy. Under high disease pressure, it is not surprising that alternative disease control products may not have performed very well. In most cases, like conventional fungicides to some degree, the efficacy of these products will be dependent on proper integrated approaches to disease control including proper fertilization, irrigation, and cultivar selection. Future studies focusing on evaluation of biological controls or biorationals will evaluate these products under conditions which will attempt to optimize their potential performance.

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Table 1. Brown patch severity influenced by various fungicides, biofungicides and soil inoculants applied preventively to a mixed perennial ryegrass and fine fescue lawn turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[y]	Brown Patch Severity 14 Jul	17 Jul	27 Jul
			----------% plot area blighted----------		
QP Strobe 50WG	0.4 oz.	28-d	0.1[x] b[w]	0.3 d	3.0 d
Heritage WG	0.4 oz.	28-d	0.1 b	3.3 cd	5.0 d
Omega	1.64 fl.oz.[z]	14-d	13.2 a	16.8 ab	21.3 bc
Omega	2.93 fl.oz.	14-d	12.3 a	13.8 abc	22.5 bc
Omega	1.64 fl.oz.	28-d	7.2 a	9.5 bcd	20.0 bc
Omega	2.93 fl.oz.	28-d	12.6 a	17.5 ab	17.5 c
Companion	3.0 fl.oz.	14-d	11.2 a	11.8 abc	30.0 ab
More	1.1 fl.oz.	14-d	9.7 a	13.8 abc	35.0 a
More	2.2 fl.oz.	28-d	7.5 a	10.5 bcd	25.0 abc
Untreated			11.3 a	22.5 a	28.8 ab
ANOVA: Treatment (P > F)			0.0001	0.0133	0.0001
Days after treatment		14-d	9	14	9
		28-d	9	14	24

[z]Water carrier was adjusted to a pH of 5.5 with Harrell's pH Buffer prior to addition of Omega

[y]Treatments were initiated on 6 June, prior to disease development. Subsequent 14-d treatments were applied on 20 June, 3 July, 18 July. Subsequent 28-d treatments were applied on 3 July.

[x]Data were arc-sin square-root transformed and means de-transformed for presentation.

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

CURATIVE DOLLAR SPOT CONTROL USING NEW AND EXISTING FUNGICIDE FORMULATIONS ON A CREEPING BENTGRASS FAIRWAY TURF, 2014

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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 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 disease development. A total of 0.75 lb $1000\text{-}ft^{-2}$ was applied as water soluble sources between 22 April and 7 June, thereafter no further nitrogen was applied to the study area prior to the initiation of treatments. Overhead irrigation was applied as needed to prevent drought stress.

The study was conducted as two separate experiments, one was initiated in July and the other in August. Treatments were identical in both experiments and consisted of recently introduced fungicides. Initial applications were made after disease development on 8 July for the July experiment and on 26 August for the August experiment. Treatments were repeated 14-d after the initial application. 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. Nitrogen was applied at a rate of 0.5 lbs $1000\text{-}ft^{-2}$ on 9 July for the July experiment and 27 August for the August experiment to assist with turf recovery. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot severity was visually assessed as a percentage of the plot area blighted by disease. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Severity data were arc-sin square root transformed for ANOVA and mean separation tests, although means presented are de-transformed values.

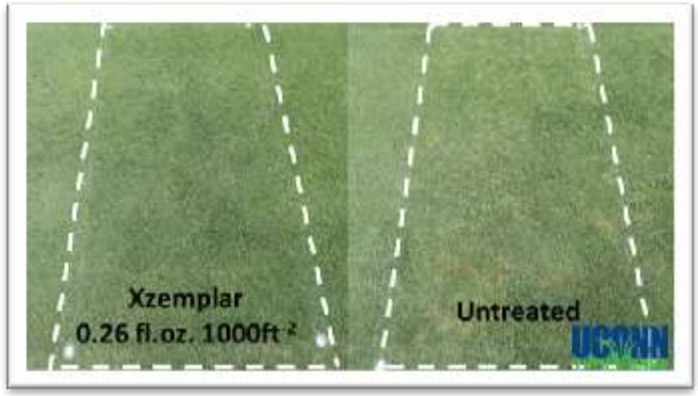

Fig. 1. Blighted turf on untreated and Xzemplar (0.26 fl oz), 2 days after reapplication at 14 DAIT

RESULTS & DISCUSSION

Plot area blighted was approximately 20-25% for the July experiment (Table 1) and 40-50% for the August experiment (Table 2) prior to application of treatments. In the July experiment, disease declined 6 days after initial treatment (DAIT;14 July), in all treatments including the untreated plots. This was likely due to unfavorable conditions for disease and the effect of nitrogen aiding in the growth of new turf. For the August experiment, similar (albeit more dramatic due to higher levels of disease) reductions were observed 7 DAIT (2 September) likely due to N fertilization.

In both experiments, treatment differences were apparent and different from untreated plots by 9 DAIT (16 July or 5 September). In the July experiment, all treatments except for Daconil Weather Stik reached acceptable levels of disease (< 5%) by this time. Recovery in treated plots was slower in the August experiment due higher initial disease incidence; although Xzemplar, Lexicon Intrinsic, and Secure provided better curative control and recovery than Daconil WetherStik 14 DAIT.

Following reapplication of all treatments in the July experiment Xzemplar, Lexicon Intrinsic, and Secure maintained acceptable disease control for the remainder of the study; whereas, Daconil Weather Stik was no different from the untreated control. During the August experiment no treatment reduced plot area blighted to less than 5%, and no differences were observed among treated plots. However, all treatments reduced dollar spot compared to the untreated control.

While the results of the two experiments were similar, the time of year and the severity of the initial disease epidemic differed between the two, allowing some different conclusions to be drawn. In the July experiment, disease started at about half the level seen at the start of the August experiment. This allowed the three most effective fungicides (Xzemplar, Lexicon Intrinsic, and Secure) to return disease to acceptable levels within the first 14-d application period. Reapplication at 14 DAIT could almost be considered a preventative treatment that served mostly to keep new disease from developing in what is obviously a disease-prone area. Daconil Weather Stik, on the other hand, only saw about 11 days of disease reduction before it began to increase again. This suggests that a closer reapplication interval (i.e. 7-d) might be necessary for curative control when using this material.

In the August experiment, the initial curative application failed to reduce disease to acceptable levels for all treatments. The higher level of turf blighted by disease is likely responsible for this. When disease is allowed to reach such a severe level (40-50% blighted turf), a 14-d reapplication interval simply is not effective enough regardless of material used. A closer interval, perhaps coupled with an additional application of N could serve to help return disease to acceptable levels.

Table 1. Dollar spot severity affected by curative applications of various fungicides on a 'Crenshaw' creeping bentgrass fairway turf at the Plant Science Research Facility in Storrs, CT initiated in July 2014.

		Dollar Spot Severity									
Treatment [z]	Rate per 1000ft^2	8 Jul	11 Jul	14 Jul	16 Jul	18 Jul	21 Jul	25 Jul	1 Aug	4 Aug	11 Aug
		% area blighted									
Xzemplar	0.26 fl. oz.	22.4[y]	21.2	8.4	2.2 b[x]	0.8 c	0.1 b	0.1 c	0.1 c	0.1 c	0.7 c
Lexicon Intrinsic	0.46 fl. oz.	26.2	25.2	15.1	4.6 b	1.0 bc	1.3 b	0.1 c	0.1 c	0.0 c	0.0 c
Secure	0.5 fl. oz.	19.8	19.7	10.0	3.6 b	0.7 c	1.5 b	1.3 c	0.0 c	0.0 c	4.0 b
Daconil WeatherStik	4.0 fl. oz.	23.2	23.6	16.0	7.5 b	6.1 b	22.2 a	20.4 b	7.4 b	32.5 b	43.7 a
Untreated		19.2	22.2	15.8	20.8 a	24.7 a	32.7 a	32.4 a	31.8 a	53.0 a	51.3 a
ANOVA: Treatment (P > F)		0.5897	0.7854	0.4886	0.0011	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		0	3	6	9	11	14	3	9	12	19

[z]Treatments were initiated on 8 July, after disease had developed. Treatments were reapplied 14-d later on 22 July.
[y]Data were arc-sin square-root transformed; means presented are de-transformed.
[x]Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

Table 2. Dollar spot severity affected by curative applications of various fungicides on a 'Crenshaw' creeping bentgrass fairway turf at the Plant Science Research Facility in Storrs, CT initiated in August 2014.

		Dollar Spot Severity						
Treatment [z]	Rate per 1000ft^2	26 Aug	29 Aug	2 Sept	5 Sept	10 Sept	17 Sept	24 Sept
		% area blighted						
Xzemplar	0.26 fl. oz.	42.4[y]	40.4	17.9	11.1 b[x]	11.7 c	8.4 b	6.5 b
Lexicon Intrinsic	0.46 fl. oz.	51.3	43.7	20.5	12.7 b	9.1 c	8.2 b	10.0 b
Secure	0.5 fl. oz.	41.1	39.1	19.2	9.3 b	13.5 c	5.8 b	12.7 b
Daconil WeatherStik	4.0 fl. oz.	51.8	43.7	20.1	16.3 b	22.9 b	9.7 b	13.0 b
Untreated		45.4	38.0	25.8	36.5 a	47.0 a	65.5 a	55.5 a
ANOVA: Treatment (P > F)		0.5272	0.8771	0.7326	0.0068	0.0001	0.0001	0.0001
Days after treatment		0	3	7	9	14	7	14

[z]Treatments were initiated on 26 July, after disease had developed. Treatments were reapplied 14-d later on 10 July.
[y]Data were arc-sin square-root transformed; means presented are de-transformed.
[x]Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

PREVENTIVE DOLLAR SPOT CONTROL WITH VARIOUS FUNGICIDES ON A CREEPING BENTGRASS FAIRWAY TURF, 2014

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INTRODUCTION

Dollar spot is a common disease of cool-season turfgrasses caused by the fungal pathogen *Sclerotinia homoeocarpa*. On golf course fairways it is characterized by light, straw-colored spots that may coalesce into larger irregularly shaped areas. It is particularly active during periods of warm daytime temperatures (80°F), cool nighttime temperatures (60°F), and high humidity. It can be managed in part with cultural practices such as maintaining moderate nitrogen fertility, reducing leaf wetness period. However, the use of fungicides is often still necessary on high priority areas such as greens, tees and fairways. The objective of this study was to evaluate the efficacy of new and existing fungicides in controlling dollar spot 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 1.25 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through October. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new fungicide formulations, currently available products applied individually, as tank mixes, and/or in rotational programs, and nutritional programs. Initial applications were made on 15 May prior to disease developing in the trial area. Subsequent applications were made at specified intervals through 18 September. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 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 12 June to 29 October. 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 de-transformed values.

RESULTS

Dollar Spot Incidence

Disease pressure was very low for an extended period at the beginning of the trial (Table 1). Initial symptoms were observed on 12 June, although dollar spot did not reach unacceptable levels (> 25 dollar spots per plot) in untreated control plots until 5 August. Disease continued to increase slowly through the end of the trial in October.

UC14-1, UC14-2, UC14-3, UC14-4 and UC14-5 all provided excellent disease control throughout the trial whether applied alone or as a tank-mix with Secure, although all plots treated with Secure showed slightly improved control at the end of the trial with little disease breakthrough even 41 DAT. There were no differences in the efficacy of UC14-1, UC14-2, and UC14-3, however UC14-3 did produce more foam when agitated than did UC14-1 or UC14-2. Secure, Velista, Secure + Velista, and Secure + Velista or Daconil Action provided excellent control of disease on all dates.

QP Fosetyl-Al + QP Chlorothalonil DF + Foursome and Chipco Signature + Daconil Ultrex provided comparable dollar spot control for the duration of the trial. Likewise, there were no disease differences between QP Chlorothalonil 720SFT + QP Ipro 2SE + QP TM Flowable + QP Tebuconazole (a tank-mix) and QP Enclave (a premix of the same fungicides).

Bayer fungicide programs resulted in near complete control of dollar spot throughout the trial. Disarm M and Disarm T both provided excellent control of disease, as did UC14-11, although the latter showed reduced residual control as of 16 and 29 October (28 and 41 DAT). Isofetamid (applied at both 14-d and 21-d intervals) also controlled disease very well, however the 21-d treatment did show moderate breakthrough at the end of the trial.

Griggs Bros. Programs, which combined low rate fungicides and various liquid and granular fertilizers, all performed very well with no statistical difference between the programs. Without fungicide, a Plant Food Co. fertilizer program containing Cal Nitrate + Sugar Cal + Omega + Green Blade offered acceptable disease control through August; however, disease increased during September and October resulting in poor control. Omega, a potential plant defense elicitor, provided some disease suppression compared to untreated turf under low disease pressure but failed to provide acceptable disease control under moderate disease pressure in September and October.

Heritage 50WG and UC14-6 were among the treatments that showed moderate disease at the beginning of the epidemic, and while both treatments regularly provided some control relative to untreated plots, disease worsened through the end of the trial and neither treatment provided adequate suppression of dollar spot.

When applied alone, Anuew, a plant growth regulator, showed increased disease relative to the untreated control at the beginning of the disease outbreak (from 5 August to 25 August), after which it was statistically identical to the control plots. However, Anuew applied in combination with Torque + Spectro 90 + 26/36. Torque (or Tourney) + Spectro 90 + 26/36 provided excellent control of dollar spot.

Turf Quality and Phytotoxicity

This trial provided a good opportunity to evaluate turf quality differences among various treatments due to the limited disease development from May through July.

Turf treated with combinations of QP Fosetyl-Al + QP Chlorothalonil DF + Foursome and Chipco Signature + Daconil Ultrex was consistently among the best quality plots throughout the trial. (Table 3). Each of these treatments contain a green pigment that likely contributed in part to improved turf quality.

All Bayer rotational programs had excellent mid-summer turf quality (i.e., July and August); however differences among the programs were evident during late-June. Quality of Bayer rotations 4 & 5 was slightly reduced compared to the other Bayer rotations on 20 June. This reduction in turf quality may be due to scheduled applications of a tank mix of Mirage and Primo MAXX during early- and mid-June in rotations 4 & 5. Conversely, in Rotations 1 – 3 applications of Mirage and Primo MAXX were always applied on separate dates. Mirage contains tebuconazole, most fungicides in this chemical class are known to cause slight to severe discoloration and growth regulation. The effect can be enhanced when DMI fungicides are applied to turf treated with plant growth regulators such as Primo MAXX. In this case, the tank mix of the two materials likely impacted turf color and growth resulting in a slight, albeit acceptable, quality reduction compared to when the two materials were applied individually one or more weeks apart.

The highest quality turf observed early on in the trial was in plots receiving Griggs Bros. Rotation 4. This rotational program featured 16-4-8 Turf Rally (13% water soluble N), which was applied at a rate of 0.64 lbs N $1000ft^{-2}$ at the initiation of the trial (15 May). Exceptional dark green color and improved density was observed in these plots 9 to 13 days after initial treatment, and quality remained greater or equal to similarly treated turf receiving 0.1 lbs N $1000ft^{-2}$ every 21-d (Griggs Bros 2 & 3) until 15 August. Both treatments received approximately 1.9 lbs N $1000ft^{-2}$ throughout the course of the trial.

Secure applied as a tank mix with UC14-4 or Velista every 21-d also provided excellent turf quality throughout most of the trial.

Unacceptable turf quality and phytotoxicity was observed in Anuew (0.18 oz) treated plots in late-May and early-June (Tables 3 & 4). Similar results were observed when Anuew (0.18 oz) was tank mixed with Torque, Spectro 90 and 26/36, although low rate applications of Anuew (0.09 oz) resulted in less phytotoxicity. During July and August Anuew treated plots provided acceptable turf quality, however bentgrass stems and stolons appeared excessively long and leggy.

CONCLUSION

In this trial, under moderate disease pressure, many of the fungicide treatments evaluated provided excellent dollar spot control.

Table 1. Dollar spot incidence influenced by various fungicides applied preventatively on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

			Dollar Spot Incidence						
Treatment	Rate per $1000ft^2$	Int[t]	12 Jun	20 Jun	27 Jun	3 Jul	10 Jul	18 Jul	27 Jul
			# of spots $18ft^{-2}$						
UC14-1	.0.5 oz.	21-d	0.0[s] c[r]	0.0 f	0.0 c	0.0 d	0.2 ef	0.0 d	0.2 b
UC14-2	0.5 oz.	21-d	0.0 c	0.0 f	0.0 c	0.2 cd	0.8 c-f	0.0 d	0.2 b
UC14-3	0.5 oz.	21-d	0.0 c	0.0 f	0.2 bc	0.0 d	0.2 ef	0.0 d	0.0 b
UC14-4	0.236 fl.oz.	21-d	0.0 c	0.0 f	0.2 bc	0.4 cd	0.2 ef	0.0 d	0.0 b
UC14-5	0.21 fl.oz.	21-d	0.0 c	0.0 f	0.2 bc	0.0 d	0.2 ef	0.0 d	0.0 b
UC14-1	0.5 oz.	21-d	0.0 c	0.0 f	0.0 c	0.0 d	0.2 ef	0.0 d	0.2 b
+ Secure	0.5 fl.oz.	21-d							
UC14-2	0.5 oz.	21-d	0.0 c	0.0 f	0.0 c	0.0 d	0.4 def	0.0 d	0.0 b
+ Secure	0.5 fl.oz.	21-d							
UC14-3	0.5 oz.	21-d	0.0 c	0.0 f	0.0 c	0.0 d	0.0 f	0.2 cd	0.0 b
+ Secure	0.5 fl.oz.	21-d							
UC14-4	0.236 fl.oz.	21-d	0.0 c	0.0 f	0.0 c	0.0 d	0.4 def	0.0 d	0.0 b
+Secure	0.5 fl.oz.	21-d							
Velista	0.3 oz.	21-d	0.0 c	0.2 ef	0.0 c	0.0 d	0.7 c-f	0.0 d	0.0 b
+ Secure	0.5 fl.oz.	21-d							
Daconil Action	1.6 fl.oz.[z]	14-d	0.0 c	0.0 f	0.2 bc	0.0 d	0.0 f	0.2 cd	0.0 b
- Velista	0.3 oz.	28-d							
- Secure	0.5 fl.oz.	28-d							
Velista	0.5 fl.oz.	14-d	0.0 c	0.0 f	0.0 c	0.0 d	0.4 def	0.2 cd	0.0 b
Secure	0.5 fl.oz.	14-d	0.0 c	0.2 ef	0.2 bc	0.0 d	0.2 ef	0.0 d	0.0 b
Secure	0.5 fl.oz.	21-d	0.0 c	0.2 ef	0.0 c	0.0 d	0.0 f	0.0 d	0.0 b
Heritage 50WG	0.4 oz.	21-d	0.0 c	1.2 cde	0.0 c	1.2 bc	1.3 b-e	0.0 d	0.4 b
UC14-6	0.4 oz.	21-d	0.9 ab	3.9 a	0.4 bc	0.9 bcd	1.6 a-d	0.0 d	0.0 b
Griggs Bros Program 1	pgm[y]	21-d	0.0 c	0.2 ef	0.0 c	0.2 cd	0.2 ef	0.0 d	0.0 b
Griggs Bros Program 2	pgm[y]	21-d	0.0 c	0.8 def	0.0 c	0.0 d	0.2 ef	0.0 d	0.0 b
Griggs Bros Program 3	pgm[y]	21-d	0.0 c	1.0 c-f	0.0 c	0.2 cd	0.6 c-f	0.0 d	0.0 b
Griggs Bros Program 4	pgm[y]	21-d	0.0 c	0.2 ef	0.4 bc	0.8 bcd	0.2 ef	0.0 d	0.0 b
Cal Nitrate	9.0 fl.oz.	14-d	0.0 c	0.5 def	0.2 bc	0.2 cd	2.0 abc	0.2 cd	0.4 b
+ Sugar Cal	3.0 fl.oz.	14-d							
+ Omega	0.35 fl.oz.	14-d							
+ Green Blade	0.35 fl.oz.	14-d							
QP Fosetyl-Al	4.0 oz.	14-d	0.0 c	0.0 f	0.0 c	0.2 cd	0.0 f	0.0 d	0.2 b
+ QP Chlorothalonil DF	3.23 fl.oz.	14-d							
+ Foursome	0.4 fl.oz.	14-d							
Chipco Signature	4.0 oz.	14-d	0.0 c	0.2 ef	0.2 bc	0.4 cd	0.7 c-f	0.0 d	0.0 b
+ Daconil Ultrex	3.23 oz.	14-d							
QP Chlorothalonil 720SFT	1.47 oz.	14-d	0.2 c	0.0 f	0.2 bc	0.4 cd	0.2 ef	0.0 d	0.2 b
+ QP Ipro 2SE	1.47 oz.	14-d							
+ QP TM Flowable	0.65 fl.oz.	14-d							
+ QP Tebuconazole	0.244 fl.oz.	14-d							
QP Enclave	3.0 fl.oz.	14-d	0.0 c	0.0 f	0.2 bc	0.0 d	0.2 ef	0.6 bc	0.2 b
Isofetamid	0.5 fl.oz.	14-d	0.0 c	0.0 f	0.0 c	0.0 d	1.1 b-f	0.0 d	0.0 b
Isofetamid	0.5 fl.oz.	21-d	0.0 c	0.6 def	0.0 c	1.1 bc	0.2 ef	0.0 d	0.0 b
Bayer Program 1	pgm[x]	14-d	0.0 c	0.0 f	0.0 c	0.0 d	0.0 f	0.0 d	0.2 b
Bayer Program 2	pgm[x]	14-d	0.0 c	0.0 f	0.0 c	0.0 d	0.0 f	0.0 d	0.0 b
Bayer Program 3	pgm[x]	14-d	0.2 c	0.0 f	0.0 c	0.0 d	0.0 f	0.0 d	0.0 b
Bayer Program 4	pgm[x]	21-d	0.0 c	0.0 f	0.0 c	0.0 d	0.0 f	0.0 d	0.0 b
Bayer Program 5	pgm[x]	28-d	0.9 ab	0.5 def	0.0 c	0.0 d	0.0 f	0.0 d	0.2 b
UC14-11	0.33 fl.oz.	14-d	0.0 c	0.0 f	0.0 c	0.0 d	0.0 f	0.0 d	0.0 b
Disarm T	0.66 fl.oz.	14-d	0.2 c	0.2 ef	0.0 c	0.0 d	0.6 c-f	0.0 d	0.0 b
Disarm M	1.0 fl.oz.	14-d	0.0 c	0.9 c-f	0.4 bc	0.0 d	0.4 def	0.0 d	0.0 b

Continued...

Table 1 (cont). Dollar spot incidence influenced by various fungicides applied preventatively on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

			Dollar Spot Incidence						
Treatment	Rate per 1000ft^2	Int	12 Jun	20 Jun	27 Jun	3 Jul	10 Jul	18 Jul	27 Jul
			# of spots 18ft^{-2}						
Torque	0.75 fl.oz.[w]	28-d	0.0 c	0.0 f	0.0 c	0.0 d	0.2 ef	0.0 d	0.0 b
+ Spectro 90	3.6 fl.oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	0.0 c	0.0 f	0.0 c	0.0 d	0.2 ef	0.0 d	0.0 b
+ Spectro 90	3.6 fl.oz.	28-d							
+ Anuew	0.09 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	0.0 c	0.0 f	0.2 bc	0.6 bcd	0.2 ef	0.0 d	0.0 b
+ Spectro 90	3.6 oz.	28-d							
+ Anuew	0.18 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Tourney	0.2 oz.[u]	28-d	0.0 c	0.0 f	0.0 c	0.0 d	0.2 ef	0.0 d	0.0 b
+ Spectro 90	3.6 oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Anuew	0.18 oz.	14-d	0.9 ab	2.9 ab	2.2 a	3.3 a	2.7 ab	2.6 a	6.1 a
Omega	1.46 fl.oz.	14-d	0.5 bc	1.5 bcd	0.4 bc	1.8 ab	1.3 b-e	0.0 d	0.5 b
Untreated			1.3 a	2.3 abc	0.8 b	3.3 a	3.6 a	1.2 b	5.5 a
ANOVA: Treatment (P > F)			0.0031	0.0001	0.0018	0.0001	0.0013	0.0001	0.0001
Days after treatment		14-d	14	8	1	7	14	8	3
		21-d	7	15	1	7	14	1	10
		28-d	28	8	15	21	28	8	17

[z]Secure (0.5 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. Velista (0.3 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[y]Refer to table 4 for program description

[x]Refer to table 5 for program description

[w]Torque (0.75 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[v]Anuew was tank-mixed and applied on 15 and 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September.

[u]Tourney (0.2 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[t]Treatments were initiated on 15 May, prior to disease development. Subsequent 14-d treatments were applied on 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September. Subsequent 21-d treatments were applied on 4 and 26 June, 17 July, 7 and 28 August, and 18 September. Subsequent 28-d treatments were applied on 12 June, 10 July, 7 August, and 5 September.

[s]Data were square-root transformed; means presented are de-transformed for presentation.

[r]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 influenced by various fungicides applied preventatively a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

			Dollar Spot Incidence						
Treatment	Rate per 1000ft^2	Int[t]	5 Aug	15 Aug	25 Aug	20 Sept	3 Oct	16 Oct	29 Oct
			# of spots 18ft^{-2}						
UC14-1	.0.5 oz.	21-d	0.2[s] de[r]	0.2 e	0.0 f	0.0 e	0.0 d	1.2 i-l	1.5 g-l
UC14-2	0.5 oz.	21-d	0.4 de	0.0 e	0.4 ef	0.0 e	0.0 d	4.2 f-k	7.5 c-f
UC14-3	0.5 oz.	21-d	0.0 e	0.2 e	0.0 f	0.0 e	0.0 d	2.9 g-l	3.7 e-k
UC14-4	0.236 fl.oz.	21-d	0.6 de	1.1 e	1.8 e	0.2 e	0.5 d	7.7 e-h	8.6 cde
UC14-5	0.21 fl.oz.	21-d	0.4 de	0.0 e	0.0 f	0.0 e	0.0 d	0.4 kl	0.4 jkl
UC14-1	0.5 oz.	21-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.0 l	0.5 jkl
+ Secure	0.5 fl.oz.	21-d							
UC14-2	0.5 oz.	21-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.0 l	0.2 kl
+ Secure	0.5 fl.oz.	21-d							
UC14-3	0.5 oz.	21-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.0 l	0.0 l
+ Secure	0.5 fl.oz.	21-d							
UC14-4	0.236 fl.oz.	21-d	0.2 de	0.0 e	0.0 f	0.0 e	0.0 d	0.0 l	0.0 l
+Secure	0.5 fl.oz.	21-d							
Velista	0.3 oz.	21-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.0 l	0.6 i-l
+ Secure	0.5 fl.oz.	21-d							
Daconil Action	1.6 fl.oz.[z]	14-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.0 l	0.0 l
- Velista	0.3 oz.	28-d							
- Secure	0.5 fl.oz.	28-d							
Velista	0.5 fl.oz.	14-d	0.0 e	0.2 e	0.0 f	0.0 e	0.0 d	0.0 l	0.0 l
Secure	0.5 fl.oz.	14-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.0 l	0.0 l
Secure	0.5 fl.oz.	21-d	0.4 de	0.0 e	0.4 ef	0.4 e	0.0 d	1.2 i-l	0.5 jkl
Heritage 50WG	0.4 oz.	21-d	15.1 c	13.5 d	21.6 cd	37.7 d	43.2 c	61.2 cd	78.5 b
UC14-6	0.4 oz.	21-d	14.1 c	13.6 d	20.4 cd	43.8 cd	51.2 bc	69.1 bcd	88.3 b
Griggs Bros Program 1	pgm[y]	21-d	0.5 de	0.4 e	0.4 ef	0.2 e	0.9 d	7.6 e-h	6.7 c-g
Griggs Bros Program 2	pgm[y]	21-d	0.6 de	0.0 e	1.2 ef	0.0 e	0.0 d	5.1 e-j	5.7 c-h
Griggs Bros Program 3	pgm[y]	21-d	0.2 de	1.0 e	1.1 ef	0.0 e	0.6 d	8.0 efg	6.1 c-g
Griggs Bros Program 4	pgm[y]	21-d	1.1 de	0.2 e	0.0 f	0.4 e	0.4 d	3.5 g-l	3.4 e-l
Cal Nitrate	9.0 fl.oz.	14-d	13.4 c	12.3 d	15.5 d	37.3 d	46.4 c	51.7 d	82.4 b
+ Sugar Cal	3.0 fl.oz.	14-d							
+ Omega	0.35 fl.oz.	14-d							
+ Green Blade	0.35 fl.oz.	14-d							
QP Fosetyl-Al	4.0 oz.	14-d	1.9 d	0.9 e	0.0 f	0.2 e	0.0 d	5.3 e-i	5.7 c-h
+ QP Chlorothalonil DF	3.23 fl.oz.	14-d							
+ Foursome	0.4 fl.oz.	14-d							
Chipco Signature	4.0 oz.	14-d	0.8 de	0.2 e	0.0 f	0.0 e	0.0 d	1.9 h-l	3.4 e-l
+ Daconil Ultrex	3.23 oz.	14-d							
QP Chlorothalonil 720SFT	1.47 oz.	14-d	0.0 e	0.0 e	0.2 ef	0.0 e	0.0 d	0.6 i-l	0.0 l
+ QP Ipro 2SE	1.47 oz.	14-d							
+ QP TM Flowable	0.65 fl.oz.	14-d							
+ QP Tebuconazole	0.244 fl.oz.	14-d							
QP Enclave	3.0 fl.oz.	14-d	0.0 e	0.4 e	0.0 f	0.0 e	0.0 d	1.1 i-l	1.3 g-l
Isofetamid	0.5 fl.oz.	14-d	0.8 de	0.0 e	0.2 ef	0.4 e	0.0 d	0.2 kl	0.2 kl
Isofetamid	0.5 fl.oz.	21-d	0.6 de	0.5 e	0.5 ef	0.0 e	0.0 d	11.7 ef	13.1 c
Bayer Program 1	pgm[x]	14-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.4 kl	0.4 jkl
Bayer Program 2	pgm[x]	14-d	0.2 de	0.0 e	0.0 f	0.0 e	0.2 d	1.5 i-l	2.4 e-l
Bayer Program 3	pgm[x]	14-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	0.6 jkl	0.6 i-l
Bayer Program 4	pgm[x]	21-d	0.0 e	0.0 e	0.2 ef	0.0 e	0.5 d	2.2 g-l	4.4 e-j
Bayer Program 5	pgm[x]	28-d	0.0 e	0.0 e	0.2 ef	0.4 e	0.0 d	4.2 f-k	3.5 e-l
UC14-11	0.33 fl.oz.	14-d	1.1 de	0.4 e	0.0 f	0.7 e	2.8 d	12.9 e	12.6 cd
Disarm T	0.66 fl.oz.	14-d	0.0 e	0.4 e	0.0 f	0.0 e	0.2 d	1.0 i-l	2.0 f-l
Disarm M	1.0 fl.oz.	14-d	0.4 de	0.0 e	0.0 f	0.0 e	0.0 d	2.0 g-l	5.1 d-i

Continued...

Table 2 (cont). Dollar spot incidence influenced by various fungicides applied preventatively a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int	Dollar Spot Incidence						
			5 Aug	15 Aug	25 Aug	20 Sept	3 Oct	16 Oct	29 Oct
			# of spots 18ft^{-2}						
Torque	0.75 fl.oz.[w]	28-d	0.2 de	0.0 e	0.0 f	0.0 e	0.0 d	0.6 i-l	1.0 h-l
+ Spectro 90	3.6 fl.oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	0.0 e	0.0 e	0.0 f	0.4 e	0.0 d	2.6 g-l	2.2 f-l
+ Spectro 90	3.6 fl.oz.	28-d							
+ Anuew	0.09 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	0.0 e	0.0 e	0.0 f	0.0 e	0.0 d	3.3 g-l	0.8 i-l
+ Spectro 90	3.6 oz.	28-d							
+ Anuew	0.18 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Tourney	0.2 oz.[u]	28-d	0.2 de	0.4 e	0.0 f	0.0 e	0.0 d	0.4 kl	0.4 jkl
+ Spectro 90	3.6 oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Anuew	0.18 oz.	14-d	56.3 a	51.5 a	50.0 a	78.6 a	102.2 a	87.5 ab	115.1 a
Omega	1.46 fl.oz.	14-d	16.5 c	20.2 c	27.1 c	52.5 bc	65.8 b	78.9 abc	100.9 ab
Untreated			38.6 b	35.9 b	37.6 b	64.8 ab	87.4 a	96.6 a	119.5 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	13	8	5	2	15	28	41
		21-d	19	8	18	2	15	28	41
		28-d	26	8	18	15	28	41	54

[z]Secure (0.5 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. Velista (0.3 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[y]Refer to table 4 for program description

[x]Refer to table 5 for program description

[w]Torque (0.75 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[v]Anuew was tank-mixed and applied on 15 and 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September.

[u]Tourney (0.2 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[t]Treatments were initiated on 15 May, prior to disease development. Subsequent 14-d treatments were applied on 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September. Subsequent 21-d treatments were applied on 4 and 26 June, 17 July, 7 and 28 August, and 18 September. Subsequent 28-d treatments were applied on 12 June, 10 July, 7 August, and 5 September.

[s]Data were square-root transformed; means presented are de-transformed for presentation.

[r]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 3. Turf quality influenced by various fungicides applied preventatively a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

			Turf Quality						
Treatment	Rate per 1000ft^2	Int[t]	26 May	30 May	6 Jun	20 Jun	3 Jul	18 Jul	15 Aug
			------ 1-9; 6=min acceptable ------						
UC14-1	.0.5 oz.	21-d	6.8 c-f[s]	6.5 d-g	6.3 c-f	7.0 d-g	7.5 c-f	8.5	7.8 b-e
UC14-2	0.5 oz.	21-d	7.0 cde	6.8 c-f	6.3 c-f	7.3 c-f	7.3 d-g	9.0	8.0 a-d
UC14-3	0.5 oz.	21-d	6.5 def	7.0 cde	6.5 b-e	7.5 b-e	7.5 c-f	8.3	7.5 c-f
UC14-4	0.236 fl.oz.	21-d	6.8 c-f	6.3 efg	6.3 c-f	6.8 efg	7.0 e-h	8.8	7.5 c-f
UC14-5	0.21 fl.oz.	21-d	6.5 def	6.8 c-f	6.3 c-f	7.0 d-g	6.3 h	8.8	7.0 efg
UC14-1	0.5 oz.	21-d	6.8 c-f	6.8 c-f	6.5 b-e	7.8 a-d	7.5 c-f	9.0	7.8 b-e
+ Secure	0.5 fl.oz.	21-d							
UC14-2	0.5 oz.	21-d	7.3 bcd	7.3 bcd	6.8 bcd	7.8 a-d	7.5 c-f	8.8	8.3 abc
+ Secure	0.5 fl.oz.	21-d							
UC14-3	0.5 oz.	21-d	7.3 bcd	7.0 cde	6.8 bcd	7.3 c-f	7.5 c-f	8.8	7.5 c-f
+ Secure	0.5 fl.oz.	21-d							
UC14-4	0.236 fl.oz.	21-d	7.5 bc	7.5 abc	7.0 abc	7.8 a-d	8.0 a-d	9.0	8.0 a-d
+Secure	0.5 fl.oz.	21-d							
Velista	0.3 oz.	21-d	7.0 cde	7.3 bcd	7.0 abc	8.0 abc	7.0 e-h	8.5	8.0 a-d
+ Secure	0.5 fl.oz.	21-d							
Daconil Action	1.6 fl.oz.[z]	14-d	7.5 bc	7.0 cde	7.3 ab	8.3 ab	7.8 b-e	9.0	8.0 a-d
- Velista	0.3 oz.	28-d							
- Secure	0.5 fl.oz.	28-d							
Velista	0.5 fl.oz.	14-d	7.5 bc	7.5 abc	6.3 c-f	7.0 d-g	6.8 fgh	9.0	8.0 a-d
Secure	0.5 fl.oz.	14-d	7.5 bc	7.5 abc	7.3 ab	7.5 b-e	7.5 c-f	9.0	8.8 a
Secure	0.5 fl.oz.	21-d	7.3 bcd	6.8 c-f	6.8 bcd	7.8 a-d	7.3 d-g	9.0	7.8 b-e
Heritage 50WG	0.4 oz.	21-d	7.0 cde	7.0 cde	6.3 c-f	6.8 efg	7.0 e-h	8.5	6.5 gh
UC14-6	0.4 oz.	21-d	6.0 f	6.8 c-f	5.8 efg	6.5 fg	6.5 gh	9.0	6.8 fgh
Griggs Bros Program 1	pgm[y]	21-d	6.8 c-f	6.5 d-g	5.3 g	6.8 efg	7.0 e-h	8.8	7.5 c-f
Griggs Bros Program 2	pgm[y]	21-d	7.0 cde	7.0 cde	6.3 c-f	7.0 d-g	7.0 e-h	8.5	8.0 a-d
Griggs Bros Program 3	pgm[y]	21-d	7.0 cde	6.5 d-g	6.3 c-f	7.3 c-f	7.8 b-e	9.0	8.3 abc
Griggs Bros Program 4	pgm[y]	21-d	9.0 a	8.0 ab	7.3 ab	7.0 d-g	7.0 e-h	9.0	7.5 c-f
Cal Nitrate	9.0 fl.oz.	14-d	6.8 c-f	6.5 d-g	6.5 b-e	7.8 a-d	8.5 ab	9.0	6.8 fgh
+ Sugar Cal	3.0 fl.oz.	14-d							
+ Omega	0.35 fl.oz.	14-d							
+ Green Blade	0.35 fl.oz.	14-d							
QP Fosetyl-Al	4.0 oz.	14-d	8.0 b	8.3 a	7.8 a	8.5 a	8.5 ab	9.0	8.8 a
+ QP Chlorothalonil DF	3.23 fl.oz.	14-d							
+ Foursome	0.4 fl.oz.	14-d							
Chipco Signature	4.0 oz.	14-d	7.3 bcd	7.3 bcd	7.8 a	8.3 ab	8.3 abc	9.0	8.8 a
+ Daconil Ultrex	3.23 oz.	14-d							
QP Chlorothalonil 720SFT	1.47 oz.	14-d	7.5 bc	7.0 cde	6.8 bcd	8.0 abc	7.0 e-h	8.5	7.5 c-f
+ QP Ipro 2SE	1.47 oz.	14-d							
+ QP TM Flowable	0.65 fl.oz.	14-d							
+ QP Tebuconazole	0.244 fl.oz.	14-d							
QP Enclave	3.0 fl.oz.	14-d	7.3 bcd	7.0 cde	6.8 bcd	7.5 b-e	7.0 e-h	9.0	8.0 a-d
Isofetamid	0.5 fl.oz.	14-d	6.5 def	6.5 d-g	6.0 d-g	6.8 efg	7.0 e-h	8.8	8.0 a-d
Isofetamid	0.5 fl.oz.	21-d	6.0 f	5.8 gh	5.3 g	6.3 g	6.5 g-h	8.3	7.5 c-f
Bayer Program 1	pgm[x]	14-d	6.8 c-f	7.0 cde	6.5 b-e	8.0 abc	8.3 abc	9.0	8.8 a
Bayer Program 2	pgm[x]	14-d	6.5 def	7.3 bcd	6.8 bcd	8.0 abc	8.3 abc	8.8	8.3 abc
Bayer Program 3	pgm[x]	14-d	7.0 cde	6.8 c-f	6.3 c-f	8.5 a	8.8 a	9.0	8.8 a
Bayer Program 4	pgm[x]	21-d	7.0 cde	6.5 d-g	6.8 bcd	7.3 c-f	8.0 a-d	8.8	8.5 ab
Bayer Program 5	pgm[x]	28-d	7.0 cde	6.3 efg	5.8 efg	7.0 d-g	8.0 a-d	8.3	8.5 ab
UC14-11	0.33 fl.oz.	14-d	7.0 cde	6.8 c-f	6.3 c-f	7.3 c-f	6.8 fgh	8.5	7.8 b-e
Disarm T	0.66 fl.oz.	14-d	6.8 c-f	7.0 cde	6.0 d-g	6.5 fg	6.8 fgh	8.5	6.8 fgh
Disarm M	1.0 fl.oz.	14-d	6.8 c-f	7.0 cde	6.8 bcd	6.5 fg	6.8 fgh	8.5	6.8 fgh

Continued...

Table 3 (cont). Dollar spot incidence influenced by various fungicides applied preventatively a creeping bentgrass fairway turf at the Plant Science Research Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int	Turf Quality						
			26 May	30 May	6 Jun	20 Jun	3 Jul	18 Jul	15 Aug
			---------------------------------- 1-9; 6=min acceptable -------------------------------------						
Torque	0.75 fl.oz.[w]	28-d	6.8 c-f	7.0 cde	7.0 abc	7.0 d-g	7.3 d-g	8.3	7.0 efg
+ Spectro 90	3.6 fl.oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	6.5 def	6.0 fgh	5.5 fg	7.3 c-f	7.0 e-h	8.5	8.0 a-d
+ Spectro 90	3.6 fl.oz.	28-d							
+ Anuew	0.09 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	6.3 ef	6.0 fgh	5.8 efg	6.8 efg	6.3 h	8.5	7.5 c-f
+ Spectro 90	3.6 oz.	28-d							
+ Anuew	0.18 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Tourney	0.2 oz.[u]	28-d	7.0 cde	7.3 bcd	7.3 ab	7.0 d-g	7.0 e-h	8.3	7.3 d-g
+ Spectro 90	3.6 oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Anuew	0.18 oz.	14-d	6.3 ef	5.3 h	4.3 g	7.0 d-g	7.3 d-g	8.5	4.8 j
Omega	1.46 fl.oz.	14-d	6.5 def	6.8 c-f	6.0 d-g	6.5 fg	6.3 h	8.5	6.0 hi
Untreated			7.0 cde	6.3 efg	6.5 b-e	6.8 efg	6.8 fgh	8.5	5.5 ij
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.1932	0.0001
Days after treatment		14-d	11	2	9	8	7	8	8
		21-d	11	15	2	16	7	1	8
		28-d	11	15	22	8	21	8	8

[z]Secure (0.5 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. Velista (0.3 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[y]Refer to table 4 for program description

[x]Refer to table 5 for program description

[w]Torque (0.75 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[v]Anuew was tank-mixed and applied on 15 and 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September.

[u]Tourney (0.2 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[t]Treatments were initiated on 15 May, prior to disease development. Subsequent 14-d treatments were applied on 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September. Subsequent 21-d treatments were applied on 4 and 26 June, 17 July, 7 and 28 August, and 18 September. Subsequent 28-d treatments were applied on 12 June, 10 July, 7 August, and 5 September.

[s]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 affected by various fungicides applied preventatively a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[t]	Phytotoxicity						
			26 May	30 May	6 Jun	20 Jun	3 Jul	18 Jul	15 Aug
			---------- 0-5; 2=max acceptable ----------						
UC14-1	.0.5 oz.	21-d	0.0 c[s]	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
UC14-2	0.5 oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
UC14-3	0.5 oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
UC14-4	0.236 fl.oz.	21-d	0.0 c	0.1 de	0.0 d	0.0 c	0.0 c	0.0 c	0.0
UC14-5	0.21 fl.oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
UC14-1	0.5 oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.3
+ Secure	0.5 fl.oz.	21-d							
UC14-2	0.5 oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
+ Secure	0.5 fl.oz.	21-d							
UC14-3	0.5 oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
+ Secure	0.5 fl.oz.	21-d							
UC14-4	0.236 fl.oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
+Secure	0.5 fl.oz.	21-d							
Velista	0.3 oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
+ Secure	0.5 fl.oz.	21-d							
Daconil Action	1.6 fl.oz.[z]	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
- Velista	0.3 oz.	28-d							
- Secure	0.5 fl.oz.	28-d							
Velista	0.5 fl.oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.3
Secure	0.5 fl.oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
Secure	0.5 fl.oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.5
Heritage 50WG	0.4 oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.3
UC14-6	0.4 oz.	21-d	0.3 c	0.5 c	0.0 d	0.0 c	0.0 c	0.0 c	0.8
Griggs Bros Program 1	pgm[y]	21-d	0.0 c	0.1 de	0.5 c	0.0 c	0.3 c	0.8 b	0.8
Griggs Bros Program 2	pgm[y]	21-d	0.0 c	0.0 e	0.5 c	0.0 c	0.0 c	0.3 c	0.5
Griggs Bros Program 3	pgm[y]	21-d	0.0 c	0.0 e	0.5 c	0.0 c	0.0 c	0.0 c	0.3
Griggs Bros Program 4	pgm[y]	21-d	0.0 c	0.0 e	0.0 d	0.3 b	1.0 b	1.0 ab	0.5
Cal Nitrate	9.0 fl.oz.	14-d	0.0 c	0.3 cde	0.3 cd	0.0 c	0.0 c	0.0 c	0.0
+ Sugar Cal	3.0 fl.oz.	14-d							
+ Omega	0.35 fl.oz.	14-d							
+ Green Blade	0.35 fl.oz.	14-d							
QP Fosetyl-Al	4.0 oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
+ QP Chlorothalonil DF	3.23 fl.oz.	14-d							
+ Foursome	0.4 fl.oz.	14-d							
Chipco Signature	4.0 oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.3 c	0.0
+ Daconil Ultrex	3.23 oz.	14-d							
QP Chlorothalonil 720SFT	1.47 oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
+ QP Ipro 2SE	1.47 oz.	14-d							
+ QP TM Flowable	0.65 fl.oz.	14-d							
+ QP Tebuconazole	0.244 fl.oz.	14-d							
QP Enclave	3.0 fl.oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
Isofetamid	0.5 fl.oz.	14-d	0.0 c	0.1 de	0.0 d	0.0 c	0.0 c	0.0 c	0.0
Isofetamid	0.5 fl.oz.	21-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
Bayer Program 1	pgm[x]	14-d	0.3 c	0.0 e	0.0 d	0.0 c	0.0 c	1.0 ab	0.0
Bayer Program 2	pgm[x]	14-d	0.0 c	0.0 e	0.3 cd	0.0 c	0.0 c	0.8 b	0.0
Bayer Program 3	pgm[x]	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	1.0 ab	0.0
Bayer Program 4	pgm[x]	21-d	0.0 c	0.4 cd	0.0 d	0.0 c	0.3 c	0.0 c	0.0
Bayer Program 5	pgm[x]	28-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	1.0 ab	0.0
UC14-11	0.33 fl.oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
Disarm T	0.66 fl.oz.	14-d	0.3 c	0.3 cde	0.0 d	0.0 c	0.0 c	0.0 c	1.0
Disarm M	1.0 fl.oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.3 c	1.0

Continued...

Table 4 (cont). Phytotoxicity affected by various fungicides applied preventatively a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

			Phytotoxicity						
Treatment	Rate per 1000ft^2	Int	26 May	30 May	6 Jun	20 Jun	3 Jul	18 Jul	15 Aug
			0-5; 2=max acceptable						
Torque	0.75 fl.oz.[w]	28-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.3
+ Spectro 90	3.6 fl.oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	1.0 b	1.3 b	1.5 b	0.0 c	0.8 b	0.8 b	0.0
+ Spectro 90	3.6 fl.oz.	28-d							
+ Anuew	0.09 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Torque	0.75 fl.oz .[w]	28-d	1.5 a	1.3 b	2.8 a	1.0 a	1.8 a	1.3 a	0.8
+ Spectro 90	3.6 oz.	28-d							
+ Anuew	0.18 oz.[v]	14-d							
- 26/36	4.0 fl.oz.	28-d							
Tourney	0.2 oz.[u]	28-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.0
+ Spectro 90	3.6 oz.	28-d							
- 26/36	4.0 fl.oz.	28-d							
Anuew	0.18 oz.	14-d	1.5 a	2.3 a	2.8 a	0.3 b	0.8 b	1.3 a	0.0
Omega	1.46 fl.oz.	14-d	0.0 c	0.0 e	0.0 d	0.0 c	0.0 c	0.0 c	0.3
Untreated			0.3 c	0.1 de	0.0 d	0.0 c	0.0 c	0.0 c	0.0
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.1279
Days after treatment		14-d	11	2	9	8	7	8	8
		21-d	11	15	2	16	7	1	8
		28-d	11	15	22	8	21	8	8

[z]Secure (0.5 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. Velista (0.3 oz.) and Daconil Action (1.6 oz.) were tank-mixed and applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[y]Refer to table 4 for program description

[x]Refer to table 5 for program description

[w]Torque (0.75 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[v]Anuew was tank-mixed and applied on 15 and 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September.

[u]Tourney (0.2 oz) and Spectro 90 (3.6 oz) were tank-mixed and applied on 15 May, 12 June, 10 July, 7 August, and 5 September. 26/36 was applied on 28 May, 26 June, 24 July, 20 August, and 18 September.

[t]Treatments were initiated on 15 May, prior to disease development. Subsequent 14-d treatments were applied on 28 May, 12 and 26 June, 10 and 24 July, 7 and 20 August, and 5 and 18 September. Subsequent 21-d treatments were applied on 4 and 26 June, 17 July, 7 and 28 August, and 18 September. Subsequent 28-d treatments were applied on 12 June, 10 July, 7 August, and 5 September.

[s]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 5. Griggs Bros. rotational fertilizer and fungicide programs application schedule.

		Application Dates												
Treatment	Int	15 May	28 May	4 June	12 June	26 June	10 July	17 July	24 July	7 Aug	20 Aug	28 Aug	5 Sept	18 Sept
Griggs Bros Program 1	21-d													
- Banner MAXX.....1.0 fl oz		x[z]												
- Daconil Action.....2.0 fl oz				x								x		
- Honor.................... 0.83 oz						x								x
- Chipco 26019.......2.0 fl oz								x						
- Secure ....0.5 fl oz										x				
- Primo MAXX ....0.25 fl oz				x		x		x		x		x		x
Griggs Bros Program 2	21-d													
- Banner MAXX.....1.0 fl oz		x												
- Daconil Action.....2.0 fl oz				x								x		
- Honor.................0.83 fl oz						x								x
- Chipco 26019.......2.0 fl oz								x						
- Secure ....0.5 fl oz										x				
- Primo MAXX ....0.25 fl oz				x		x		x		x		x		x
- Urea ....0.1 lb N		x		x		x		x		x		x		x
Griggs Bros Program 3	21-d													
- Banner MAXX.....1.0 fl oz		x												
- Daconil Action.....2.0 fl oz				x								x		
- Honor.................0.83 fl oz						x								x
- Chipco 26019.......2.0 fl oz								x						
- Secure ....0.5 fl oz										x				
- Primo MAXX ....0.25 fl oz				x		x		x		x		x		x
- Burley Green........7.0 fl oz		x		x		x		x		x		x		x
- Tuff Turf ....6.0 fl oz		x		x		x		x		x		x		x
Griggs Bros Program 4	21-d													
- Banner MAXX.....1.0 fl oz		x												
- Daconil Action.....2.0 fl oz				x								x		
- Honor.................0.83 fl oz						x								x
- Chipco 26019.......2.0 fl oz								x						
- Secure ....0.5 fl oz										x				
- Primo MAXX ....0.25 fl oz				x		x		x		x		x		x
- 16-4-8 Turf Rally.....4.0 lb		x												
- Bio-Blend............3.0 fl oz		x												
- Fairphyte.............3.0 fl oz		x		x		x		x		x		x		x

[z]Indicates application on date listed above

Table 6. Bayer rotational fungicide programs application schedule.

		Application Dates												
Treatment	Int	15 May	28 May	4 June	12 June	26 June	10 July	17 July	24 July	7 Aug	20 Aug	28 Aug	5 Sept	18 Sept
Bayer Program 1	14-d													
- Tartan..................2.0 fl oz		x[z]												
- Fiata ....4.4 fl oz			x			x			x					x
- Daconil Ultrex......... 3.2 oz			x			x			x					x
- Mirage.................2.0 fl oz					x								x	
- Mirage.................1.0 fl oz							x			x				
- Interface ....4.0 fl oz											x			
- Primo MAXX ....0.25 fl oz			x			x			x					x
Bayer Program 2	14-d													
- Tartan..................2.0 fl oz		x												
- Daconil Ultrex......3.2 fl oz			x			x			x					x
- Fiata ....5.9 fl oz			x			x			x					x
- Mirage.................2.0 fl oz					x								x	
- Mirage.................1.0 fl oz							x			x				
- Interface ....4.0 fl oz											x			
- Primo MAXX ....0.25 fl oz			x			x			x					x
Bayer Program 3	14-d													
- Tartan..................2.0 fl oz		x												
- Fiata ....4.4 fl oz			x		x	x	x		x	x			x	x
- Daconil Ultrex......3.2 fl oz			x			x			x					x
- Mirage.................2.0 fl oz					x								x	
- Mirage.................1.0 fl oz							x			x				
- Interface ....4.0 fl oz											x			
- Primo MAXX ....0.25 fl oz			x			x			x					x
Bayer Program 4	21-d													
- Tartan..................2.0 fl oz		x												
- Fiata ....5.9 fl oz				x		x		x		x		x		x
- Mirage.................2.0 fl oz				x								x		
- Chipco 26019.......4.0 fl oz						x				x				x
- Mirage.................1.5 fl oz								x						
- Interface ....4.0 fl oz				x								x		
- Primo MAXX ....0.25 fl oz				x		x		x		x		x		x
Bayer Program 5	28-d													
- Tartan..................2.0 fl oz		x												
- Fiata ....8.8 fl oz					x		x			x			x	
- Mirage.................2.0 fl oz					x		x						x	
- Daconil Ultrex......3.2 fl oz					x		x			x			x	
- Chipco 26019.......4.0 fl oz										x				
- Primo MAXX ....0.25 fl oz					x		x			x			x	

[z]Indicates application on date listed above

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PREVENTIVE DOLLAR SPOT CONTROL USING NEW AND EXISTING FUNGICIDE FORMULATIONS ON A CREEPING BENTGRASS FAIRWAY TURF, 2014

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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 a 'MacKenzie' 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 0.25 lb N 1000-ft^{-2} was applied as water soluble sources from April through August. Scimitar was applied on 21 May and Dylox was applied on 31 May for the control of white grubs and surface feeding caterpillars. Heritage TL was applied on 10 June for control of brown patch. 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 15 May prior to disease developing in the trial area. Subsequent applications were made on a 21-day interval through 27 August. Due to a lack of material, Turfcide was not included in any treatment application after 6 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. 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 17 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 data were square-root transformed for ANOVA and mean separation tests, although means presented are de-transformed values.

RESULTS AND DISCUSSION

Dollar Spot Incidence

Although initial disease symptoms were observed as early as 6 June, dollar spot pressure was low until early August, after which incidence of the disease increased substantially (Table 1 & 2). By 4 August, plots treated with Turfcide + Par, UC14-7 + Par, or UC14-8 + Par provided poor levels of disease control regardless of rate and were not statistically different from untreated plots. Treatments containing Torque (0.6 fl oz), or UC14-9 (7.41 fl oz) provided good control at this date. Emerald (0.13 and 0.18 oz) also provided excellent control of disease regardless of rate.

Disease increased moderately through 15 August. All treatments containing Torque continued to provide acceptable levels of control, although treatments tank-mixed with Turfcide (4.0 and 8.0 fl oz) + Par performed slightly better than treatments containing Torque alone.

As of 17 September, all treatments provided unacceptable levels of control except treatments containing Torque, UC14-9, or Emerald, and all 4 AMVAC Programs. It is worth noting that dollar spot incidence in Turfcide + Par treated plots was statistically similar to UC14-7 + Par plots. Interestingly, Turfcide was last applied on 6 August, 41 days prior to the last observation date; whereas UC14-7 + Par was applied 20 days before this final observation. Regardless, neither treatment provided acceptable dollar spot control throughout much of this trial.

Turf Quality and Phytotoxicity

Turf quality (Table 3 & 4) was primarily influenced by phytotoxicity prior to August, and was influenced by both phytotoxicity and dollar spot incidence as the severity of the infestation increased.

Plots treated with UC14-8 exhibited moderate, albeit acceptable levels of phytotoxicity on 6 June (3 DAT) through 26 June. (Table 5). On 2 July, 7 days after reapplication, phytotoxicity briefly reached unacceptable levels, but completely disappeared by 11 July (16 DAT). Plots treated with Torque + Turfcide + Par also exhibited some phytotoxicity through June and early July, though it remained acceptable during this time period.

Warmer and drier conditions led to more severe and persistent phytotoxic effects for several treatments during early to late August. UC14-8 caused unacceptable levels of phytotoxicity on 8 Aug (2 DAT). Turfcide + Par, UC14-7 + Par, and UC14-9 also exhibited some phytotoxicity, especially at higher rates of application, although severity levels were acceptable. Following reapplication on 27 August, phytotoxicity increased to unacceptable levels for the high rate of UC14-7 + Par as well as UC14-9 + Par as of 2 DAT. UC14-8 exhibited very severe phytoxicity at this time (29 August), with tissue appearing yellow-brown in stark contrast to the surrounding treatments. The addition of Turfcide (8.0 fl.oz.), UC14-7 or UC14-8 to tank mixes of Torque + Par generally enhanced phytotoxicity compared to Torque alone.

Turfcide, UC14-7, or UC14-8 tank mixed with Par only, failed to provide acceptable dollar spot control during moderate disease pressure. The addition of Torque as a tank mix partner did improve dollar spot control of all the aforementioned treatments applied individually. Applications of Turfcide, UC14-7, UC14-8, and UC14-9 all resulted in phytotoxic chlolortic discoloration of turf, particularly during high temperatures in August. This effect was apparent despite the addition of Par, a green pigmented spray pattern indicator. Applications of these products to bentgrass should be restricted to spring and fall timings when temperatures are lower to avoid discoloration of turf.

Table 1. Dollar spot incidence influenced by various fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[v]	6 Jun	16 Jun	20 Jun	2 Jul	11 Jul	18 Jul	25 Jul	1 Aug
			Dollar Spot Incidence							
			# of spots 18ft^{-2}							
Turfcide + Harrell's Par	4.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.0[u]	0.2	1.9 abc[t]	3.9 ab	3.3 abc	5.5 abc
Turfcide + Harrell's Par	8.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.0	0.2	0.8 bc	0.9 b-f	0.6 cde	5.1 bc
UC14-7 + Harrell's Par	4.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.2	0.2	1.7 abc	2.9 a-d	2.7 bcd	9.0 ab
UC14-7 + Harrell's Par	8.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.0	0.0	0.0 c	0.2 ef	0.4 cde	4.1 bcd
UC14-8	8.0 fl.oz.	21-d	0.0	0.0	0.4	0.2	1.4 abc	2.6 a-e	2.9 bcd	9.0 ab
Torque	0.6 fl.oz.	21-d	0.0	0.0	0.0	0.0	0.6 bc	0.9 b-f	0.6 cde	2.4 cde
Torque + Turfcide + Harrell's Par	0.6 fl.oz. 4.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.0	0.0	0.0 c	0.2 ef	0.2 de	0.4 de
Torque + Turfcide + Harrell's Par	0.6 fl.oz. 8.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.0	0.0	0.0 c	0.2 ef	0.0 e	1.6 cde
Torque + UC14-7 + Harrell's Par	0.6 fl.oz. 4.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.7	0.0	0.0 c	0.2 ef	0.4 cde	0.2 de
Torque + UC14-7 + Harrell's Par	0.6 fl.oz. 8.0 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.2	0.0	0.4 bc	0.9 b-f	0.4 cde	1.0 cde
Torque + UC14-8	0.6 fl.oz. 8.0 fl.oz.	21-d	0.0	0.0	0.0	0.0	0.4 bc	0.2 ef	0.2 de	0.2 de
UC14-9 + Harrell's Par	7.41 fl.oz. 0.37 fl.oz.	21-d	0.0	0.0	0.0	0.0	0.6 bc	0.6 c-f	0.6 cde	0.8 cde
AMVAC Program 1[z]		21-d	0.0	0.0	0.2	0.2	0.2 c	0.5 def	0.0 e	0.2 de
AMVAC Program 2[y]		21-d	0.0	0.0	0.0	0.0	0.0 c	0.0 f	0.0 e	0.2 de
AMVAC Program 3[x]		21-d	0.3	0.0	0.0	0.0	0.2 c	0.2 ef	0.2 de	0.2 de
AMVAC Program 4[w]		21-d	0.0	0.0	0.2	0.0	0.0 c	0.4 def	0.0 e	0.5 de
Emerald	0.13 oz.	21-d	0.0	0.0	0.2	0.4	0.0 c	0.0 f	0.6 cde	0.0 e
Emerald	0.18 oz.	21-d	0.0	0.8	0.2	0.0	0.2 c	0.6 c-f	0.4 cde	0.4 de
Harrell's Par	0.37 fl.oz.	21-d	0.0	0.3	1.2	2.1	2.5 ab	3.5 abc	4.4 ab	10.3 ab
Untreated			0.0	0.3	0.8	1.3	4.2 a	6.4 a	8.4 a	13.5 a
ANOVA: Treatment ($P > F$)			0.4750	0.0596	0.3579	0.4289	0.0468	0.0057	0.0016	0.0001
Days after treatment		21-d	3	13	17	7	16	1	8	15

[z]Torque (0.6 fl.oz.), Turfcide (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[y]Torque (0.6 fl.oz.), Turfcide (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[x]Torque (0.6 fl.oz.), UC14-7 (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[w]Torque (0.6 fl.oz.), UC14-7 (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[v]Treatments were initiated on 15 May, prior to disease development. Subsequent 21-d treatments were made on 3 and 25 June, 17 July, 6 and 27 August. However, the last application of Turfcide was on 6 August, regardless of treatment.

[u] Data were square-root transformed, with means de-transformed for presentation

[t] 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 2. Dollar spot incidence influenced by various fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per $1000ft^2$	Int[v]	Dollar Spot Incidence						
			4 Aug	6 Aug	8 Aug	15 Aug	25 Aug	29 Aug	17 Sept
			# of spots $18ft^{-2}$						
Turfcide	4.0 fl.oz.	21-d	20.0[u] a[t]	27.7 a	19.2 ab	24.6 abc	39.5 a	54.5 ab	89.4 ab
+ Harrell's Par	0.37 fl.oz.								
Turfcide	8.0 fl.oz.	21-d	14.3 a	23.5 a	11.7 bcd	17.2 bc	29.1 a	35.1 bc	70.3 bc
+ Harrell's Par	0.37 fl.oz.								
UC14-7	4.0 fl.oz.	21-d	22.3 a	26.0 a	21.1 ab	29.2 abc	48.7 a	48.4 abc	109.2 a
+ Harrell's Par	0.37 fl.oz.								
UC14-7	8.0 fl.oz.	21-d	13.2 ab	21.2 a	13.2 bc	15.6 c	27.6 a	27.6 cd	49.2 c
+ Harrell's Par	0.37 fl.oz.								
UC14-8	8.0 fl.oz.	21-d	17.7 a	37.0 a	19.7 ab	29.2 ab	42.3 a	48.0 abc	84.5 ab
Torque	0.6 fl.oz.	21-d	4.2 bc	9.2 b	7.4 cde	5.9 d	9.6 b	12.4 de	16.9 d
Torque	0.6 fl.oz.	21-d	0.9 c	4.2 bc	1.1 ef	0.6 e	3.4 b	3.5 ef	4.8 d-g
+ Turfcide	4.0 fl.oz.								
+ Harrell's Par	0.37 fl.oz.								
Torque	0.6 fl.oz.	21-d	1.7 c	4.8 bc	1.2 ef	0.4 e	2.6 b	3.4 ef	3.9 efg
+ Turfcide	8.0 fl.oz.								
+ Harrell's Par	0.37 fl.oz.								
Torque	0.6 fl.oz.	21-d	3.2 c	5.8 bc	4.4 c-f	2.1 de	7.1 b	8.0 ef	8.9 def
+ UC14-7	4.0 fl.oz.								
+ Harrell's Par	0.37 fl.oz.								
Torque	0.6 fl.oz.	21-d	2.7 c	6.9 b	3.3 def	1.6 de	6.2 b	7.1 ef	8.9 def
+ UC14-7	8.0 fl.oz.								
+ Harrell's Par	0.37 fl.oz.								
Torque	0.6 fl.oz.	21-d	2.4 c	6.1 bc	1.5 ef	1.9 de	7.0 b	6.1 ef	9.2 def
+ UC14-8	8.0 fl.oz.								
UC14-9	7.41 fl.oz.	21-d	2.3 c	6.6 b	2.3 ef	1.5 de	6.5 b	5.7 ef	10.6 de
+ Harrell's Par	0.37 fl.oz.								
AMVAC Program 1[z]		21-d	4.1 bc	4.5 bc	2.3 ef	1.5 de	6.7 b	7.8 ef	1.4 efg
AMVAC Program 2[y]		21-d	0.6 c	0.7 c	0.8 f	0.9 de	3.4 b	3.1 ef	1.3 fg
AMVAC Program 3[x]		21-d	2.4 c	4.6 bc	2.6 ef	0.7 e	4.6 b	6.4 ef	5.1 d-g
AMVAC Program 4[w]		21-d	1.9 c	4.1 bc	1.3 ef	1.1 de	8.1 b	12.4 de	8.2 d-g
Emerald	0.13 oz.	21-d	1.1 c	4.4 bc	3.6 def	2.0 de	4.2 b	8.5 ef	5.7 d-g
Emerald	0.18 oz.	21-d	0.0 c	2.1 bc	1.5 ef	0.4 e	1.5 b	0.9 f	0.5 g
Harrell's Par	0.37 fl.oz.	21-d	22.3 a	32.6 a	24.2 ab	31.9 a	43.5 a	55.7 ab	88.3 ab
Untreated			23.4 a	35.6 a	31.7 a	32.8 a	49.1 a	63.7 a	92.4 ab
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		21-d	18	20	2	9	19	2	20

[z]Torque (0.6 fl.oz.), Turfcide (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[y]Torque (0.6 fl.oz.), Turfcide (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[x]Torque (0.6 fl.oz.), UC14-7 (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[w]Torque (0.6 fl.oz.), UC14-7 (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[v]Treatments were initiated on 15 May, prior to disease development. Subsequent 21-d treatments were made on 3 and 25 June, 17 July, 6 and 27 August. However, the last application of Turfcide was on 6 August, regardless of treatment.

[u] Data were square-root transformed, with means de-transformed for presentation

[t] 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 3. Turf quality influenced by various fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft²	Int[v]	Turf Quality 30 May	6 Jun	16 Jun	2 Jul	11 Jul	18 Jul	21 Jul
			---------- 1-9; 6=min acceptable ----------						
Turfcide + Harrell's Par	4.0 fl.oz. + 0.37 fl.oz.	21-d	8.0	8.8 a[u]	8.3 a	8.0 a	8.3 abc	8.0 bc	8.0 ab
Turfcide + Harrell's Par	8.0 fl.oz. + 0.37 fl.oz.	21-d	7.8	8.0 abc	7.5 a-d	7.0 cde	8.3 abc	8.5 ab	8.0 ab
UC14-7 + Harrell's Par	4.0 fl.oz. + 0.37 fl.oz.	21-d	8.0	8.0 abc	7.8 abc	8.0 a	8.0 bcd	8.0 bc	8.3 ab
UC14-7 + Harrell's Par	8.0 fl.oz. + 0.37 fl.oz.	21-d	8.0	8.3 ab	7.0 cd	6.8 de	8.3 abc	8.8 ab	8.0 ab
UC14-8	8.0 fl.oz.	21-d	7.5	5.5 f	7.0 cd	6.0 fg	7.5 cd	7.5 c	6.5 d
Torque	0.6 fl.oz.	21-d	8.0	7.3 cde	7.0 cd	6.5 ef	8.0 bcd	8.5 ab	7.8 bc
Torque + Turfcide + Harrell's Par	0.6 fl.oz. + 4.0 fl.oz. + 0.37 fl.oz.	21-d	8.0	8.5 ab	8.0 ab	7.8 ab	8.3 abc	8.8 ab	8.8 a
Torque + Turfcide + Harrell's Par	0.6 fl.oz. + 8.0 fl.oz. + 0.37 fl.oz.	21-d	8.0	7.8 bcd	7.8 abc	6.8 de	9.0 a	9.0 a	7.8 bc
Torque + UC14-7 + Harrell's Par	0.6 fl.oz. + 4.0 fl.oz. + 0.37 fl.oz.	21-d	8.0	8.3 ab	8.0 ab	7.5 abc	8.8 ab	8.5 ab	8.5 ab
Torque + UC14-7 + Harrell's Par	0.6 fl.oz. + 8.0 fl.oz. + 0.37 fl.oz.	21-d	8.0	7.8 bcd	7.3 bcd	7.0 cde	9.0 a	8.8 ab	7.8 bc
Torque + UC14-8	0.6 fl.oz. + 8.0 fl.oz.	21-d	8.0	6.5 e	7.3 bcd	5.8 g	8.3 abc	8.8 ab	8.0 ab
UC14-9 + Harrell's Par	7.41 fl.oz. + 0.37 fl.oz.	21-d	8.0	8.0 abc	7.5 a-d	6.5 ef	8.5 ab	8.3 abc	8.0 ab
AMVAC Program 1[z]		21-d	8.0	6.8 e	8.0 ab	7.8 ab	8.8 ab	8.5 ab	8.8 a
AMVAC Program 2[y]		21-d	8.0	6.8 e	7.5 a-d	7.3 bcd	9.0 a	9.0 a	8.8 a
AMVAC Program 3[x]		21-d	8.0	6.8 e	7.5 a-d	8.0 a	9.0 a	8.8 ab	8.3 ab
AMVAC Program 4[w]		21-d	8.0	6.5 e	8.0 ab	6.8 de	8.5 ab	8.8 ab	8.3 ab
Emerald	0.13 oz.	21-d	7.5	6.8 e	6.8 d	6.8 de	7.5 cd	7.5 c	7.8 bc
Emerald	0.18 oz.	21-d	7.8	7.0 de	7.0 cd	7.5 abc	8.0 bcd	8.3 abc	8.0 ab
Harrell's Par	0.37 fl.oz.	21-d	8.0	8.5 ab	7.0 cd	7.5 abc	8.0 bcd	8.3 abc	8.0 ab
Untreated			7.5	7.3 cde	7.3 bcd	7.3 bcd	7.3 d	7.5 c	7.0 cd
ANOVA: Treatment (P > F)			0.1207	0.0001	0.0055	0.0001	0.0022	0.0066	0.0027
Days after treatment		21-d	15	3	13	7	16	1	4

[z]Torque (0.6 fl.oz.), Turfcide (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[y]Torque (0.6 fl.oz.), Turfcide (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[x]Torque (0.6 fl.oz.), UC14-7 (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[w]Torque (0.6 fl.oz.), UC14-7 (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[v]Treatments were initiated on 15 May, prior to disease development. Subsequent 21-d treatments were made on 3 and 25 June, 17 July, 6 and 27 August. However, the last application of Turfcide was on 6 August, regardless of treatment.

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

Table 4. Turf quality influenced by various fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per $1000ft^2$	Int[v]	Turf Quality 1 Aug	8 Aug	25 Aug	29 Aug	17 Sept
			-------------------- 1-9; 6=min acceptable				----------------------
Turfcide	4.0 fl.oz.	21-d	6.8 e[u]	6.3 cde	5.5 de	5.0 gh	4.0 ef
+ Harrell's Par	0.37 fl.oz.						
Turfcide	8.0 fl.oz.	21-d	7.5 cde	6.3 cde	5.8 de	6.0 d-g	4.5 e
+ Harrell's Par	0.37 fl.oz.						
UC14-7	4.0 fl.oz.	21-d	7.3 de	6.5 cd	5.5 de	5.5 e-h	3.3 f
+ Harrell's Par	0.37 fl.oz.						
UC14-7	8.0 fl.oz.	21-d	7.8 b-e	6.5 cd	6.0 cd	6.3 c-f	4.5 e
+ Harrell's Par	0.37 fl.oz.						
UC14-8	8.0 fl.oz.	21-d	6.8 e	5.0 f	5.0 e	4.5 h	3.8 ef
Torque	0.6 fl.oz.	21-d	8.0 a-d	7.0 abc	7.3 ab	7.0 a-d	6.8 cd
Torque	0.6 fl.oz.	21-d	8.8 ab	8.0 a	7.5 ab	7.8 a	7.8 ab
+ Turfcide	4.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Torque	0.6 fl.oz.	21-d	8.5 abc	6.8 bcd	7.3 ab	7.5 ab	7.0 bcd
+ Turfcide	8.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Torque	0.6 fl.oz.	21-d	8.8 ab	8.0 a	7.0 ab	7.3 abc	7.5 abc
+ UC14-7	4.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Torque	0.6 fl.oz.	21-d	8.3 a-d	7.3 abc	7.0 ab	6.5 b-e	6.5 d
+ UC14-7	8.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Torque	0.6 fl.oz.	21-d	8.3 a-d	5.3 ef	6.8 bc	5.0 gh	6.5 d
+ UC14-8	8.0 fl.oz.						
UC14-9	7.41 fl.oz.	21-d	8.5 abc	7.3 abc	6.8 bc	6.0 d-g	6.5 d
+ Harrell's Par	0.37 fl.oz.						
AMVAC Program 1[z]		21-d	8.3 a-d	8.0 a	7.3 ab	7.3 abc	7.8 ab
AMVAC Program 2[y]		21-d	8.3 a-d	7.0 abc	7.5 ab	7.3 abc	8.0 a
AMVAC Program 3[x]		21-d	9.0 a	8.0 a	7.8 a	7.3 abc	7.3 a-d
AMVAC Program 4[w]		21-d	8.5 abc	7.8 ab	7.5 ab	6.8 a-d	7.3 a-d
Emerald	0.13 oz.	21-d	7.8 b-e	6.8 bcd	7.3 ab	7.8 a	7.0 bcd
Emerald	0.18 oz.	21-d	7.8 b-e	8.0 a	7.3 ab	7.3 abc	7.8 ab
Harrell's Par	0.37 fl.oz.	21-d	6.8 e	5.8 def	5.3 de	5.3 fgh	4.0 ef
Untreated			6.8 e	5.8 def	5.0 e	5.0 gh	3.5 f
ANOVA: Treatment (P > F)			0.0002	0.0001	0.0001	2	21
Days after treatment		21-d	15	2	19	0.0001	0.0001

[z]Torque (0.6 fl.oz.), Turfcide (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[y]Torque (0.6 fl.oz.), Turfcide (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[x]Torque (0.6 fl.oz.), UC14-7 (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[w]Torque (0.6 fl.oz.), UC14-7 (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[v]Treatments were initiated on 15 May, prior to disease development. Subsequent 21-d treatments were made on 3 and 25 June, 17 July, 6 and 27 August. However, the last application of Turfcide was on 6 August, regardless of treatment.

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

Table 5. Phytotoxicity affected by various fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[v]	Phytotoxicity							
			30 May	6 Jun	9 Jun	16 Jun	20 Jun	26 Jun	2 Jul	11 Jul
			0-5; 2=max acceptable							
Turfcide	4.0 fl.oz.	21-d	0.0	0.0 d	0.0 e[u]	0.0 c	0.3 bc	0.3 de	0.0 g	0.0
+ Harrell's Par	0.37 fl.oz.									
Turfcide	8.0 fl.oz.	21-d	0.0	0.0 d	0.3 de	0.3 bc	0.8 ab	0.3 de	1.0 c-f	0.0
+ Harrell's Par	0.37 fl.oz.									
UC14-7	4.0 fl.oz.	21-d	0.0	0.0 d	0.0 e	0.0 c	0.3 bc	0.0 e	0.0 g	0.0
+ Harrell's Par	0.37 fl.oz.									
UC14-7	8.0 fl.oz.	21-d	0.0	0.0 d	0.8 cd	0.8 ab	1.0 a	0.5 de	1.0 c-f	0.0
+ Harrell's Par	0.37 fl.oz.									
UC14-8	8.0 fl.oz.	21-d	0.0	2.0 a	2.0 a	0.8 ab	1.0 a	2.0 a	2.3 a	0.0
Torque	0.6 fl.oz.	21-d	0.0	0.8 bc	0.0 e	0.5 abc	0.0 c	1.3 bc	1.0 c-f	0.0
Torque	0.6 fl.oz.	21-d	0.0	0.0 d	0.0 e	0.0 c	0.3 bc	0.0 e	0.0 g	0.0
+ Turfcide	4.0 fl.oz.									
+ Harrell's Par	0.37 fl.oz.									
Torque	0.6 fl.oz.	21-d	0.0	0.0 d	0.8 cd	0.3 bc	0.8 ab	0.5 de	1.0 c-f	0.0
+ Turfcide	8.0 fl.oz.									
+ Harrell's Par	0.37 fl.oz.									
Torque	0.6 fl.oz.	21-d	0.0	0.0 d	0.3 de	0.0 c	0.3 bc	0.5 de	0.5 efg	0.0
+ UC14-7	4.0 fl.oz.									
+ Harrell's Par	0.37 fl.oz.									
Torque	0.6 fl.oz.	21-d	0.0	0.0 d	1.0 bc	1.0 a	0.8 ab	0.8 cd	1.8 abc	0.0
+ UC14-7	8.0 fl.oz.									
+ Harrell's Par	0.37 fl.oz.									
Torque	0.6 fl.oz.	21-d	0.0	1.3 b	1.5 ab	0.5 abc	1.0 a	2.0 a	2.0 ab	0.0
+ UC14-8	8.0 fl.oz.									
UC14-9	7.41 fl.oz.	21-d	0.0	0.0 d	1.0 bc	0.8 ab	1.0 a	0.5 de	0.8 d-g	0.0
+ Harrell's Par	0.37 fl.oz.									
AMVAC Program 1[z]		21-d	0.0	0.8 bc	0.3 de	0.5 abc	0.8 ab	0.0 e	0.0 g	0.0
AMVAC Program 2[y]		21-d	0.0	0.5 cd	0.0 e	0.0 c	0.8 ab	0.3 de	1.5 a-d	0.0
AMVAC Program 3[x]		21-d	0.0	0.5 cd	0.0 e	0.3 bc	0.5 abc	0.3 de	0.3 fg	0.0
AMVAC Program 4[w]		21-d	0.0	0.5 cd	0.5 cde	0.3 bc	0.5 abc	0.5 de	1.3 b-e	0.0
Emerald	0.13 oz.	21-d	0.0	0.5 cd	0.0 e	0.3 bc	0.0 c	1.8 ab	0.5 efg	0.0
Emerald	0.18 oz.	21-d	0.0	0.5 cd	0.3 de	0.5 abc	0.3 bc	0.3 de	0.3 fg	0.0
Harrell's Par	0.37 fl.oz.	21-d	0.0	0.0 d	0.0 e	1.0 a	0.0 c	0.3 de	0.0 g	0.0
Untreated			0.0	0.5 cd	0.5 cde	0.4 abc	0.3 bc	1.3 bc	0.0 fg	0.0
ANOVA: Treatment (P > F)			1.0000	0.0001	0.0001	0.0060	0.0008	0.0001	0.0001	1.0000
Days after treatment		21-d	15	3	6	13	17	1	7	16

[z]Torque (0.6 fl.oz.), Turfcide (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[y]Torque (0.6 fl.oz.), Turfcide (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[x]Torque (0.6 fl.oz.), UC14-7 (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[w]Torque (0.6 fl.oz.), UC14-7 (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[v]Treatments were initiated on 15 May, prior to disease development. Subsequent 21-d treatments were made on 3 and 25 June, 17 July, 6 and 27 August. However, the last application of Turfcide was on 6 August, regardless of treatment.

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

Table 6. Phytotoxicity affected by various fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[v]	Phytotoxicity 18 Jul	21 Jul	25 Jul	1 Aug	8 Aug	11 Aug	15 Aug	29 Aug	17 Sept
			---- 0-5; 2=max acceptable ----								
Turfcide + Harrell's Par	4.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	0.3 d[u]	0.3 de	0.3 bc	0.3 e	0.8 fg	1.0 ef	0.3 g	0.5 abc
Turfcide + Harrell's Par	8.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	1.0 bc	1.0 ab	0.3 bc	1.3 bc	1.8 d	1.5 de	0.3 g	0.8 ab
UC14-7 + Harrell's Par	4.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	0.3 d	0.5 cd	0.5 abc	0.5 de	0.8 fg	0.8 fg	1.3 def	0.3 bc
UC14-7 + Harrell's Par	8.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	1.0 bc	1.3 a	1.0 a	1.8 b	2.0 cd	2.0 bcd	2.8 b	1.0 a
UC14-8	8.0 fl.oz.	21-d	0.0	2.3 a	1.3 a	0.5 abc	3.3 a	3.5 a	2.8 a	3.8 a	1.0 a
Torque	0.6 fl.oz.	21-d	0.0	0.0 d	0.0 e	0.0 c	0.3 e	0.0 h	0.0 h	0.8 efg	0.0 c
Torque + Turfcide + Harrell's Par	0.6 fl.oz. + 4.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	0.3 d	0.3 de	0.3 bc	0.3 e	0.5 fgh	0.3 gh	0.5 fg	0.5 abc
Torque + Turfcide + Harrell's Par	0.6 fl.oz. + 8.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	1.0 bc	0.8 bc	1.0 a	1.3 bc	1.8 d	2.0 bcd	0.8 efg	0.8 ab
Torque + UC14-7 + Harrell's Par	0.6 fl.oz. + 4.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	0.8 c	0.3 de	0.8 ab	1.0 cd	0.8 fg	0.8 fg	1.5 de	0.8 ab
Torque + UC14-7 + Harrell's Par	0.6 fl.oz. + 8.0 fl.oz. + 0.37 fl.oz.	21-d	0.0	1.3 b	1.0 ab	1.0 a	1.5 bc	2.5 bc	2.5 ab	2.8 b	1.0 a
Torque + UC14-8	0.6 fl.oz. + 8.0 fl.oz.	21-d	0.0	1.0 bc	0.8 bc	0.8 ab	3.0 a	3.0 ab	2.3 abc	3.8 a	1.0 a
UC14-9 + Harrell's Par	7.41 fl.oz. + 0.37 fl.oz.	21-d	0.0	1.0 bc	1.0 ab	0.8 ab	1.0 cd	1.5 de	1.5 de	2.5 bc	1.0 a
AMVAC Program 1[z]		21-d	0.0	0.0 d	0.0 e	0.3 bc	0.3 e	0.3 gh	0.5 fgh	1.0 d-g	0.0 c
AMVAC Program 2[y]		21-d	0.0	0.0 d	0.0 e	0.3 bc	0.5 de	1.0 ef	1.8 cd	1.5 de	0.3 bc
AMVAC Program 3[x]		21-d	0.0	0.0 d	0.0 e	0.0 c	0.3 e	0.5 fgh	0.5 fgh	1.0 d-g	0.3 bc
AMVAC Program 4[w]		21-d	0.0	0.0 d	0.0 e	0.8 ab	1.0 cd	1.8 d	1.8 cd	1.5 de	0.5 abc
Emerald	0.13 oz.	21-d	0.0	0.0 d	0.0 e	0.3 bc	0.0 e	0.0 h	0.0 h	1.0 d-g	0.0 c
Emerald	0.18 oz.	21-d	0.0	0.0 d	0.0 e	0.0 c	0.0 e	0.0 h	0.0 h	1.8 cd	0.0 c
Harrell's Par	0.37 fl.oz.	21-d	0.0	0.0 d	0.0 e	0.0 c	0.0 e	0.0 h	0.0 h	0.3 g	0.3 bc
Untreated			0.0	0.0 d	0.0 e	0.3 bc	0.3 e	0.0 h	0.3 gh	0.3 g	0.0 c
ANOVA: Treatment (P > F)			1.0000	0.0001	0.0001	0.0013	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		21-d	1	4	8	15	2	5	9	2	21

[z]Torque (0.6 fl.oz.), Turfcide (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[y]Torque (0.6 fl.oz.), Turfcide (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[x]Torque (0.6 fl.oz.), UC14-7 (4.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[w]Torque (0.6 fl.oz.), UC14-7 (8.0 fl.oz.), and Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 15 May, 25 June, and 6 August. 26GT (3.0 fl.oz.) and Daconil Ultrex (3.25 oz.) were tank-mixed and applied on 3 June, 17 July, and 27 August.

[v]Treatments were initiated on 15 May, prior to disease development. Subsequent 21-d treatments were made on 3 and 25 June, 17 July, 6 and 27 August. However, the last application of Turfcide was on 6 August, regardless of treatment.

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

PREVENTIVE DOLLAR SPOT CONTROL WITH CONSAN TURF ON A CREEPING BENTGRASS FAIRWAY TURF, 2014

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INTRODUCTION

Dollar spot is a common disease of cool-season turfgrass caused by the fungal pathogen *Sclerotinia homoeocarpa*. On golf course fairways it is characterized by light, straw-colored spots that may coalesce into larger irregularly shaped areas. It is particularly active during periods of warm daytime temperatures (80°F), cool nighttime temperatures (60°F), and high humidity. It can be managed through maintaining moderate nitrogen fertility, reducing leaf wetness period and through the use of various fungicides. The objective of this study was to evaluate the efficacy of Consan Turf for preventive dollar spot control on a creeping bentgrass fairway turf.

MATERIALS AND 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 0.75 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through August. Overhead irrigation was applied as needed to prevent drought stress.

Treatments were applied individually, or as tank mixes. Initial applications were made on 19 June prior to disease developing in the trial area. Subsequent applications were made every 14-d on 23 July, 6 and 21 August. During the initial application of Consan Turf considerable foam in the mix solution and bubbles on the turf canopy were produced. Thereafter, Shake Down, an anti-foaming agent, was added at a concentration of 1.0 fl.oz. 100 gal^{-1} of spray mixture, prior to addition of all Consan Turf treatments. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 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 3 July to 25 August. 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.

RESULTS AND DISCUSSION

Dollar Spot Incidence, Phytotoxicity, and Turf Quality

Disease pressure was low during July, although dollar spot increased substantially throughout August. No treatment provided acceptable dollar spot control when disease was evident, and no differences in disease incidence were observed among any treatment. Turf quality of all treatments had become unacceptable (i.e., < 6) by 15 August due to disease incidence.

A moderate phytotoxic effect was observed on plots treated with Consan Turf, especially at the high rate (3.6 fl oz) or when mixed with Fairphyte. This effect was most evident 2-7 DAT diminishing over a period of approximately 14-d. The phytotoxcicty did not have a major effect on turf quality under moderate summer temperatures during late July and August but more severe phytotoxcicty was observed in plots during increased temperatures in late June (Fig. 1).

Fig. 1. Phytotoxcicty was observed in plots treated with Consan Turf alone (right) and Consan Turf + Fairphyte (left).

When agitated in a water carrier, Consan Turf produced a substantial amount of foam that persisted for several minutes before dissipating (Fig. 2). Bubbles were also produced during application, causing substantial drift even in low winds (Fig. 3). This was problematic for ensuring application accuracy, and increased the risk of application to untreated areas. After the initial application date, Shake Down, an anti-foaming agent, was added to the carrier prior to addition of Consan Turf at the maximum rate of 1 oz. / 100 gal. This slightly reduced the persistence of the foam, however bubbles were still formed during application. To eliminate foam, Shake Down was required at 10 times the recommended rate (Fig. 2).

Based on this trial, Consan Turf does not appear to be an effective option for preventive dollar spot control.

Fig. 2. Consan Turf (left) produced an excessive amount of foam compared to Consan Turf + Shake Down (10 fl.oz. 100 gal^{-1} solution; right) following agitation.

Fig. 3. Bubbles were produced and persisted on the turf canopy of Consan Turf treatments.

Table 1. Dollar spot incidence influenced by Consan Turf applied preventatively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Dollar Spot Incidence						
		3 Jul	10 Jul	18 Jul	27 Jul	8 Aug	15 Aug	25 Aug
		# of spots 18ft^{-2}						
Consan Turf	1.6 fl.oz.	0.0	0.5	0.0	2.7	23.3	32.0	32.8
Consan Turf	3.2 fl.oz.	0.5	0.5	0.0	7.7	35.3	44.8	42.0
Fairphyte	4.0 fl.oz.	0.0	1.0	0.0	5.7	26.5	35.0	34.5
Fairphyte + Consan Turf	4.0 fl.oz. + 1.6 fl.oz.	0.0	1.0	0.0	1.8	19.0	24.3	27.8
Burley Green	0.1 lb N	0.3	0.0	0.3	7.3	29.5	39.8	42.8
Untreated		0.0	0.3	0.0	6.6	26.8	34.5	38.0
ANOVA: Treatment (P > F)		0.1320	0.2394	0.4509	0.2349	0.6344	0.6256	0.7505
Days after treatment[z]		14	1	9	4	2	9	4

[z]Treatments were initiated on 19 June, prior to disease development. Subsequent applications were made on 23 July, 6 August and 21 August.

Table 2. Turf quality influenced by Consan Turf applied preventatively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Turf Quality			
		20 Jun	3 Jul	18 Jul	15 Aug
		1-9; 6=min acceptable			
Consan Turf	1.6 fl.oz.	6.8	7.0	7.8	5.5 a[y]
Consan Turf	3.2 fl.oz.	7.0	6.8	8.0	4.3 b
Fairphyte	4.0 fl.oz.	7.0	7.0	8.3	5.8 a
Fairphyte + Consan Turf	4.0 fl.oz. + 1.6 fl.oz.	7.0	6.8	8.5	5.3 a
Burley Green	0.1 lb N	7.5	7.8	8.0	5.5 a
Untreated		7.0	7.0	8.3	5.5 a
ANOVA: Treatment (P > F)		0.6112	0.0693	0.4917	0.0471
Days after treatment[z]		1	14	9	9

[z]Treatments were initiated on 19 June, prior to disease development. Subsequent applications were made on 23 July, 6 August and 21 August.

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

Table 3. Phytotoxicity affected by Consan Turf applied preventatively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Phytotoxicity			
		3 Jul	18 Jul	8 Aug	15 Aug
		0-5; 2=max acceptable			
Consan Turf	1.6 fl.oz.	0.0	0.0	0.0 c[y]	0.3 b
Consan Turf	3.2 fl.oz.	0.3	0.0	1.0 ab	1.5 a
Fairphyte	4.0 fl.oz.	0.0	0.0	0.5 bc	0.0 b
Fairphyte + Consan Turf	4.0 fl.oz. + 1.6 fl.oz.	0.3	0.0	1.5 a	1.0 ab
Burley Green	0.1 lb N	0.0	0.0	0.0 c	0.0 b
Untreated		0.0	0.0	0.0 c	0.0 b
ANOVA: Treatment (P > F)		0.5988	1.0000	0.0030	0.0218
Days after treatment[z]		14	9	2	9

[z]Treatments were initiated on 19 June, prior to disease development. Subsequent applications were made on 23 July, 6 August and 21 August.

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

PREVENTIVE DOLLAR SPOT CONTROL WITH BIOFUNGICIDES AND SOIL INOCULANTS WITH AND WITHOUT REDUCED RATE FUNGICIDE APPLICATIONS ON A CREEPING BENTGRASS FAIRWAY TURF, 2014

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INTRODUCTION

Dollar spot is a common disease of cool-season turfgrasses caused by the fungal pathogen *Sclerotinia homoeocarpa*. The disease is capable of causing disease from May through October throughout much of the northern United States. Fungicides and cultural practices are routinely applied to high value turf surfaces (e.g., greens, tees, fairways, athletic fields) during this period to control dollar spot. Biofungicides and soil inoculants containing bacteria and/or fungi may enhance turf tolerance or suppress turf pathogen growth to limit disease. If effective, these products could offer turf managers alternatives to traditional fungicides with reduced environmental impacts. These alternative products could also potentially be used in combination with reduced rates of traditional fungicides to minimize total amount of active ingredient applied. The objectives of this trial were to evaluate biofungicides and soil inoculants for preventive dollar spot control with and without reduced rates of traditional fungicides.

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. Maintenance applications of nitrogen were limited to 0.75 lb N 1000-ft^{-2} was applied as water soluble sources from April through July to encourage dollar spot. An application of Daconil Ultrex was applied at 3.2 oz 1000-ft^{-2} to delay the onset of disease until treatments had been initiated. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of biofungicides, soil inoculants and urea with and without rotational fungicide programs. Initial applications were made on 29 May prior to disease developing in the trial area. Subsequent applications were made at specified intervals through 8 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 1.0 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.

Dollar spot incidence was assessed as a count of individual disease foci within each plot from 12 June to 11 August. Dollar spot severity was visually assessed as the plot area blighted by dollar spot on 15 August once individual spots could no longer be distinguished. 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 transformed or arc-sin square root transformed, respectively for ANOVA and mean separation tests, although means presented are de-transformed values.

RESULTS & DISCUSSION

Disease pressure was moderate throughout most of the trial. Initial symptoms were developed on 12 June, becoming unacceptable (> 25 dollar spots per plot) in the untreated control and other treatments by 20 June (Table 1).

Dollar spot incidence and severity were predominantly influenced by the application of fungicide rotational programs, regardless of biofungicide or soil inoculant tank mixes. All treatments that included the high or low rate fungicide programs provided excellent dollar spot control throughout this study. No significant differences between low and high rate fungicide programs were observed throughout the trial. This is likely due to the moderate disease pressure observed in this trial.

Biofungicides and soil inoculants applied without fungicides did not provide season long acceptable disease control. However, some treatments provided suppression of the disease improving control over others. EcoGuard provided good dollar spot suppression and acceptable turf quality (Table 3) through 3 July. However, disease severity increased to unacceptable levels thereafter which continued to increase through the end of the trial. This biofungicide contains the bacterium *Bacillus licheniformis* and has been shown in similar studies to suppress dollar spot. At the rate EcoGurad was applied in this study the product also provides 0.14 lbs N 1000-ft^{-2}. A comparison treatment of urea applied to deliver the same N rate as EcoGuard provided statistically identical results in this study (Tables 1-4).

Turf quality differences were closely related to disease severity in this trial. No treatment resulted in unacceptable phytotoxicity (Table 4).

CONCLUSION

Biofungicides and soil inoculants applied alone did not provide acceptable dollar spot control. Urea provided equivalent or better disease suppression compared to biofungicides and soil inoculants in this trial. Due to excellent disease control obtained with fungicides in this trial it is still unclear whether biofungicides and soil inoculants could be used in a program with reduced rates of fungicides to provide acceptable disease control and reduced chemical input.

Table 1. Dollar spot incidence influenced by biofungicides and soil inoculants with and without reduced rate fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per $1000ft^2$	Int[w]	Dollar Spot Incidence 12 Jun	20 Jun	30 Jun	3 Jul	11 Jul	17 Jul
			-------- # of spots $18ft^{-2}$ --------					
Companion	4.0 fl.oz.	14-d	6.3[v] a-e[u]	23.9 bc	36.8 ab	56.4 ab	61.6 ab	74.6 ab
More	0.37 fl.oz.	14-d	14.8 a	49.7 a	52.1 a	72.1 a	55.9 ab	87.8 ab
Turfshield Plus G + Quantum Growth VSC + Quantum Growth Light	2.0 lbs[z] 2.0 fl.oz. 2.0 fl.oz.	28-d 14-d 14-d	7.0 a-d	55.2 a	59.5 a	83.8 a	92.5 a	99.9 a
Serenade Optimum	0.31oz.	14-d	9.6 abc	38.0 ab	47.8 a	61.5 ab	73.0 a	95.6 a
EcoGuard	20.0 fl.oz.	14-d	2.9 c-g	13.7 c	10.4 cd	31.2 bc	26.9 c	38.4 c
Urea (46-0-0)	0.14 lbs N	14-d	5.2 b-f	17.2 bc	17.8 bc	25.6 c	38.3 bc	51.4 bc
Rotational Fungicide Pgm	full rate[y]	14-d	0.2 g	0.2 d	0.2 e	0.0 d	0.0 d	0.0 d
Rotational Fungicide Pgm	low rate[x]	14-d	1.2 efg	1.4 d	3.4 de	3.5 d	0.6 d	0.0 d
Companion + Rotational Fungicide Pgm	4.0 fl.oz. low rate[x]	14-d	0.2 g	1.9 d	5.1 cde	2.3 d	0.4 d	0.0 d
More + Rotational Fungicide Pgm	0.37 fl.oz. low rate[x]	14-d	0.9 fg	2.0 d	7.6 cde	4.4 d	1.1 d	0.2 d
Turfshield Plus G + Quantum Growth VSC + Quantum Growth Light + Rotational Fungicide Pgm	2.0 lbs[z] 2.0 fl.oz. 2.0 fl.oz. low rate[x]	28-d 14-d 14-d	0.4 g	0.6 d	3.5 de	1.1 d	0.2 d	0.0 d
Serenade Optimum + Rotational Fungicide Pgm	0.31 oz. low rate[x]	14-d	2.0 d-g	1.4 d	7.1 cde	5.8 d	1.2 d	0.2 d
EcoGuard + Rotational Fungicide Pgm	20.0 fl.oz. low rate[x]	14-d	0.0 g	0.7 d	1.6 de	0.8 d	0.0 d	0.0 d
Urea (46-0-0) + Rotational Fungicide Pgm	0.14 lbs N low rate[x]	14-d	1.5 d-g	1.3 d	6.8 cde	3.9 d	0.0 d	0.0 d
Untreated			11.3 ab	36.5 ab	49.8 a	60.6 ab	73.1 a	77.2 ab
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	14	8	3	6	14	6
		28-d	14	22	3	6	14	20

[z]Plots treated with Turfshield Plus G received 0.1 inch of irrigation immediately following treatment application. Plots were allowed to dry before Quantum Growth treatments were applied.

[y]Bayleton FLO (0.25 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.75 fl.oz.) was applied on 12 June. Honor (0.83 oz.) was applied on 27 June. Chipco 26019 (3.0 fl.oz.) was applied on 11 July. Secure (0.5 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[z]Bayleton FLO (0.20 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.0 fl.oz.) was applied on 12 June. Honor (0.55 oz.) was applied on 27 June. Chipco 26019 (2.0 fl.oz.) was applied on 11 July. Secure (0.4 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[w]Treatments were initiated on 29 May, prior to disease development. Subsequent 14-d treatments were applied on 12 and 27 June, 11 and 25 July, and 8 August. Subsequent 28-d treatments were applied on 27 June and 25 July.

[v]Data were square-root transformed with means de-transformed 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 ($\alpha = 0.05$).

Table 2. Dollar spot incidence influenced by biofungicides and soil inoculants with and without reduced rate fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[w]	Dollar Spot Incidence Aug 1	Dollar Spot Incidence Aug 11	Dollar Spot Severity Aug 15
			---- # of spots 18ft^{-2} ----		--% plot area blighted--
Companion	4.0 fl.oz.	14-d	132.0 [v] ab[u]	189.5 a	24.5 a
More	0.37 fl.oz.	14-d	141.4 a	177.9 a	25.3 a
Turfshield Plus G	2.0 lbs[z]	14-d	163.2 a	199.6 a	29.8 a
+ Quantum Growth VSC	2.0 fl.oz.	14-d			
+ Quantum Growth Light	2.0 fl.oz.	28-d			
Serenade Optimum	0.31oz.	14-d	133.1 ab	189.8 a	27.3 a
EcoGuard	20.0 fl.oz.	14-d	72.3 c	81.5 b	15.4 b
Urea (46-0-0)	0.14 lbs N	14-d	91.8 bc	109.4 b	14.8 b
Rotational Fungicide Pgm	full rate[y]	14-d	0.0 d	0.4 c	0.0[t] c
Rotational Fungicide Pgm	low rate[x]	14-d	0.2 d	0.5 c	0.1 c
Companion	4.0 fl.oz.	14-d	0.0 d	0.4 c	0.1 c
+ Rotational Fungicide Pgm	low rate[x]				
More	0.37 fl.oz.	14-d	0.0 d	0.8 c	0.0 c
+ Rotational Fungicide Pgm	low rate[x]				
Turfshield Plus G	2.0 lbs[z]	28-d	0.0 d	0.4 c	0.0 c
+ Quantum Growth VSC	2.0 fl.oz.	14-d			
+ Quantum Growth Light	2.0 fl.oz.	14-d			
+ Rotational Fungicide Pgm	low rate[x]				
Serenade Optimum	0.31 oz.	14-d	0.0 d	1.9 c	0.1 c
+ Rotational Fungicide Pgm	low rate[x]				
EcoGuard	20.0 fl.oz.	14-d	0.0 d	0.0 c	0.0 c
+ Rotational Fungicide Pgm	low rate[x]				
Urea (46-0-0)	0.14 lbs N	14-d	0.0 d	0.4 c	0.1 c
+ Rotational Fungicide Pgm	low rate[x]				
Untreated			126.6 ab	159.5 a	22.0 ab
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0001
Days after treatment		14-d	6	3	7
		28-d	6	16	20

[z]Plots treated with Turfshield Plus G received 0.1 inch of irrigation immediately following treatment application. Plots were allowed to dry before Quantum Growth treatments were applied.

[y]Bayleton FLO (0.25 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.75 fl.oz.) was applied on 12 June. Honor (0.83 oz.) was applied on 27 June. Chipco 26019 (3.0 fl.oz.) was applied on 11 July. Secure (0.5 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[z]Bayleton FLO (0.20 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.0 fl.oz.) was applied on 12 June. Honor (0.55 oz.) was applied on 27 June. Chipco 26019 (2.0 fl.oz.) was applied on 11 July. Secure (0.4 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[w]Treatments were initiated on 29 May, prior to disease development. Subsequent 14-d treatments were applied on 12 and 27 June, 11 and 25 July, and 8 August. Subsequent 28-d treatments were applied on 27 June and 25 July.

[v]Data were square-root transformed with means de-transformed 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 square-root transformed with means de-transformed for presentation.

Table 3. Turf quality influenced by biofungicides and soil inoculants with and without reduced rate fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[w]	Turf Quality 6 Jun	Turf Quality 20 Jun	Turf Quality 3 Jul
			---------- 1-9; 6=min acceptable ----------		
Companion	4.0 fl.oz.	14-d	6.3	5.5 cd[v]	4.8 ef
More	0.37 fl.oz.	14-d	6.0	5.3 d	4.8 ef
Turfshield Plus G	2.0 lbs[z]	14-d	6.3	5.3 d	4.5 f
+ Quantum Growth VSC	2.0 fl.oz.	14-d			
+ Quantum Growth Light	2.0 fl.oz.	28-d			
Serenade Optimum	0.31oz.	14-d	6.5	5.5 cd	4.8 ef
EcoGuard	20.0 fl.oz.	14-d	6.5	6.5 bc	6.3 cd
Urea (46-0-0)	0.14 lbs N	14-d	7.0	6.3 bcd	5.8 de
Rotational Fungicide Pgm	full rate[y]	14-d	6.3	6.5 bc	7.0 abc
Rotational Fungicide Pgm	low rate[x]	14-d	6.5	6.5 bc	6.5 cd
Companion	4.0 fl.oz.	14-d	6.0	6.5 bc	6.8 bcd
+ Rotational Fungicide Pgm	low rate[x]				
More	0.37 fl.oz.	14-d	6.5	6.5 bc	6.8 bcd
+ Rotational Fungicide Pgm	low rate[x]				
Turfshield Plus G	2.0 lbs[z]	28-d	6.3	6.8 ab	7.0 abc
+ Quantum Growth VSC	2.0 fl.oz.	14-d			
+ Quantum Growth Light	2.0 fl.oz.	14-d			
+ Rotational Fungicide Pgm	low rate[x]				
Serenade Optimum	0.31 oz.	14-d	6.5	7.0 ab	7.0 abc
+ Rotational Fungicide Pgm	low rate[x]				
EcoGuard	20.0 fl.oz.	14-d	6.3	7.3 ab	8.0 a
+ Rotational Fungicide Pgm	low rate[x]				
Urea (46-0-0)	0.14 lbs N	14-d	6.8	7.8 a	7.8 ab
+ Rotational Fungicide Pgm	low rate[x]				
Untreated			6.3	5.5 cd	4.8 ef
ANOVA: Treatment ($P > F$)			0.1884	0.0001	0.0001
Days after treatment		14-d	8	8	6
		28-d	8	22	6

[z]Plots treated with Turfshield Plus G received 0.1 inch of irrigation immediately following treatment application. Plots were allowed to dry before Quantum Growth treatments were applied.

[y]Bayleton FLO (0.25 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.75 fl.oz.) was applied on 12 June. Honor (0.83 oz.) was applied on 27 June. Chipco 26019 (3.0 fl.oz.) was applied on 11 July. Secure (0.5 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[z]Bayleton FLO (0.20 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.0 fl.oz.) was applied on 12 June. Honor (0.55 oz.) was applied on 27 June. Chipco 26019 (2.0 fl.oz.) was applied on 11 July. Secure (0.4 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[w]Treatments were initiated on 29 May, prior to disease development. Subsequent 14-d treatments were applied on 12 and 27 June, 11 and 25 July, and 8 August. Subsequent 28-d treatments were applied on 27 June and 25 July.

[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 affected by biofungicides and soil inoculants with and without reduced rate fungicides applied preventively to a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Int[w]	Phytotoxicity 6 Jun	Phytotoxicity 20 Jun
			----- 0-5; 2=max acceptable -----	
Companion	4.0 fl.oz.	14-d	0.0	0.0 d
More	0.37 fl.oz.	14-d	0.0	0.0 d
Turfshield Plus G	2.0 lbs[z]	14-d	0.0	0.0 d
+ Quantum Growth VSC	2.0 fl.oz.	14-d		
+ Quantum Growth Light	2.0 fl.oz.	28-d		
Serenade Optimum	0.31oz.	14-d	0.0	0.0 d
EcoGuard	20.0 fl.oz.	14-d	0.0	0.0 d
Urea (46-0-0)	0.14 lbs N	14-d	0.0	0.0 d
Rotational Fungicide Pgm	full rate[y]	14-d	0.0	1.3 a[v]
Rotational Fungicide Pgm	low rate[x]	14-d	0.0	1.0 ab
Companion	4.0 fl.oz.	14-d	0.0	0.8 bc
+ Rotational Fungicide Pgm	low rate[x]			
More	0.37 fl.oz.	14-d	0.0	1.3 a
+ Rotational Fungicide Pgm	low rate[x]			
Turfshield Plus G	2.0 lbs[z]	28-d	0.0	1.0 ab
+ Quantum Growth VSC	2.0 fl.oz.	14-d		
+ Quantum Growth Light	2.0 fl.oz.	14-d		
+ Rotational Fungicide Pgm	low rate[x]			
Serenade Optimum	0.31 oz.	14-d	0.0	0.8 bc
+ Rotational Fungicide Pgm	low rate[x]			
EcoGuard	20.0 fl.oz.	14-d	0.0	0.5 c
+ Rotational Fungicide Pgm	low rate[x]			
Urea (46-0-0)	0.14 lbs N	14-d	0.0	0.8 bc
+ Rotational Fungicide Pgm	low rate[x]			
Untreated			0.0	0.0 d
ANOVA: Treatment (P > F)			1.0000	0.0001
Days after treatment		14-d	8	8
		28-d	8	22

[z]Plots treated with Turfshield Plus G received 0.1 inch of irrigation immediately following treatment application. Plots were allowed to dry before Quantum Growth treatments were applied.

[y]Bayleton FLO (0.25 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.75 fl.oz.) was applied on 12 June. Honor (0.83 oz.) was applied on 27 June. Chipco 26019 (3.0 fl.oz.) was applied on 11 July. Secure (0.5 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[z]Bayleton FLO (0.20 fl.oz.) was applied on 29 May and 8 August. Daconil Action (2.0 fl.oz.) was applied on 12 June. Honor (0.55 oz.) was applied on 27 June. Chipco 26019 (2.0 fl.oz.) was applied on 11 July. Secure (0.4 fl.oz.) was applied on 25 July. Primo MAXX (0.25 fl.oz.) was applied on 12 and 27, 11 and 25 July, and 8 August.

[w]Treatments were initiated on 29 May, prior to disease development. Subsequent 14-d treatments were applied on 12 and 27 June, 11 and 25 July, and 8 August. Subsequent 28-d treatments were applied on 27 June and 25 July.

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

USE OF PEONIES TO CONSERVE SPRING TIPHIA PARASITOIDS OF WHITE GRUBS: A THREE YEAR STUDY

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INTRODUCTION

The parasitic wasp *Tiphia vernalis* or spring Tiphia attacks the larval or grub stage of Japanese and oriental beetles. These parasitoids feed on the 3rd instar grubs during spring. A state survey indicated that spring Tiphia wasps are found in all counties and adult wasp numbers peak during the last week of May (Ramoutar and Legrand 2007). Spring Tiphia adults have been observed feeding on honeydew deposits from soft scales or aphids on tree foliage. This is not surprising because many parasitoid wasp species visit flowers to obtain nectar and/or pollen that provide essential nutrients thereby increasing their survival. During the time when spring Tiphia are active, there are limited plant resources that they can use to obtain nectar. Thus, one approach in conservation biological control is to provide food resources to these natural enemies either through food sprays or by incorporating flowering plant habitats that could provide food resources over a period of time. The objective of this study was to determine if the use of peonies in the landscape can attract and enhance parasitism of Japanese and oriental beetle grubs in turfgrass.

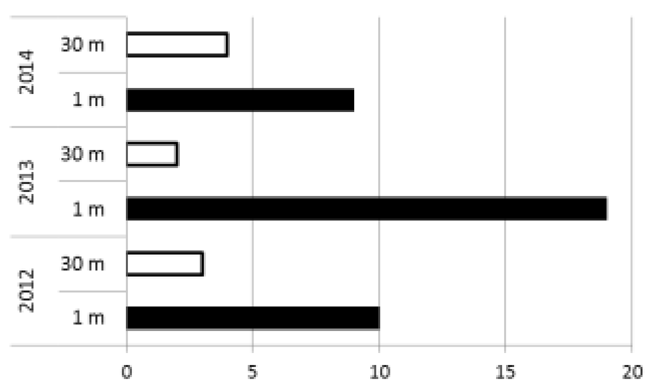
MATERIALS & METHODS

Peonies, *Paeonia lactiflora*, were selected for this evaluation because of their extrafloral nectar production. Peonies secrete extrafloral nectar through the calyx of unopened flower buds. In addition, previous studies had determined their attractiveness to *Tiphia* wasps and their lack of susceptibility to Japanese beetle adult feeding (Legrand 2010). A row of 36 peonies was set up in the middle of a Kentucky bluegrass field. Starting in summer 2011, twelve artificial infestations of Japanese beetles were set up in 1.8 m x 3.6 m areas covered by polyester noseeum netting. Six areas were adjacent alongside the peonies and six areas were at 30 m away from the peony beds. Japanese beetle adults were held under the netting to have them oviposit in these areas. Netted areas were set up in the late summer previous to the spring time when Tiphia adults are active attacking grubs. After Tiphia activity was over, parasitism on white grubs was evaluated in mid-June by taking soil core samples (83.6 cm^2 in area and 15.2 cm deep) with a standard cup-cutter. Sample depth needs to be at least 15cm because parasitized grubs are found deeper in the soil profile than healthy grubs. Sixty samples were taken at 1m from the peonies and 60 samples were taken at 30 m from the peonies. White grubs were collected and taken to the laboratory for identification and determination of parasitism. Data on parasitism frequency were analyzed with a Chi-square test.

RESULTS & DISCUSSION

A significant association was found between sample location (1 m and 30 m from peonies) and the number of parasitized Japanese and oriental beetle grubs in years 2012 and 2013 (Chi-Square = 8.84, $P = 0.03$). Figure 1 presents the total number of Japanese and oriental beetle grubs found to be parasitized by the spring Tiphia in each year of the study. More grubs were found to be parasitized by Tiphia at 1 m away from the peonies in comparison to 30 m away. However, the location and parasitism association was not significant in 2014. In each year of the study, peony foliage and flowers remained free from any significant insect damage either from scarab beetles or other insects. Moreover, Tiphia wasps were observed to actively feed on the peony nectar. The provision of sugary or nectar sources is important for attracting Tiphia and also for increasing their survival (Rogers and Potter 2004). Previous work had shown that peonies are best at providing nectar resources in comparison to other landscape ornamentals (Legrand 2010). The addition of peonies to the landscape can provide this resource for Tiphia wasps and as observed through this study parasitism levels could be manipulated at least in 2 out of 3 years. Peonies can provide a valuable aesthetic function in the landscape and have the potential to be a component of conservation biological control involving Tiphia wasps.

Figure 1. Total number of Japanese and oriental beetle grubs found to be parasitized by the spring Tiphia (*Tiphia vernalis*) at 1 m and 30 m away from peonies.



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AERIFICATION RECOVERY OF A CREEPING BENTGRASS PUTTING GREEN TURF INFLUENCED BY SIGNATURE AND NORTICA PROGRAMS, 2014

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INTRODUCTION

Aeration is an important cultural practice that relives soil compaction, increases soil air porosity, and helps reduce organic matter. This practice is typically performed one to two times per year on putting greens. While the practice has significant agronomic benefits, it does temporarily reduce surface uniformity and may disrupt play. Due to the perceived perception of this practice, aeration may not be performed as often as it should be to maintain good growing conditions in some cases, or it may be done at times which reduce the impact on play, but which reduce turf recovery rate. Practices which minimize disruption of play associated with aeration would help turf managers accomplish this valuable cultural and reduce golfer inconvenience.

A number of products are available today which purportedly improve various plant health attributes increasing turf tolerance to abiotic and biotic stress. Signature is a green pigmented formulation of fosetyl-Al which has been shown to improve cellular membrane stability and photosynthesis under ultraviolet (UV) light stress. Nortica is a biological nematode management product which contains the bacterium *Bacillus firmus*. This beneficial organism colonizes plant roots and deters root feeding nematodes. The objective of this trial was to determine whether Signature and Nortica could improve plant health and increase turf recovery from aeration.

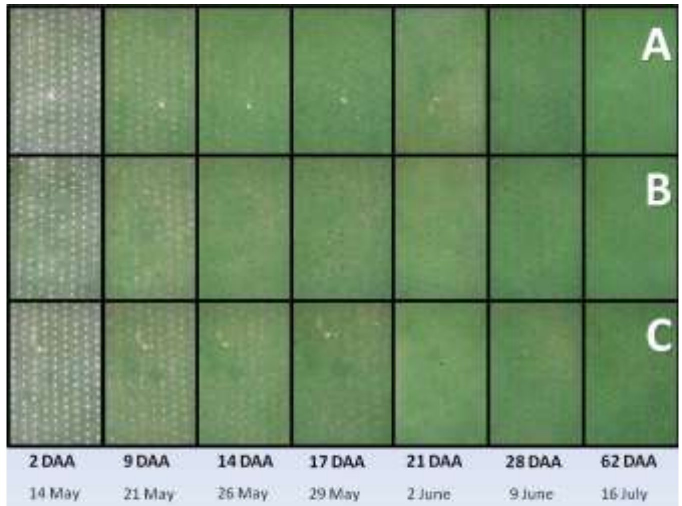

Figure 2. Aeration recovery of Daconil Ultrex + Signature + Nortica (A), Daconil Ultrex + Signature (B), and untreated (C) from 2 through 62 days after aeration (DAA) on a creeping bentgrass putting green turf.

MATERIALS AND METHODS

A field study was conducted on a 'Penn A-4' 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 five days wk^{-1} at a bench setting of 0.14-inches. A total of 1.0 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through June. Subdue MAXX was applied on 29 April for control of yellow tuft. Secure was applied at 0.5 fl.oz. on 27 May, followed by an application of Emerald (0.18 oz) on 31 May for dollar spot control. Scimitar GC and Dylox 80 were applied on 21 May and 31 May for control of annual bluegrass weevil. Overhead irrigation was applied as needed to prevent drought stress.

The trial utilized a split-plot design arranged in a 2 x 5 factorial with aeration as the main plot and treatment as the subplot. Aeration was conducted with 3/8 inch hollow tines on a 1.5 x 2.0 inch spacing to a depth of 2.5 inches on 12 May with a Toro ProCore 648. Following aeration cores were removed and the entire study was sand topdressed and brushed to fill the holes. Treatments consisted of a tank mix of Daconil Ultrex + Signature and Nortica applied alone or in combination. A tank mix of KNO_3 + Urea at rates to equal the amount of nitrogen and potassium delivered by Nortica applications was also included as a fertility control.

Initial treatment applications were made on 28 April and 12 May. Nortica and of KNO_3 + Urea initially applied the same day as aeration. Both treatments were mixed in solution and sprayed over the open aeration holes and watered in with a 0.1 inch of irrigation before sand topdressing was applied. Subsequent applications were made at specified treatment intervals through the end of June. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Main plots measured 3 x 30 ft and subplots were 3 x 6 ft with four replications.

Percent green turf cover and dark green color index were determined using digital image analysis in SigmaScan ver. 5.0. Digital images of the same area of each plot were taken using a light box which contains four compact fluorescent bulbs and restricts ambient light to standardize image exposure conditions. Images were taken at least every 7-d after aeration until all plots reached ≥ 98% green turf cover. 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. Preplanned orthogonal contrasts were used to identify significant treatment effects and to make specific treatment comparisons.

RESULTS AND DISCUSSION

Prior to aeration, turf treated with Daconil Ultrex + Signature had greater turf quality compared to turf where the combination was not applied (Table 2). Thereafter, aeration reduced percent green turf cover and turf quality compared to non-aerated plots throughout the remainder of the trial (Tables 1 & 2). Percent green turf cover was reduced as much as 21% on average by aeration compared to non-aerated, and quality was below the acceptable level (Tables 1 & 2). Spray treatments had no effect on green turf cover in aerated plots 2 days after aeration (DAA). However, pre-planned orthogonal contrasts indicate that all spray treatments improved percent green turf cover 12% on average compared to untreated by 9 DAA; resulting in an improvement of turf quality by 14 DAA. Turf quality was considered acceptable or better in all treated aerated plots by 18 DAA (30 May); whereas untreated aerated plots remained unacceptable for up to 39 days (20 June; Table 2).

Among treated, aerated plots, those receiving Daconil Ultrex + Signature had slightly more percent green turf cover (0.65 to 2.1%) 21 to 28 DAA than those that did not receive the combination. However, turf quality was significantly improved by as much as 1.3 points in Daconil Ultrex + Signature plots from 18 to 25 DAA and at 45 DAA in aerated and non-aerated plots. No differences in dark green color index were detected by the F test among any treatments during this time (30 May to 27 June; Table 3) suggesting that quality enhancements observed were not directly related to color.

Rotating Nortica with Daconil Ultrex + Signature had no effect on percent green turf cover throughout the trial. Although the addition of Nortica did improve turf quality of Daconil Ultrex + Signature treated plots above the minimum acceptable level compared to the combination alone at 14 DAA and later on at 45 DAA. However, comparisons between Nortica and an equivalent amount of nitrogen and potassium derived from KNO_3 and urea did not identify any significant differences between the treatments for any parameter measured in this trial (Tables 1, 2, and 3). With exception to the initial root length measurement taken prior to application of either treatment (Table 4). Root length measurements taken at the conclusion of the trial did not show any differences among the treatments; only a slight reduction in rooting associated with aeration.

Application of Daconil Ultrex + Signature, Nortica, or KNO_3 + Urea all improved turf aeration recovery in the Spring. These treatments helped increase turf cover resulting in acceptable quality 21 – 25 days faster than untreated turf. Based on the results from this study it is not clear exactly how these treatments improved aeration recovery. However, in the case of Daconil Ultrex + Signature, it may be possible that applications of these fungicides 2 weeks prior to cultivation helped suppress weak pathogens, thereby enhancing turf recuperative ability compared to non-fungicide treated plots. Nortica and KNO_3 + Urea also improved aeration recovery. Both treatments contain equivalent amounts of N and K and provided 0.113 lbs N and 0.169 lbs K_2O 1000-ft^{-2} per application. Nortica also contains *Bacillus firmus*, a bacterium that purportedly colonizes turfgrass roots and protects them against nematodes. In this trial, Nortica did improve turf quality of Daconil Ultrex + Signature treated plots on a couple of dates compared to the later two products applied alone. However, no differences between Nortica and KNO_3 + Urea were observed. Therefore, it appears that improvements in turf quality when Nortica was applied with Daconil Ultrex + Signature are more likely attributable to increased N and K fertility rather than bacterial colonization of roots. No differences in root length were observed among any treatments at the conclusion in this study. These data suggest that an application of Daconil Ultrex + Signature prior to aeration particularly, with increased N fertility, may increase turf recovery from aeration.

Table 1. Percent green turf cover following spring aeration influenced by Signature and Nortica programs on a 'Penn A-4' creeping bentgrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Application Dates[x]	Green Turf Cover 14 May	21 May	26 May	29 May	2 Jun	9 June
			%					
Aeration[z]		B						
Daconil Ultrex	3.2 oz.	ACE	56.8	91.3	97.4	98.1	99.4	99.8
+ Chipco Signature	4.0 oz.	ACE						
- Nortica WP10	12.9 oz.[y]	BDF						
Daconil Ultrex	3.2 oz.	ACE	71.9	88.1	95.6	97.1	98.6	99.7
+ Chipco Signature	4.0 oz.	ACE						
Nortica WP10	12.9 oz.[y]	BDF	54.7	86.2	94.1	94.2	96.6	98.9
KNO_3	.0.36 lb[y]	BDF	57.0	89.0	95.6	96.0	97.2	99.3
+ Urea	0.138 lb	BDF						
Untreated			50.9	76.3	89.1	88.4	92.9	98.2
No Aeration								
Daconil Ultrex	3.2 oz.	ACE	88.4	97.6	99.3	99.3	99.8	99.9
+ Chipco Signature	4.0 oz.	ACE						
- Nortica WP10	12.9 oz.[y]	BDF						
Daconil Ultrex	3.2 oz.	ACE	94.4	96.7	98.7	98.7	99.3	99.9
+ Chipco Signature	4.0 oz.	ACE						
Nortica WP10	12.9 oz.[y]	BDF	59.0	93.3	96.9	96.5	97.9	99.5
KNO_3	0.36 lb[y]	BDF	75.1	93.5	97.2	96.6	98.1	99.5
+ Urea	0.138 lb	BDF						
Untreated			80.0	91.4	96.2	95.5	97.2	99.5
ANOVA: Treatment (P > F)			0.0006	0.0006	0.0001	0.0005	0.0001	0.0025
Orthogonal Contrasts			*P > F*					
Aeration vs. No Aeration			< 0.0001	< 0.0001	< 0.0001	0.0071	0.0077	0.0093
Within Aeration Plots:								
Treated vs. Untreated			0.2440	0.0004	< 0.0001	< 0.0001	< 0.0001	0.0002
Daconil + Signature vs. No Daconil + Signature			0.2278	0.4418	0.1635	0.0835	0.0176	0.0177
With Daconil + Signature:								
Nortica vs. No Nortica			0.1319	0.4074	0.2533	0.5872	0.5470	0.7434
Without Daconil + Signature:								
Nortica vs. KNO_3 + Urea			0.8117	0.4803	0.3570	0.3658	0.5909	0.3718
Within No Aeration Plots:								
Treated vs. Untreated			0.9322	0.2244	0.1521	0.1413	0.1017	0.4408
Daconil + Signature vs. No Daconil + Signature			0.0015	0.1824	0.0946	0.0893	0.0706	0.1620
With Daconil + Signature:								
Nortica vs. No Nortica			0.5422	0.8216	0.7032	0.7434	0.7020	0.8802
Without Daconil + Signature:								
Nortica vs. KNO_3 + Urea			0.1102	0.9652	0.8598	0.9775	0.8997	0.8719
Days after aeration			2	9	14	17	21	28
Days after application			16	9	14	3	7	14

[z]Plots were aerated with 0.375 in. diameter hollow tines on a 1.5 x 2.0 in. spacing to a depth of 2.5 in. Thereafter, cores were removed, treatments were applied, and sand was topdressed and brushed to fill holes on 12 May.
[y]Plots treated with Nortica WP10 or KNO_3+Urea received 0.1 inch of irrigation immediately following treatment application.
[x]A=28 Apr; B=12 May; C=26 May; D=9 Jun; E=23 Jun; F=7 Jul.

Table 2. Turf quality following spring aeration influenced by Signature and Nortica programs on a 'Penn A-4' creeping bentgrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

			Turf Quality							
Treatment	Rate per 1000ft^2	Application Dates[x]	7 May	12 May	21 May	26 May	30 May	6 Jun	20 Jun	27 Jun
			1-9; 6=min acceptable							
Aeration[z]		B								
Daconil Ultrex	3.2 oz.	ACE	7.5	8.5	5.8	6.8	8.0	7.8	8.3	9.0
+ Chipco Signature	4.0 oz.	ACE								
- Nortica WP10	12.9 oz.[y]	BDF								
Daconil Ultrex	3.2 oz.	ACE	7.5	8.0	4.8	5.0	7.3	7.3	7.5	8.5
+ Chipco Signature	4.0 oz.	ACE								
Nortica WP10	12.9 oz.[y]	BDF	6.3	6.5	4.5	5.0	6.3	6.3	7.8	8.0
KNO_3	.0.36 lb[y]	BDF	6.5	6.8	5.0	6.3	6.5	6.5	8.3	8.0
+ Urea	0.138 lb	BDF								
Untreated			6.5	6.8	4.3	4.5	5.8	5.8	7.3	8.0
No Aeration										
Daconil Ultrex	3.2 oz.	ACE	7.5	8.0	8.0	8.5	8.8	8.8	9.0	9.0
+ Chipco Signature	4.0 oz.	ACE								
- Nortica WP10	12.9 oz.[y]	BDF								
Daconil Ultrex	3.2 oz.	ACE	7.3	8.0	8.0	7.8	8.3	8.3	8.8	9.0
+ Chipco Signature	4.0 oz.	ACE								
Nortica WP10	12.9 oz.[y]	BDF	6.3	6.8	7.0	7.3	7.3	7.0	9.0	8.5
KNO_3	0.36 lb[y]	BDF	6.5	7.0	7.8	7.8	7.5	7.3	8.8	8.3
+ Urea	0.138 lb	BDF								
Untreated			7.0	7.0	7.5	7.5	7.0	7.0	7.0	8.3
ANOVA: Treatment (P > F)			0.0133	0.0004	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001
Orthogonal Contrasts			*P > F*							
Aeration vs. No Aeration			0.7987	0.8043	<.0001	<.0001	<.0001	<.0001	<.0001	0.0084
Within Aeration Plots:										
Treated vs. Untreated			0.2132	0.0620	0.0976	0.0185	0.0015	0.0009	0.0264	0.0542
Daconil + Signature vs. No Daconil + Signature			0.0011	<.0001	0.2117	0.5797	0.0005	0.0005	0.6368	0.0001
With Daconil + Signature: Nortica vs. No Nortica			1.0000	0.2729	0.0816	0.0099	0.1051	0.2255	0.0527	0.0432
Without Daconil + Signature: Nortica vs. KNO_3 + Urea			0.5694	0.5803	0.3737	0.0577	0.5808	0.5403	0.1880	1.0000
Within No Aeration Plots:										
Treated vs. Untreated			0.7185	0.2261	0.6713	0.5360	0.0132	0.0168	0.0059	0.0265
Daconil + Signature vs. No Daconil + Signature			0.0030	0.0014	0.1215	0.1724	0.0014	<.0001	1.0000	0.0009
With Daconil + Signature: Nortica vs. No Nortica			0.5694	1.0000	1.0000	0.2447	0.2734	0.2255	0.5052	1.0000
Without Daconil + Signature: Nortica vs. KNO_3 + Urea			0.5694	0.5803	0.1861	0.4348	0.5808	0.5403	0.5052	0.2982
Days after aeration			--	--	9	14	18	25	39	45
Days after application			9	14	9	14	4	11	11	4

[z]Plots were aerated with 0.375 in. diameter hollow tines on a 1.5 x 2.0 in. spacing to a depth of 2.5 in. Thereafter, cores were removed, treatments were applied, and sand was topdressed and brushed to fill holes on 12 May.

[y]Plots treated with Nortica WP10 or KNO_3+Urea received 0.1 inch of irrigation immediately following treatment application.

[x]A=28 Apr; B=12 May; C=26 May; D=9 Jun; E=23 Jun; F=7 Jul.

Table 3. Dark green color index following spring aeration influenced by Signature and Nortica programs on a 'Penn A-4' creeping bentgrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Application Dates[x]	14 May	21 May	26 May	29 May	2 Jun	9 June
			Dark Green Color Index					
			---------- index ----------					
Aeration[z]		B						
Daconil Ultrex	3.2 oz.	ACE	0.651	0.590	0.604	0.631	0.607	0.649
+ Chipco Signature	4.0 oz.	ACE						
- Nortica WP10	12.9 oz.[y]	BDF						
Daconil Ultrex	3.2 oz.	ACE	0.644	0.577	0.592	0.620	0.595	0.637
+ Chipco Signature	4.0 oz.	ACE						
Nortica WP10	12.9 oz.[y]	BDF	0.651	0.596	0.608	0.620	0.588	0.632
KNO_3	.0.36 lb[y]	BDF	0.661	0.600	0.615	0.632	0.600	0.636
+ Urea	0.138 lb	BDF						
Untreated			0.650	0.617	0.618	0.638	0.604	0.630
No Aeration								
Daconil Ultrex	3.2 oz.	ACE	0.613	0.577	0.608	0.634	0.609	0.653
+ Chipco Signature	4.0 oz.	ACE						
- Nortica WP10	12.9 oz.[y]	BDF						
Daconil Ultrex	3.2 oz.	ACE	0.597	0.566	0.596	0.625	0.597	0.645
+ Chipco Signature	4.0 oz.	ACE						
Nortica WP10	12.9 oz.[y]	BDF	0.642	0.580	0.610	0.621	0.595	0.637
KNO_3	0.36 lb[y]	BDF	0.638	0.590	0.615	0.632	0.602	0.640
+ Urea	0.138 lb	BDF						
Untreated			0.630	0.581	0.609	0.623	0.595	0.639
ANOVA: Treatment ($P > F$)			0.0005	0.0026	0.0413	0.4194	0.3223	0.0900
Orthogonal Contrasts			---------- $P > F$ ----------					
Aeration vs. No Aeration			<.0001	0.0008	0.9753	0.7162	0.8141	0.0876
Within Aeration Plots:								
Treated vs. Untreated			0.8638	0.0034	0.0405	0.1089	0.2887	0.1316
Daconil + Signature vs. No Daconil + Signature			0.3309	0.0565	0.0204	0.8857	0.2555	0.0958
With Daconil + Signature: Nortica vs. No Nortica			0.5813	0.2207	0.1150	0.2305	0.1673	0.1211
Without Daconil + Signature: Nortica vs. KNO_3 + Urea			0.4514	0.7027	0.3596	0.1707	0.1884	0.5801
Within No Aeration Plots:								
Treated vs. Untreated			0.4352	0.7666	0.7910	0.5259	0.3494	0.4102
Daconil + Signature vs. No Daconil + Signature			0.0004	0.0760	0.0575	0.5831	0.4607	0.0607
With Daconil + Signature: Nortica vs. No Nortica			0.1923	0.2950	0.1333	0.3425	0.1336	0.2706
Without Daconil + Signature: Nortica vs. KNO_3 + Urea			0.7333	0.3741	0.4629	0.2274	0.3992	0.6797
Days after aeration			2	9	14	17	21	28
Days after application			16	9	14	3	7	14

[z]Plots were aerated with 0.375 in. diameter hollow tines on a 1.5 x 2.0 in. spacing to a depth of 2.5 in. Thereafter, cores were removed, treatments were applied, and sand was topdressed and brushed to fill holes on 12 May.

[y]Plots treated with Nortica WP10 or KNO_3+Urea received 0.1 inch of irrigation immediately following treatment application.

[x]A=28 Apr; B=12 May; C=26 May; D=9 Jun; E=23 Jun; F=7 Jul.

Table 4. Root length following spring aeration influenced by Signature and Nortica programs on a ‘Penn A-4’ creeping bentgrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2014.

Treatment	Rate per 1000ft^2	Application Dates[x]	Root Length 8 May	Root Length 30 Jun
			--------- inches ---------	
Aeration[z]		B		
Daconil Ultrex	3.2 oz.	ACE	4.4	6.1
+ Chipco Signature	4.0 oz.	ACE		
- Nortica WP10	12.9 oz.[y]	BDF		
Daconil Ultrex	3.2 oz.	ACE	4.4	6.1
+ Chipco Signature	4.0 oz.	ACE		
Nortica WP10	12.9 oz.[y]	BDF	4.5	6.0
KNO_3	.0.36 lb[y]	BDF	4.6	5.5
+ Urea	0.138 lb	BDF		
Untreated			4.8	6.7
No Aeration				
Daconil Ultrex	3.2 oz.	ACE	3.9	6.5
+ Chipco Signature	4.0 oz.	ACE		
- Nortica WP10	12.9 oz.[y]	BDF		
Daconil Ultrex	3.2 oz.	ACE	4.7	6.1
+ Chipco Signature	4.0 oz.	ACE		
Nortica WP10	12.9 oz.[y]	BDF	4.1	7.1
KNO_3	0.36 lb[y]	BDF	4.0	6.5
+ Urea	0.138 lb	BDF		
Untreated			4.4	6.0
ANOVA: Treatment (P > F)			0.2558	0.0666
Orthogonal Contrasts			--------- *P > F* ---------	
Aeration vs. No Aeration			0.0557	0.0057
Within Aeration Plots:				
Treated vs. Untreated			0.2470	0.5284
Daconil + Signature vs. No Daconil + Signature			0.5249	0.2841
With Daconil + Signature:				
Nortica vs. No Nortica			0.9006	0.9199
Without Daconil + Signature:				
Nortica vs. KNO_3 + Urea			0.7392	0.2509
Within No Aeration Plots:				
Treated vs. Untreated			0.3469	0.1448
Daconil + Signature vs. No Daconil + Signature			0.3449	0.1302
With Daconil + Signature:				
Nortica vs. No Nortica			0.0457	0.4301
Without Daconil + Signature:				
Nortica vs. KNO_3 + Urea			0.8513	0.2308
Days after aeration			--	48
Days after application			10	7

[z]Plots were aerated with 0.375 in. diameter hollow tines on a 1.5 x 2.0 in. spacing to a depth of 2.5 in. Thereafter, cores were removed, treatments were applied, and sand was topdressed and brushed to fill holes on 12 May.

[y]Plots treated with Nortica WP10 or KNO_3+Urea received 0.1 inch of irrigation immediately following treatment application.

[x]A=28 Apr; B=12 May; C=26 May; D=9 Jun; E=23 Jun; F=7 Jul.

EVALUATING ALTERNATIVE PESTICIDE-FREE ATHLETIC FIELD MANAGEMENT STRATEGIES FOR NEW ENGLAND 2014

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INTRODUCTION

As of July 1, 2010, the state of Connecticut 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). In previous experiments, Japanese beetles have shown a preference to laying their eggs in some cool-season grasses compared to common and hybrid bermudagrasses laying (Wood et al., 2009). Bermudagrass offers a number of desirable qualities that could be potentially beneficial under environmental conditions in Southern New England.

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, preserving soil physical properties, and maintaining 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 may likely increase 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/rhizomatous 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 (surface hardness and traction) for athletic fields subjected to simulated traffic.

MATERIALS AND METHODS

The research is includes 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) (Fig. 1) 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. 'Latitude 36' bermudagrass was established via sprigs while two other varieties, 'Yukon' and 'Rivera' were seeded.

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 (Fig. 2). The perennial ryegrass in the warm-season study was seeded the subsequent fall 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 additional half application of rubber was added in the May of 2014.

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 minimal pesticide plots of each study in both years (6 August, 2013 and (29 May, 2014) for post-emergent control of seasonal grassy and broadleaf weeds. The cool-season study received an application of Compass 50WDG (0.25 oz/1000ft^2) on 15 June, 2013 to all plots as a curative treatment for pythium foliar blight. Heritage TL (1 fl oz/1000ft^2) and Daconil Ultrex (3.2 oz/1000ft^2) was applied on 19 September, 2013 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 in 2013 (19 August) and 2014 (3 June) 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 in. per plot and was applied to treatments in the warm-season study at a rate of 0.5 in. 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 application when initially seeded/sprigged (18-24-12, 0.72lbs of N 1000ft^{-2}). 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} in 2013 (includes starter) and 4.0 lbs N 1000ft^{-2} in 2014 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

Warm-Season Study

All varieties of bermudagrass were extremely aggressive, but ‘Latitude 36’ had higher percent cover than the other cultivars (May-Nov.) (Fig. 5). Thebermudagrasses went into dormancy much quicker than cool-season grasses. The ‘Yukon’ variety went into and came out of dormancy sooner than the other two varieties (Fig. 3). The main concerns with the bermudagrasses are their ability to survive the harsh winters of Connecticut and their ability to suit the needs of sports turf managers once dormancy occurs. All three varieties survived the winter and thrived during the warm summer months.

Figure 3. Bermudagrass goes dormant mid to late October. Crumb rubber delayed dormancy about one week. (October 28, 2013). Due to early dormancy, a bermudagrass monostand would likely not be considered acceptable aesthetically in Southern New England.

The use of crumb rubber delayed dormancy by approximately one week (Fig. 4) and showed an increase in percent cover for grasses throughout the growing season.

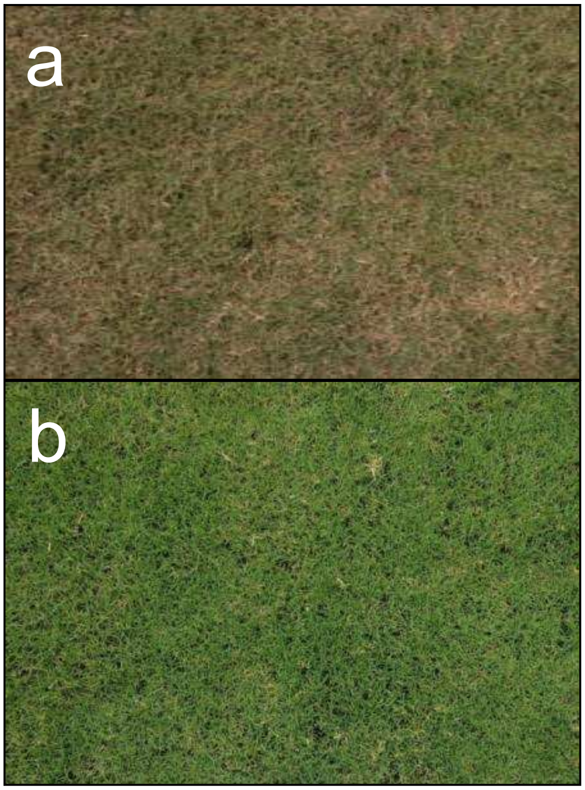

Figure 4. 'Latitude 36' Bermudagrass plots on October 15, 2014. a) no crumb rubber, and b) with crumb rubber. The plots with crumb rubber applications were able to retain color longer than those without rubber.

The use of rubber also increased density and slightly reduced the percentage of weeds found in plots during the summer months. However, crumb rubber should not be considered a method of weed control (Fig. 6).

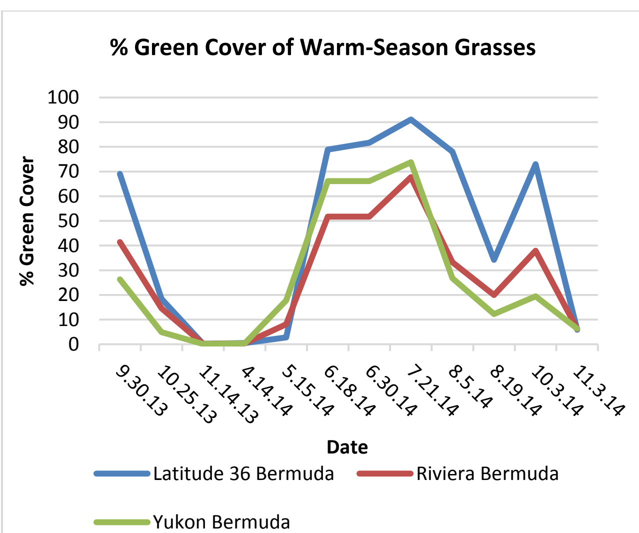

Figure 5. 'Latitude 36' had the highest percent cover throughout the growing season.

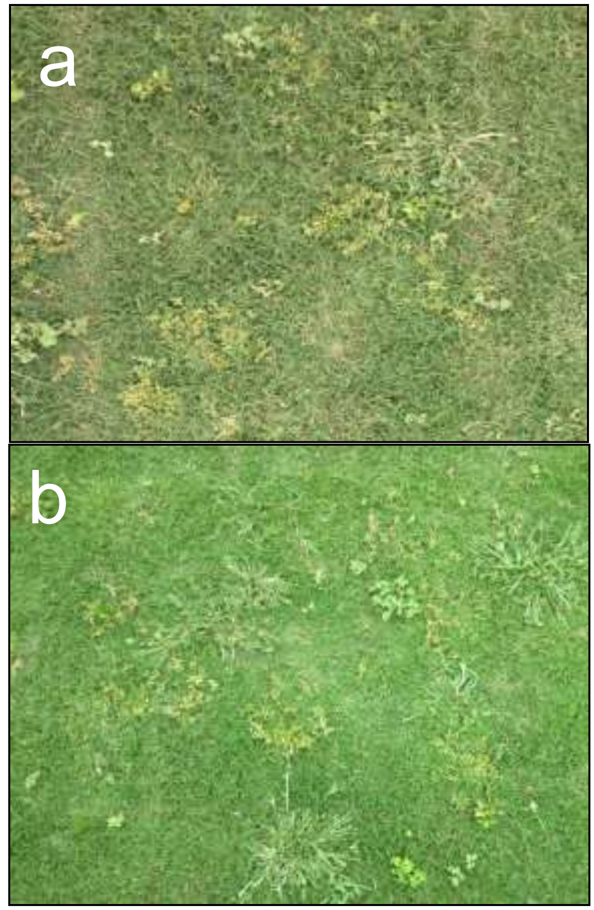

Figure 6. Weeds remain a concern even with warm season grasses. a) 'Riviera', pesticide-free, and b) 'Latitude 36', pesticide-free on August 26, 2014.

The use of pesticides decreased weeds and increased density during the summer months.

Cool-Season Study

Perennial ryegrass preformed much better visually than the other grasses with regards to initial establishment. The cool-season plots required two curative fungicide applications and two post emergent herbicide applications during the establishment phase in 2013. However, the warm-season plots required no additional pesticide applications.

Supina bluegrass showed increased cover (Fig. 7.) and quality as compared to other grasses throughout the growing seasons. Plots with crumb rubber applications showed increased cover and quality as the number of traffic events increased.

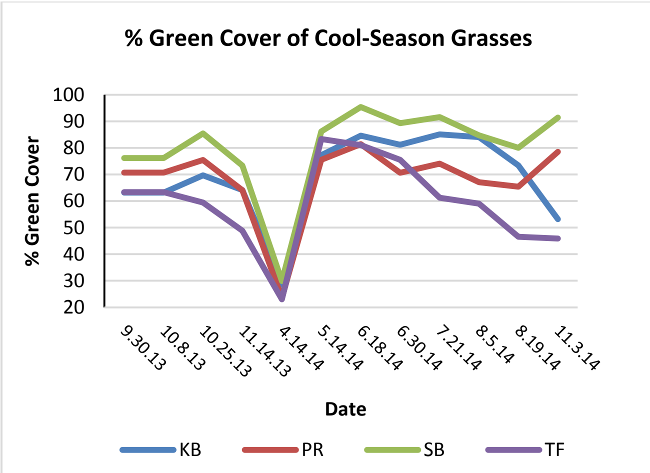

Figure 7. Supina bluegrass showed significantly higher percent cover throughout the growing season as compared to the other three cool season grasses.

The use of pesticides decreased weed pressure throughout the season and crumb rubber reduced weeds during the hottest summer months (Fig. 8).

Figure 8. Supina bluegrass plots showed increased weed pressure and decreased color without applications of pesticides or crumb rubber.

These results are preliminary and are not conclusive. Based on results to date, a monostand of bermudagrass does not appear to be a viable option for sports fields in Southern New England. However the results show that it can survive our winters and it has potential to offer considerable advantages in a mixed stand with cool-season species. More research needs to be done to provide additional information on best management practices for pesticide-free athletic fields in New England.

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ORGANIC TURF AND NO-PESTICIDE TURF DEMONSTRATION FOR HOME LAWNS AND ATHLETIC FIELDS 2014

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INTRODUCTION

As of July 1, 2010, the state of Connecticut banned the use of all lawn care pesticides 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. This demonstration site was established to evaluate various systems of management.

Each system that is evaluated represents a specific type of management regime. The Integrated Pest Management (IPM) system utilizes thresholds for management of pests. The calendar based system follows a step by step program based on application timing. The Integrated System Management (ISM) is based on best management practices and places applications based on the principle of prevention and least potentially harmful applications. The pesticide-free applications are based on current Connecticut law and were managed without pesticides but utilize synthetic fertilizers. The Organic system utilized only organic treatments.

The high and low treatments for the organic and pesticide-free treatments look at the two extremes of applications because many turf managers and homeowners are limited by budget or time. The best management practices are not always a realistic plan of action. The high and low systems demonstrate the difference between the intensity of management and provide feasible recommendations.

This study was designed with the following objectives; 1) reduce nitrogen and phosphorus applications, 2) identify advantages and disadvantages of each management system, and 3) create a hands on demonstration site and education resource for training industry professionals how to manage turfgrass without pesticides.

METHODS AND MATERIALS

The field is divided into two separate studies – athletic field and home lawn. The athletic field section (190ft x 100ft) was seeded with a mix of 70% Kentucky bluegrass and 30% perennial ryegrass (% seed by weight). The home lawn section (190ft x 100ft) was seeded with a mix of 60% Kentucky bluegrass, 20% perennial ryegrass and 20% fine fescue (10% chewings and 10% creeping red) (% seed by weight). The studies consist of individual plots measuring 20ft x 30ft with eight treatments replicated three times. The treatments or "systems" evaluated are : 1) Organic High, 2) Organic Low, 3) Pesticide-free High, 4) Pesticide-free Low, 5) Calendar Based, 6) IPM, 7) ISM, 8) None (untreated control).

Initial soil samples were taken from each plot to determine pesticide levels and to compare pesticide residues from each management system (Fig 1).

Figure 1. Soil samples were taken to determine if there is a buildup of pesticide residues from different management systems over time.

Each management system received applications of fertilizer, insect and weed control appropriate for each treatment. (Tables 1-4) These applications will be repeated as needed during 2015 growing season along with an aggressive overseeding plan.

The athletic field was mowed at 2.5 inches twice per week and the home lawn was mowed once per week at 3.5 inches. Mowing began in late April and continued through November. Fields were irrigated as needed.

A specially designed traffic machine traffic was used on the athletic field portion of the study area to provide simulated athletic field wear to the field. This imposed wear simulates the intense traffic most athletic fields must endure on a perennial basis. Traffic was initiated in late fall 2014.

During this growing season custom Japanese beetle tents were constructed in an effort to increase white grub pressure in the athletic field experimental section. These tents were placed on the athletic field plots. Adult Japanese beetles were added daily after being collected from lure traps (Great Lakes IPM, Inc). The adults were then encouraged to mate and lay their eggs within the plots. The boxes were rotated every three days until all locations of the plot had been covered. The results of these treatments will not become fully apparent until the spring growing season. As the growing season progresses differences in treatments will become increasingly noticeable.

Figure 2. a) Japanese beetle tents on the athletic field section of the study. b) Adult Japanese beetles were collected daily and distributed to the tents.

RESULTS AND DISCUSSION TO DATE

The management systems that received the lowest levels of fertilization had lower color ratings throughout the season.
Plots that received chemical weed treatments had lower weed pressure throughout the season. Clover was the most prevelant weed present in the both the athletic field and home lawn studies.

These demonstration areas witll be uitilized throughout, the 2015 growing season for educational programing.

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Table 1. Chemical and cultural applications to the athletic field demonstration area.					
Management System	Application Timing (Active Ingredient)				
	May	June	July	August	September
1) Organic High				*Heterorhabditis bacteriophora*§	Solid tine Cultivation¶
2) Organic Low					
3) Pesticide-free High				*Heterorhabditis bacteriophora*	Solid tine Cultivation
4) Pesticide-free Low					
5) Calendar Based	Dithiopyr†	Chlorantraniliprole‡			
6) Integrated Pest Management (IPM)					
7) Integrated Systems Management (ISM)	Dithiopyr	Chlorantraniliprole			
8) None (untreated control)					

†Greenview Fairway Formula with Crabgrass Preventer (3.4lb/1000ft^2)
‡Acelepryn G (50 lbs/acre)
§Nemasys G (1 billion/acre)
¶Cultivation was at a 1.5 inch spacing to a depth of 3in.

Table 2. Chemical and cultural applications to the home lawn demonstration area.				
Management System	Application Timing (Active Ingredient)			
	May	June	July	August
1) Organic High				*Heterorhabditis bacteriophora*¶
2) Organic Low				
3) Pesticide-free High				*Heterorhabditis bacteriophora*
4) Pesticide-free Low				
5) Calendar Based	Pendimethalin†	2,4-D‡ Mecoprop-p‡ Chlorantraniliprole§		
6) Integrated Pest Management (IPM)				
7) Integrated Systems Management (ISM)	Pendimethalin	Chlorantraniliprole		
8) None (untreated control)				

†Scotts Step 1 (2.7lb /M)
‡Scotts Step 2 (2.9lb/M)
§Acelepryn G (50lb/acre)
¶Nemasys G (1billion/acre)

Table 3. Fertilizer applications to the athletic field demonstration area.							
Management System	**Fertilizer Timing (lbs of product per application)**						**Total lbs N/1000ft^2**
	May	**June**	**July**	**August**	**September**	**October**	
1) Organic High	9-0-0 (22.2lb/M) [†]			6-0-3 (33.4lb/M) [¶]			4
2) Organic Low	9-0-0 (11.1lb/M)			6-0-3 (16.7lb/M)			2
3) Pesticide-free High	9-0-0 (22.2lb/M)			30-0-10 (3.3lb/M)		30-0-10 (3.3lb/M)	4
4) Pesticide-free Low	9-0-0 (11.1lb/M)					30-0-10 (3.3lb/M)	2
5) Calendar Based	27-0-5 (3.7lb/M) [‡]			30-0-10 (6.6 lb/M)	40-0-0 (2.5lb/M) [#]		4
6) Integrated Pest Management (IPM)	30-0-10 (5lb/M) [§]			30-0-10 (3.3lb/M)	40-0-0 (2.5lb/M)		4
7) Integrated Systems Management (ISM)	27-0-5 (3.7lb/M)			30-0-10 (6.6lb/M)		45-0-0 (2.2lb/M) [††]	4
8) None (untreated control)							0

[†]Agway (Corn Gluten)
[‡]Greenview Fairway Formula (Ammoniacal, Water Insoluble , Urea and Water Soluble Nitrogen)
[§]Harrell's Polyon (Ammoniacal and Urea Nitrogen)
[¶] Harrington's Organic OS-Summer (Soy and Alfalfa)
[#]Lebanon Turf MethEx40 (Methylene Ureas and Urea)
[††] Urea (Urea)

Table 4. Fertilizer applications to the home lawn demonstration area.							
Management System	**Fertilizer Timing (lbs of product per application)**						**Total lbs N/1000ft^2**
	May	**June**	**July**	**August**	**September**	**October**	
1) Organic High	9-0-0 (22.2lb/M) [†]			6-0-3 (16.7lb/M) [¶]			3
2) Organic Low	9-0-0 (11.1lb/M)						1
3) Pesticide-free High	9-0-0 (22.2lb/M)					30-0-10 (3.3lb/M)	3
4) Pesticide-free Low	9-0-0 (11.1lb/M)						1
5) Calendar Based	28-0-7 (2.7lb/M) [‡]	28-0-3 (2.9lb/M) [‡]		32-0-4 (2.5lb/M) [‡]		32-0-12 (2.0lb/M) [‡]	3
6) Integrated Pest Management (IPM)	30-0-10 (3.3lb/M) [§]			30-0-10 (3.3lb/M)		30-0-10 (3.3lb/M)	3
7) Integrated Systems Management (ISM)	28-0-7 (2.7lb/M)				40-0-0 (2.5lb/M) [#]		3
8) None (untreated control)							0

[†]Agway (Corn Gluten)
[‡]Scotts 4 Step Program (Ammoniacal, Water Insoluble , Urea and Water Soluble Nitrogen)
[§]Harrell's Polyon (Ammoniacal and Urea Nitrogen)
[¶]Harrington's Organic Solutions OS-Summer (Soy and Alfalfa)
[#]Lebanon Turf MethEx40 (Methylene Ureas and Urea)

SOLVITA® SOIL TEST KITS TO CATEGORIZE TURFGRASS SITE RESPONSIVENESS TO NITROGEN FERTILIZATION – 2014 RESULTS

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INTRODUCTION

The ability to predict the nitrogen mineralization potential of any turfgrass site would be a valuable tool in nutrient management. Guiding nitrogen fertilization based on an objective soil test should help to avoid too little or too much nitrogen applied to turf that often occurs when using subjective criteria to determine how much nitrogen a turf needs. Insufficient or excessive nitrogen applications can lead to poor aesthetic and functional turf performance, increases in certain diseases and insects, and water quality problems when excess N is applied. The Solvita® company offers two field test kits that have been developed to measure the biologically-active C and N fractions in soil organic matter: the Soil CO_2-Burst and Soil Labile Amino Nitrogen (SLAN) Test Kits, respectively (http://solvita.com/soil). These kits are designed for on-site use, without the need to send soil samples to a laboratory. There is some preliminary evaluation of these kits for field crops that looks promising as guides to N fertilization, but currently there has been no evaluation of these kits on turfgrass soils. The Soil CO_2-Burst Test kit measures the amount of CO_2 that is presumably released from microbial respiration and degradation of the labile-C fraction of the soil organic matter. Soil microbial respiration is positively correlated to soil fertility and crop yield response. It should also function as the same indicator in turf soils with respect to turf growth and quality. The SLAN Test kit presumably measures the labile amino-N fraction of the soil organic matter which should indicate the mineralization potential of the soil. The objective of this research is to determine if these new commercially-available field test kits can categorize turf soils as to their responsiveness to N fertilization.

MATERIALS & METHODS

In September of 2007, an organic composted fertilizer (Suståne 5-2-4, all natural fine grade) was incorporated into the 15-cm depth of 1 × 1 m plots at two adjacent sites at 23 different rates ranging from 0 to 392 kg available N/ha/year. After compost incorporation, one site was seeded to tall fescue (*Festuca arundinacea* cvs. Shortstop II, Dynasty, Crossfire II), and the other was seeded to Kentucky bluegrass (*Poa pratensis* cv. America). The experiments were set out as randomized complete block designs with three replicates. In November of 2008, 2009, 2010, 2012, and 2013, plots were solid-tined aerified and compost was applied again to the same plots using the same rates, and brushed into the aerification holes. Additional treatments in each year include urea in split applications (May, June, Sept., Oct.) at 49, 98, 147, and 196 kg N/ha/year. The synthetic urea treatments were included so that response of the compost treatments could be matched to that of the synthetic N rate. Urea plots also received 98 kg of K_2O and P_2O_5 at the first urea application in the form of potassium sulfate and triple super phosphate. In early May of 2014 before urea application, soil samples were collected from each plot to a depth of 10-cm below the thatch layer, air-dried, then sieved to pass a 20-mesh screen. These samples were analyzed with the Solvita® Soil CO_2-Burst and Soil Labile Amino Nitrogen (SLAN) Test Kits. At approximately every two weeks during the growing season, turf color quality was measured using Spectrum CM1000 Chlorophyll and TCM500 NDVI Turf Color meters. Typically, greener turf is related to higher reading values with these meters. Turf growth (yield of clippings) was collected monthly.

Linear regression models were applied to determine the response of Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N as a function of organic fertilizer rates. Linear and quadratic regression models were used to determine the relationship of mean NDVI readings, mean CM1000 readings and the sum of the clippings yields as a function of Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N. The REG procedure of SAS 9.3 (SAS Institute, Cary, NC) was used for the linear and quadratic regression analyses. Logistic curves of binary responses for the probabilities of organic fertilizer plot NDVI, CM1000, and clippings yield values being less than the mean responses obtain from the 150 and 200 kg N ha^{-1} urea treatments (which would typically be the maximum recommended rates of N for lawns in our climate) in relation to Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations were determined with linear binary logistic models ($a + bx = \{\ln[\pi/(1-\pi)]\}$, where π is the probability of the organic fertilizer response being equal to or exceeding the mean response from the 150 and 200 kg N ha^{-1} urea treatments) using the LOGISTIC procedure of SAS 9.3.

RESULTS

Soil CO_2-C and NH_3-N Concentrations as a Function of Organic Fertilizer Rate

Increasing organic fertilizer rates were generally correlated with increasing Solvita® CO_2-Burst CO_2-C concentrations in a significant ($p<0.05$) but weak linear response (Fig. 1, panels A and B), and with SLAN NH_3-N concentrations in a significant ($p<0.05$) and moderately strong linear response (Fig. 2, panels A and B). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

Turfgrass Color as a Function of Soil CO_2-C and NH_3-N Concentrations

Turfgrass color, as measured by NDVI and CM1000 meters, was significantly ($p<0.05$) and linearly associated with Solvita® CO_2-Burst CO_2-C concentrations (Fig. 1, panels C, D, E, and F), and quadratically ($p<0.001$) with SLAN NH_3-N concentrations (Fig. 2, panels C, D, E, and F). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

Turfgrass Clipping Yield as a Function of Soil CO_2-C and NH_3-N Concentrations

Turfgrass clippings yield was significantly ($p<0.05$) and linearly associated with Solvita® CO_2-Burst CO_2-C concentrations for Kentucky bluegrass (Fig. 1, panel G; although the association was weak), but not for tall fescue ($p>0.05$) (Fig. 1, panel H). Turfgrass clippings yield was significantly ($p<0.001$) and quadratically associated with Solvita® SLAN NH_3-N concentrations (Fig. 2, panels G and H). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

Predicting Turfgrass Response as a Function of Soil CO_2-C and NH_3-N Concentrations

Inclusion of the urea treatments provide a convenient way to determine an equivalent response obtained from the organic fertilizer treatments, and to predict turfgrass response based on these equivalent responses. Using binary logistic regression, we were able to calculate the probability of equaling or exceeding the mean response of that obtained from the urea 150 and 200 kg N ha^{-1} yr^{-1} rates. These urea rates are typically the maximum recommended seasonal N loading amounts for cool-season turfgrass lawns in our climate; N rates above 200 kg N ha^{-1} yr^{-1} generally would not be recommended for established lawns.

Estimates of the binary logistic regression coefficient parameters and their associated *p*-values are given in Table 1. As a guide for the reader, the Wald *p*-values are used to determine the significance of the slope for the logistic regression (considered significant when $p<0.05$). The Hosmer-Lemeshow *p*-value indicates the significance of the goodness-of-fit test. The model is considered a good fit for the data when the Hosmer-Lemeshow *p*-value >0.05.

For the Soil CO_2-Burst CO_2-C concentrations, significant ($p<0.05$) logistic regression were found only for Kentucky bluegrass NDVI and CM1000, for tall fescue clippings yield, or for NDVI when species were combined (Table 1). Of the significant models, the fits were weak and predictive power was relatively poor, most likely due to the large amount of variation present in the Soil CO_2-Burst CO_2-C concentration data (see Fig. 1). At best, the predictive model could only estimate that there was ≤ 90% chance that turfgrass response of the organic fertilizer plots would equal or exceed the mean response from the urea 150, and 200 kg N ha^{-1} yr^{-1} rates at the very highest concentrations of CO_2-C (Fig. 3 panels A, B, and C). The predictive power or logistic model fits were not improved by combining the species (Fig. 3 panel C).

For the SLAN NH_3-N concentrations, significant ($p<0.05$) logistic regression were found for all NDVI, CM1000, and clippings yield models for Kentucky bluegrass, tall fescue, and when species were combined (Table 1). Predictive power for SLAN NH_3-N concentrations was much better than the Soil CO_2-Burst CO_2-C concentrations. Best model fits and predictive power were observed with Kentucky bluegrass NDIV and CM1000 (Table 1). The predictive models suggested that once SLAN NH_3-N concentrations ranged between 150 and 200 mg kg^{-1}, there was a 70% to near 100% probability of equaling or exceeding the mean response from the urea 150, and 200 kg N ha^{-1} yr^{-1} rates (Fig. 4 panels D, E, and F). The predictive power or logistic model fits were not improved by combining the species (Fig. 4 panel F).

Table 1. Logistic regression coefficients for binary response of NDVI, CM1000, and clippings yield values being equal to or exceeding the mean response for the urea 150 and 200 kg ha^{-1} treatments for Kentucky bluegrass and tall fescue lawns in relation to Solvita® Soil CO_2-Burst CO_2-C and SLAN NH_3-N concentrations for the 2014 growing season.

	CO_2-Burst Test CO_2-C Concentrations									
	Kentucky bluegrass					Tall fescue				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-2.7310	0.0355	0.0239	0.1095	0.0324	-0.6231	0.0072	0.5213	0.0080	0.3691
CM1000	-2.7091	0.0376	0.0188	0.1204	0.1428	-0.0189	0.0038	0.7363	0.0022	0.9478
Yield	-0.2444	0.0184	0.2558	0.0286	0.2875	-0.9513	0.0257	0.0492	0.0831	0.7929

	SLAN NH_3-N Concentrations									
	Kentucky bluegrass					Tall fescue				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-16.895	0.1185	0.0002	0.4731	0.5863	-8.9001	0.0649	0.0026	0.2284	0.7748
CM1000	-14.771	0.1056	0.0002	0.4255	0.3210	-8.3714	0.0640	0.0032	0.2154	0.6822
Yield	-9.639	0.0772	0.0024	0.2719	0.5334	-7.9959	0.0669	0.0054	0.2010	0.1520

	CO_2-Burst Test CO_2-C Concentrations					SLAN NH_3-N Concentrations				
	Kentucky bluegrass + Tall fescue combined					Kentucky bluegrass + Tall fescue combined				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-1.1899	0.0191	0.0287	0.0477	0.0105	-8.0855	0.0601	<.0001	0.2346	0.8075
CM1000	-0.5129	0.0094	0.2660	0.0121	0.1410	-4.9959	0.1056	0.0371	0.1253	0.3661
Yield	-0.0786	0.0170	0.0872	0.0322	0.4214	-7.2796	0.0622	0.0002	0.1992	0.8983

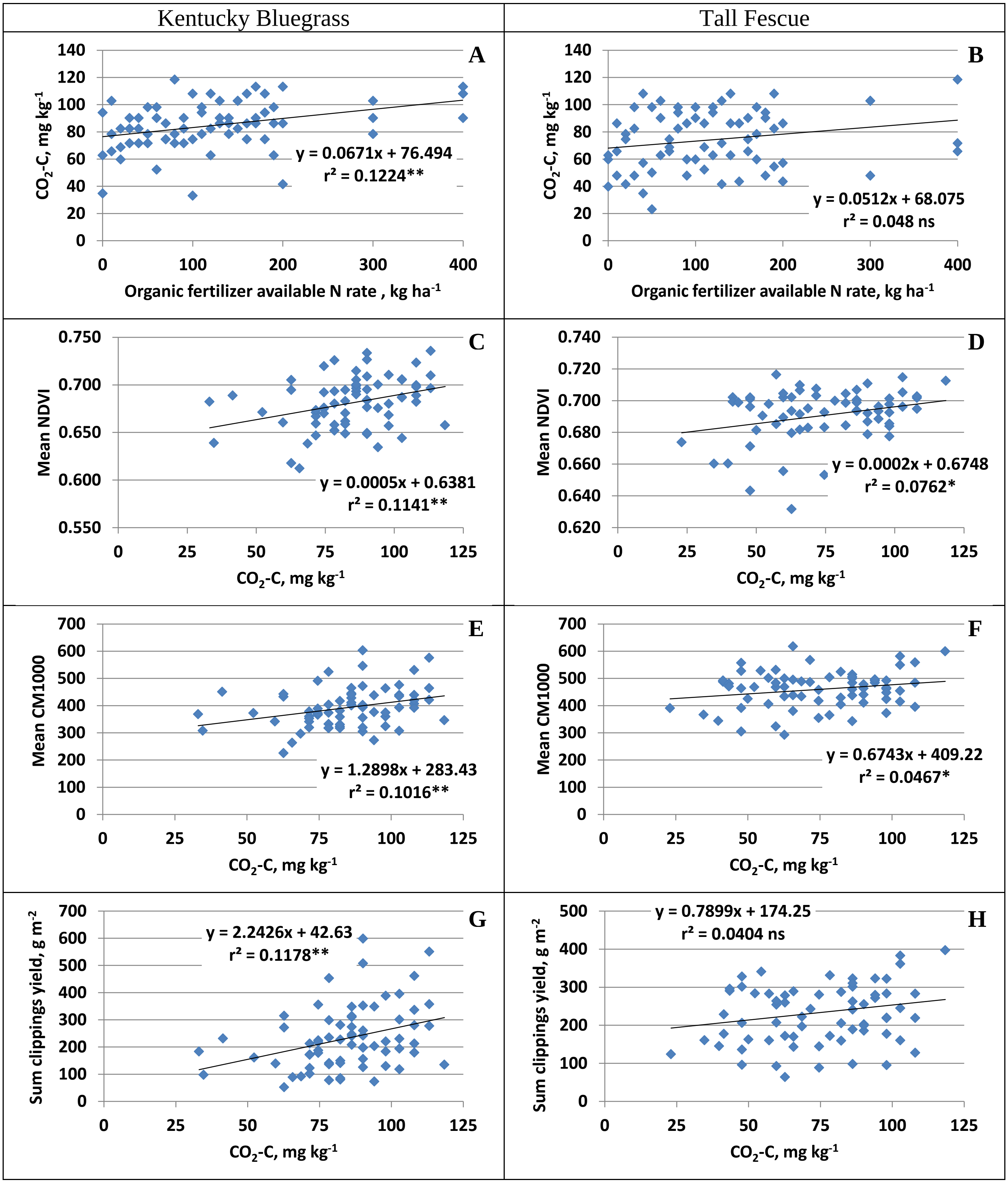

Fig. 1. Effects of organic fertilizer rate (panels A and B) on the production of CO_2-C as measured with the Solvita® CO_2-Burst Test Kit, and relationship between Solvita® CO_2-Burst Test CO_2-C and: NDVI readings from organic fertilizer plots (panels C and D); CM1000 readings from organic fertilizer plots (panels E and F); and clippings yield from organic fertilizer plots (panels G and H). The first column of panels correspond to Kentucky bluegrass (*Poa pratensis*), and the second column of panels correspond to tall fescue (*Festuca arundinacea*). Significance of coefficient of determination (r^2) for the linear response: * (p<0.05), ** (p<0.01), and ns not significant (p>0.05).

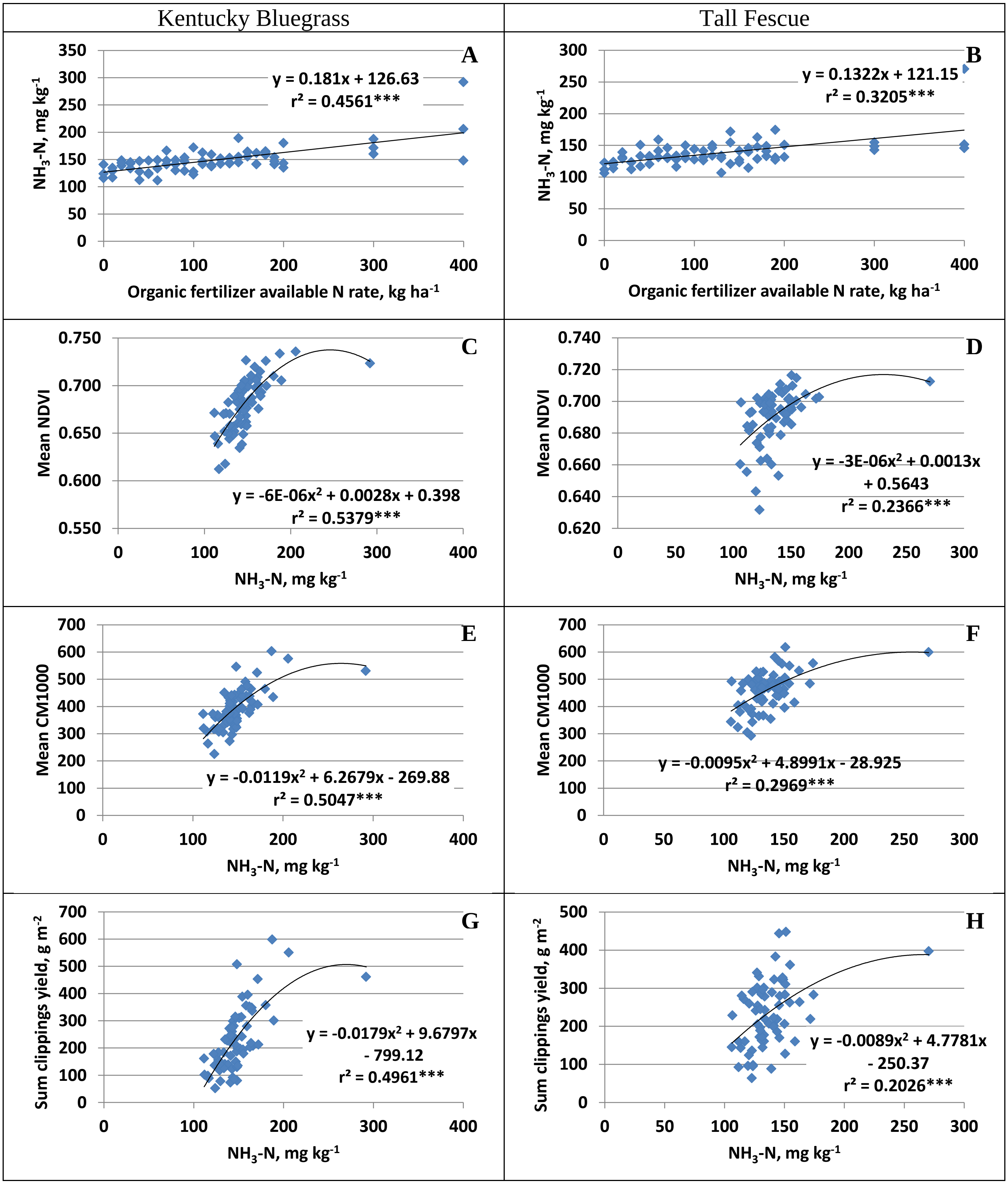

Fig. 2. Effects of organic fertilizer rate (panels A and B) on the production of NH_3-N as measured with the Solvita® Soil Labile Amino Nitrogen (SLAN) Test Kit, and relationship between Solvita® SLAN Test NH_3-N and: NDVI readings from organic fertilizer plots (panels C and D); CM1000 readings from organic fertilizer plots (panels E and F); and clippings yield from organic fertilizer plots (panels G and H). The first column of panels correspond to Kentucky bluegrass (*Poa pratensis*), and the second column of panels correspond to tall fescue (*Festuca arundinacea*). Significance of coefficient of determination (r^2) for the linear and quadratic response: *** (p<0.001).

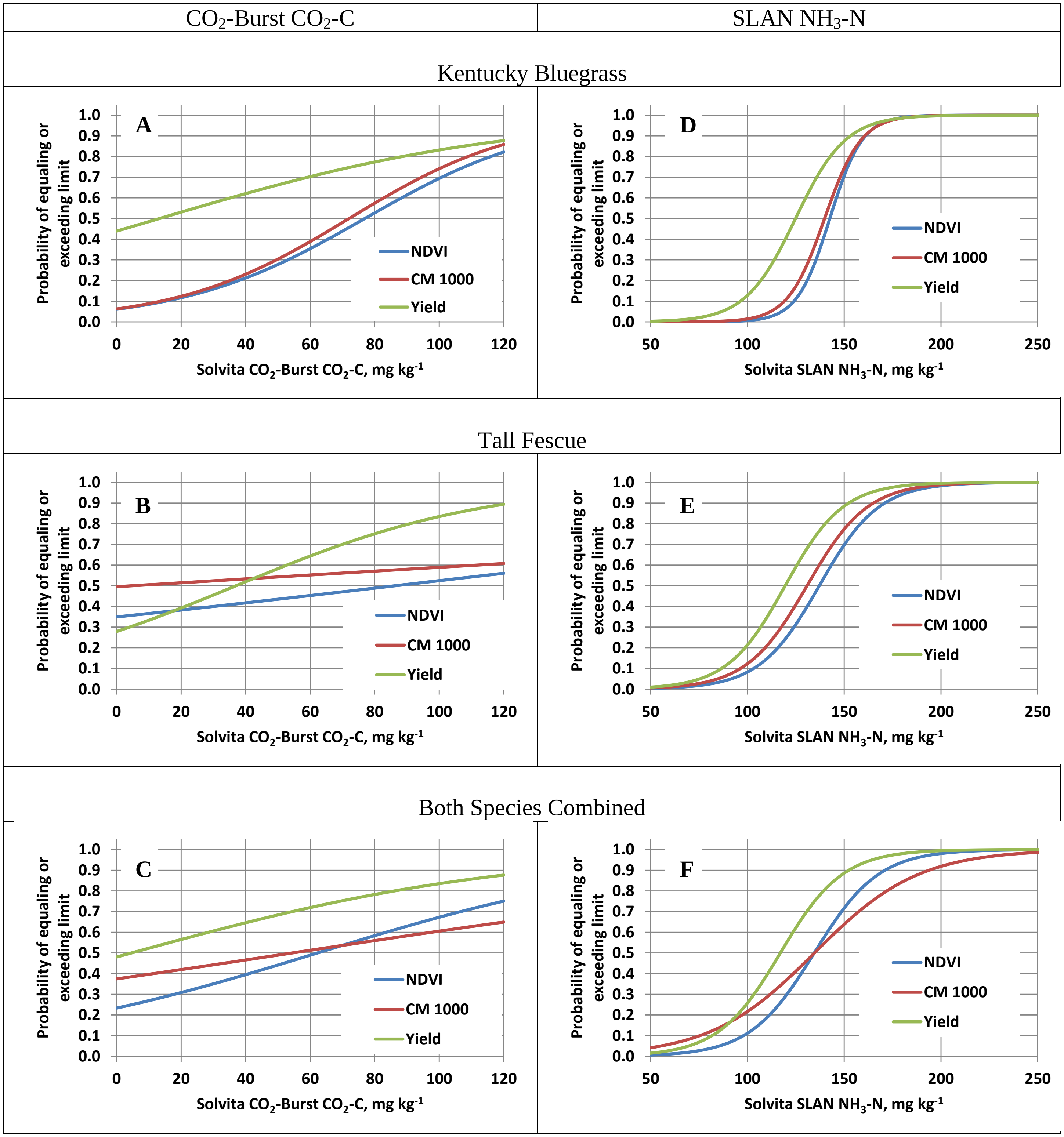

Fig. 3. Probability curves of equaling or exceeding the NDVI, CM1000, and clippings yield values of that obtained from the mean response of urea at the 150 and 200 kg N ha^{-1} rates in relation to Solvita® Soil CO_2-Burst CO_2-C concentrations (panels A, B, and C) and SLAN NH_3-N concentrations (panels D, E, and F) for the 2014 growing season. Mean urea response at the 150 and 200 kg N ha^{-1} rates for NDVI (relative unit), CM1000 (relative unit), and sum of the monthly clippings yield (g m^{-2}) values were 0.678, 370, and 137 for Kentucky bluegrass, respectively; 0.696, 461, and 173 for tall fescue, respectively; and 0.687, 415, and 155 across both species combined, respectively.

Fig. 4. Kentucky bluegrass response in 2014 to varying rates of organic-composted fertilizer.

Fig. 5. Tall fescue response in 2014 to varying rates of organic-composted fertilizer.

SUMMARY AND CONCLUSIONS

The preliminary 1st-yr results of this study suggest that the Solvita® SLAN Test kit shows promise in estimating cool-season turfgrass lawn response as a function of soil NH_3-N concentrations in soil samples collected in the spring prior to fertilization. The SLAN results were considered to be more reliable than the Solvita® Soil CO_2-Burst test kit results with these preliminary data. Much more variability was observed for the CO_2-C concentration data than for NH_3-N concentration data.

The SLAN data suggest that once Solvita® soil NH_3-N concentrations approach 200 mg kg^{-1} in a soil sample collected in the spring prior to N fertilization, there is a high probability that turfgrass response would be equivalent to or exceed the response that would be obtained from a split application of urea at 150 to 200 kg N ha^{-1} yr^{-1}. With these preliminary SLAN results, a delineation of general categories of turfgrass response to N fertilization, based on probabilities of obtaining benchmark values of NDVI, CM1000, and or turfgrass clippings from that expected from urea at rates from at 150 to 200 kg N ha^{-1} yr^{-1} can be proposed: when SLAN NH_3-N concentrations are <140 mg kg^{-1} in soil samples collected in the spring prior to N fertilization, there is a high probability (50% or greater chance) that the turf would respond to N fertilization.

When SLAN NH_3-N concentrations are between 150 and 200 mg kg^{-1}, there is about a 30% chance or less that turf would respond to N fertilization. In these cases, only moderate or low amounts of supplemental N would be required for optimum response. When SLAN NH_3-N concentrations exceed 200 mg kg^{-1}, there is a near 0% chance that turf would respond to N fertilization. In these cases, supplemental N should be withheld and applied only in special cases where turf response is less than optimum after growth is monitored before applying N. Application of supplemental N in areas when SLAN exceed 200 mg kg^{-1} increases the likelihood of N losses from the system and more problems with insect and disease pests.

The SLAN responses are very similar to the trends obtained in previous research on these same plots when predicting turfgrass response to the Illinois Soil N Test (ISNT)-N concentrations obtained from a spring soil sample across 5 years (2008-2012) (Geng et al., 2014). Although the ISNT-N concentrations that delineated response categories was higher than SLAN NH_3-N concentrations, the results from the 2014 growing season suggest that ISNT-N and Solvita® SLAN NH_3-N concentrations should be highly correlated, and of equivalent power in predicting whether or not Kentucky bluegrass or tall fescue lawns would respond to additional supplemental N fertilizer. However, this is speculative on our part at this time, and we would need to validate this by analyzing the archived 2008-2012 soil samples for SLAN NH_3-N concentrations, then correlating to existing ISNT-N values.

Since these conclusions are based on only one year of data, caution needs to be exercised in using the 2014 results and with their interpretation. As more data are collected, different conclusions and delineation ranges may come forth. However, we are encouraged with the preliminary results, and think that the tests (especially the SLAN) could provide an objective guide for N fertilization of cool-season turfgrass lawns.

ACKNOWLEDGEMENTS

Funding for this research is provided by The New England Regional Turfgrass Foundation and the Storrs Agricultural Experiment Station. Suståne all natural 5-2-4 for the study was donated by Rich Hawkes of Suståne Natural Fertilizer, Inc. This project is being conducted in collaboration with Will Brinton and Woods End® Laboratories.

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KENTUCKY BLUGRASS AND TALL FESCUE LAWN RESPONSE TO SEAWEED EXTRACTS – 2014 RESULTS

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INTRODUCTION

Seaweed (*Ascophyllum* and related species) extracts applied to horticulturally-important plants have been reported to act as biostimumlants for root and shoot growth, increase stress abiotic tolerance, and to act as inducers of plant defenses against pathogens and insect pests (reviewed in Sangha et al., 2014). Several previous research reports have suggested that seaweed extracts applied to turfgrass prior to stress periods reduces stress severity and incidence, and may shorten the recovery period compared to turfgrass that did not receive seaweed extracts (Zhang et al., 2003a,b,c; Zhang and Ervin, 2004, 2008;. Koske and Gemma, 2005; Butler and Hunter, 2007; Xu and Huang, 2010; Zhang et al., 2010).

There is little published information available on turfgrass lawn response to seaweed extracts in southern New England. This research was conducted to determine effects of several commercially-available seaweed extract products, and one experimental product, on the quality of Kentucky bluegrass (*Poa pratensis*) and turf-type tall fescue (*Festuca arundinacea*) lawns.

MATERIALS & METHODS

Separate, but adjacent, field plot experiments were conducted on established stands of Kentucky bluegrass and turf-type tall fescue in 2013 on a fine sandy-loam soil. The experiments were set out as randomized complete block designs with three replicates. Treatments consisted of the following seaweed extract products, rates (of the concentrate), and frequency of applications: Sea Green Organics liquefied seaweed at 1, 2, 3, 4, 5, and 6 fl. oz. per 1000ft^2 every week, and 1, 2, 3, 4, 5, and 6 fl. oz. per 1000ft^2 every two weeks; Ocean Organics Guarantee Organic 0-0-1 and experimental EXP DRX at 3 fl. oz. per 1000ft^2 every week, and 6 fl. oz. per 1000ft^2 every two weeks; Neptune's Harvest Plant Food 0-0-1 at 3 fl. oz. per 1000ft^2 every week, and 6 fl. oz. per 1000ft^2 every two weeks; Sarkli/Repêchage Ltd. AgriForce Standard and AgriForce 50 at 3 fl. oz. per 1000ft^2 every week, and 6 fl. oz. per 1000ft^2 every two weeks; and a tap water control every week and every two weeks with the other treatment applications. The extract concentrate was applied in tap water by using a CO_2-backpack sprayer calibrated to deliver a total volume of 2 gals per 1000ft^2. In 2013, treatment application was delayed, and extracts were not applied until beginning on July 17, 2013. Thereafter, treatments were applied every week or every two-weeks depending on treatment regime through Nov. 21, 2013. The turf was managed as medium to high quality lawn; mowed at a 3-inch cutting height as needed throughout the growing season. Across the growing season in 2013, 1 lb N per 1000ft^2 was applied in May and another 1 lb N per 1000ft^2 was applied in October, using urea (45-0-0) as the N source.

The same plots were used in 2014 and received the same treatments as in 2013.Treatments were applied weekly or biweekly beginning on May 14, 2014 and ending on October 26, 2014, by using a CO_2-backpack sprayer calibrated to deliver a total volume of 2 gals per 1000ft^2. The turf was managed as medium to high quality lawn; mowed at a 3-inch cutting height as needed throughout the growing season. All treatments received a seasonal total of 3 lbs N/1000ft^2, in three split application: 1 lb of N/1000ft^2 using Harrell's 22-2-22 on May 7 and June 10, and 0.5 lbs of N/1000ft^2 using Harrell's 22-2-22 and 0.5 lbs of N/1000ft^2 using urea (45-0-0) on October 1, 2014. Crabgrass preemergent herbicide (prodiamine at 0.42 oz./1000ft^2) was applied April 22, 2014. Broadleaf herbicide (Speedzone at 1.8 fl. oz./1000ft^2) was applied September 29, 2014. No insect control materials were applied in 2014. Acelepryn was applied in 2013, and it was expected that residual control would be sufficient in 2014 from that 2013 application. No supplemental irrigation was supplied in 2014.

Turfgrass color, as indicated by Normalized Difference Vegetative Index (NDVI) was measured with a Spectrum FieldScout CM 1000 NDVI Chlorophyll Meter (Spectrum Technologies, Inc., Aurora, IL) on 19 dates at approximately weekly or biweekly intervals, beginning on May 13, 2014 and ending on Oct. 27, 2014. In general, higher NDVI readings with this meter indicate the more greener the turf. NDVI was chosen to detect effects of seaweed extracts on turf quality, since turf color is sensitive to changes in environmental conditions, especially stress. The nitrogen fertility regime and pest control products were applied to minimize any nutrient deficiencies or plant damage as a limiting factor for turfgrass color. We assumed any changes in turfgrass color would, therefore, be related to abiotic stress conditions.

Mean NDVI readings across all sampling dates were calculated for each individual plot, and the data were analyzed for mean treatment differences by using analysis of variance. The GLM procedure of SAS 9.3 (SAS Institute, Cary, NC) was used for the statistical analyses.

RESULTS

Weather Conditions

In general, few stress periods were present in the 2014 growing season. No visual observations of turf stress were noted. Mean maximum monthly temperatures did not exceed 80ºF for any month (Table 1). Across the 6 months of the study (May through Oct.) there were only 30 days where maximum temperatures were ≥80ºF, and no days exceeded 89 ºF; the highest temperature recorded being 86ºF on Sept. 3, 2014. June and Sept. precipitation totals were below normal by 2.2 and 2.6 inches, respectively. But, timely rains alleviated any potential water-stress problems.

Table 1. Mean monthly maximum and minimum temperatures, and precipitation totals during the study period in 2014.

	Temperature			Precipitation	
Month	Mean max.ºF	Mean min.ºF	Number of. days ≥80ºF	Sum, inches	Normal, inches
May	65.5	47.6	2	5.22	3.98
June	73.5	56.4	5	2.27	4.45
July	77.8	62.4	10	4.38	3.94
August	75.2	58.3	8	3.25	3.82
September	71.1	52.7	5	1.53	4.09
October	59.3	44.8	0	5.90	4.61

NDVI

Overall, analysis of variance indicated no significant differences in treatment NDVI differences within each of the species across the growing season. Out of 19 sampling dates, only one date in each species showed significant treatment differences in NDVI, but no consistent treatment effects were seen across the two species at those two dates.

Averaged across the 19 sampling dates (May through October), there were no NDVI differences between species, among the seaweed extract treatments, and no significant interaction between species and treatments. Mean NDVI response for the two species are shown in Fig. 1.

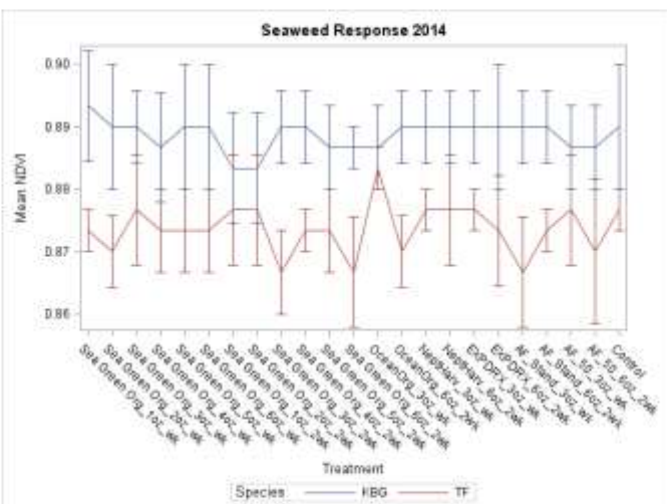

Fig. 1. Mean NDVI across the 19 sampling dates in the 2014 growing season (May through October) for each species (KBG=Kentucky bluegrass; TF=tall fescue) and seaweed extract treatments. Vertical bars for each mean represent the standard errors.

Mean NDVI differences across sampling dates were observed, but this was expected since turfgrass color changes with season (Fig. 2).

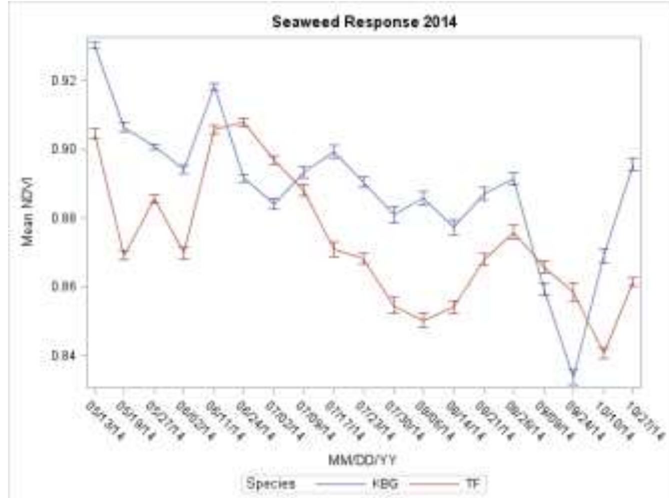

Fig. 2. Mean NDVI across the seaweed extract treatments in the 2014 growing season (May through October) for each species (KBG=Kentucky bluegrass; TF=tall fescue) and sampling date. Vertical bars for each mean represent the standard errors.

SUMMARY

No significant differences in turf color, as measured by NDVI, were observed for either species or between seaweed extract treatments in 2014. All products performed equally well, and no better than a tap-water control treatment. Considering that there were few days where environmental stress conditions were imposed during the 2014 growing season, the lack of differences between treatments is not surprising.

ACKNOWLEDGEMENTS

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Fig. 3. Applying the seaweed extract to the plots (Katery Hyatt on the left, and Patrick McIntosh on the right).

Fig. 4. Kentucky bluegrass seaweed extract study plots during the 2014 UConn Turf Field Day. (Photo credits: Kim Bova, Kim Bova Photography, www.kimbova.com)

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NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2012 NATIONAL TALL FESCUE TEST – 2014 RESULTS

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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.

Management Practices

Since establishment, all plots and cultivars received the same management protocol throughout the study. Management practices for 2014 were as follows:

<u>Mowing</u> - Plots were maintained at a mowing height of 2.75 inches and mowed three times per week. Clippings were returned.
<u>Irrigation</u> – irrigation was applied only to prevent severe drought stress. In 2014 irrigation was applied on three different occasions.
<u>Fertilizer and pesticide applications</u>
4/22/14 - Pre-emergent 0.42oz/1,000 ft^2 Prodiamine. 65 WDG,
5/7/14 - 1# N /1,000 ft^2, 50% SCU 22-2-22.
5/23/14 – Lime application – 50#/1,000 ft^2
9/29/14 - Speed Zone broadleaf herbicide, 1.8 fl. Oz/1,000 ft^2
10/21/14 - 1#N/1,000 ft^2, 60% SCU 25-0-12.
11/5/14 - Lime application – 50#/1,000 ft^2

Spring Green-up Ratings

Spring green-up ratings were taken and recorded (Table 2) on April 25 2014. Green-up measures the transition from winter dormancy to active spring growth. Ratings were based on a scale of 1-9, with 1 equaling brown turf and 9 equaling dark green turf.

Red Thread Ratings

Red Thread occurrence was evaluated on two occasions, June 6, and July 10, 2014. Disease ratings were based on percent of infection were based on percent of infection within each plot (Table 2).

Quality Ratings

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2014 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

Visual leaf texture ratings were taken in the late spring (May 21, 2014) while the grass was actively growing and not under stress conditions. 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 taken in the late spring (May 21, 2014) while the grass was actively growing and not under stress conditions. Ratings were based on visual color with 1 being light green and 9 being dark green. Areas of plots that contained browning tissue (chlorosis or necrotic) from outside factors such as disease were not considered for genetic color (Table 2).

RESULTS & DISCUSSION

Results for spring green up, genetic color, leaf texture, red thread incidence and monthly quality ratings, are provided in Table 2.

A few general observations noted were: mean quality values showed a greater degree of diversity in overall quality ratings when compared with the first full year of the study (2013). In 2014, red thread disease was noted throughout the plots within the study and ratings were taken. There was a high degree of variation for red thread among plots, and no significance between entries noted (p>0.05). All plots exhibitied very good drought avoidance characteristics in 2014. Supplemental water was only needed on three separate occasions during the growing season.

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

Table 1 *(continued)* *- Sponsors and Entries*			
SPONSOR	**ENTRY**	**SPONSOR**	**ENTRY**
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
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- July 2014)

Table 2. Tall Fescue NTEP results 2014 for spring green-up, genetic color (ratings 1-9, where 9 equals darker green), leaf texture (rating 1-9, where 9 equals the finest texture leaf blade, % red thread[1] (rating 0 equals no disease), turfgrass quality (rating 1-9, where 9 equals the highest turf quality). Table is listed with highest mean quality cultivars listed first.

	Spring green up	Genetic color	Texture	Red thread %		Quality						
Entry	04/25/14	05/20/14	05/21/14	06/06/14	07/10/14	05/20/14	06/23/14	07/18/14	08/19/14	09/22/14	10/20/14	mean
PPG-TF-157	4.7	8.0	7.0	1.0	2.0	8.0	7.7	7.3	7.3	7.7	7.7	7.6
IS-TF 310 SEL	4.3	8.0	7.0	2.7	6.7	8.0	7.3	5.7	7.0	7.7	7.3	7.2
PPG-TF-115	4.7	6.7	5.7	3.3	3.0	7.0	7.7	7.3	7.0	7.0	6.7	7.1
W41	5.7	7.0	5.7	4.2	9.3	7.0	7.0	6.7	7.7	7.3	7.0	7.1
Burl TF-69	4.0	7.7	6.3	5.3	6.3	6.7	7.7	6.7	7.0	7.0	7.0	7.0
PPG-TF-142	5.0	8.7	7.3	0.8	1.3	6.3	7.7	7.0	6.7	7.3	7.0	7.0
U43	5.0	6.7	6.0	2.7	8.3	6.7	6.3	5.7	6.7	8.3	8.0	6.9
U45	4.7	7.3	5.7	3.3	5.7	6.3	7.0	6.7	7.3	7.3	7.0	6.9
IS-TF 311	6.0	7.0	6.3	3.7	10.3	6.7	7.3	6.0	6.7	7.3	7.3	6.9
LTP-TWUU	6.0	7.0	6.3	3.0	6.7	7.0	7.0	6.3	6.7	6.7	7.7	6.9
SRX-TPC	4.7	7.0	6.3	1.3	1.7	7.0	7.3	6.3	6.7	7.3	6.7	6.9
ZW44	4.7	7.0	6.0	2.3	5.3	7.0	7.0	6.3	6.7	7.7	6.7	6.9
K12-MCD	4.3	6.0	6.3	4.8	10.7	6.3	6.7	6.7	7.7	7.0	6.7	6.8
Pick-W43	5.7	7.0	6.0	3.3	7.7	7.0	7.0	5.7	6.0	7.7	7.7	6.8
PPG-TF-145	6.3	8.0	6.0	0.5	2.0	6.7	8.0	7.0	6.0	7.0	6.3	6.8
LSD	4.7	7.0	6.0	1.2	1.3	7.3	7.0	6.7	6.3	7.3	6.0	6.8
IS-TF 284 M2	4.7	8.3	6.0	1.3	2.7	7.0	7.7	6.3	6.7	6.7	6.0	6.7
LTP-FSD	5.3	6.7	6.0	1.3	3.0	6.7	6.7	6.3	7.0	6.7	7.0	6.7
PPG-TF-135	5.0	6.0	6.0	2.3	6.0	7.0	7.0	6.3	6.3	6.3	7.3	6.7
PPG-TF-137	5.0	7.0	6.3	1.8	3.3	6.7	7.0	6.0	5.7	7.7	7.3	6.7
PPG-TF-151	4.3	6.7	6.0	3.0	6.7	7.3	6.7	6.3	6.3	7.0	6.7	6.7
W45	6.0	6.7	7.0	2.0	3.3	7.0	6.7	6.0	6.3	7.0	7.3	6.7
Hemi	5.3	6.7	6.3	3.0	6.7	7.0	7.0	6.0	6.3	6.7	7.0	6.7
IS-TF 330	4.3	7.7	6.3	1.0	4.7	7.0	7.0	6.3	6.0	6.7	7.0	6.7
IS-TF 291	5.3	7.0	6.0	1.7	5.0	6.0	6.3	6.0	6.7	7.3	7.3	6.6
T31	5.7	7.0	6.0	2.0	11.7	7.0	7.3	5.7	6.0	7.0	6.7	6.6
TF-287	5.3	7.0	6.3	1.7	5.0	6.7	6.7	6.3	6.3	6.7	7.0	6.6
Bizem	4.7	7.0	6.0	1.0	7.0	6.0	7.0	6.3	6.7	6.7	6.7	6.6
DB1	3.7	7.7	6.0	1.3	4.3	6.7	7.0	6.3	6.3	7.0	6.0	6.6

PPG-TF-105	4.3	7.7	6.3	5.3	9.3	6.0	6.3	6.0	6.3	7.7	7.0	6.6
PST-5BRK	6.0	6.7	6.3	2.3	4.7	6.0	7.0	6.3	6.3	6.7	7.0	6.6
PPG-TF-152	5.3	7.7	6.7	1.3	6.7	6.7	6.7	6.3	6.3	6.3	6.7	6.5
PST-5EX2	5.7	5.7	4.7	0.7	1.3	6.0	6.7	6.0	6.7	7.0	6.7	6.5
PST-5SALT	5.0	6.0	6.3	2.7	11.3	6.7	6.7	5.7	6.0	7.3	6.7	6.5
ATF 1754	5.3	6.3	5.0	1.2	3.0	5.7	7.0	6.0	6.3	7.0	6.7	6.4
Faith	6.0	6.3	5.3	2.3	6.3	6.0	6.3	6.0	6.3	7.0	7.0	6.4
Fesnova	4.3	6.7	6.3	2.0	3.3	6.7	6.3	5.7	6.3	7.0	6.7	6.4
Grade 3	5.3	6.7	5.3	3.3	7.7	5.7	6.3	6.0	6.3	7.3	7.0	6.4
MET 6 SEL	3.3	6.3	5.3	0.7	3.7	5.7	6.7	6.0	6.7	6.7	7.0	6.4
PST-5MVD	5.7	5.7	6.0	1.0	1.7	6.0	6.7	6.3	6.7	6.7	6.3	6.4
F711	5.7	6.7	6.3	2.3	5.0	6.3	6.3	6.0	5.7	6.3	7.7	6.4
IS-TF 272	4.7	8.3	7.3	6.0	8.0	7.0	6.7	5.7	5.7	7.7	5.7	6.4
IS-TF 305 SEL	4.7	8.0	6.0	3.0	7.0	6.3	6.7	6.0	6.0	6.7	6.7	6.4
MET-3	5.0	6.3	6.0	2.5	5.0	6.7	6.3	5.7	6.0	6.7	7.0	6.4
PPG-TF-139	5.7	7.0	6.3	1.3	3.3	6.7	7.0	6.7	5.7	6.3	6.0	6.4
PPG-TF-170	4.7	6.0	7.0	4.0	15.0	6.0	5.7	5.7	6.0	7.3	7.7	6.4
PST-5R05	5.7	6.0	5.3	7.0	9.3	6.0	6.7	5.7	6.3	7.3	6.3	6.4
RAD-TF-83	3.3	8.0	5.3	3.2	6.7	6.0	7.0	5.7	6.0	7.0	6.7	6.4
Falcon IV	5.3	5.7	5.0	2.0	5.0	5.7	6.7	6.0	6.3	6.7	6.7	6.3
OR-21	7.0	8.0	6.3	3.2	7.7	7.3	6.7	6.0	5.7	6.3	6.0	6.3
PPG-TF-148	5.7	6.3	6.3	4.3	9.3	5.7	6.3	6.0	6.3	6.7	7.0	6.3
PPG-TF-156	4.7	6.7	6.3	3.3	6.7	5.3	6.3	5.7	6.3	7.3	7.0	6.3
PSG-GSD	5.3	5.7	6.0	1.3	4.0	6.0	6.3	6.0	6.0	7.0	6.7	6.3
PST-57DT	6.0	5.3	5.0	2.8	5.0	6.3	6.7	5.7	6.0	7.3	6.0	6.3
RAD-TF-88	2.3	7.7	7.0	4.7	13.0	5.7	5.7	5.3	6.3	7.7	7.3	6.3
Bullseye	6.3	6.7	6.7	2.0	6.0	6.7	6.3	5.7	6.0	6.7	6.3	6.3
Falcon V	5.3	6.7	5.7	4.0	6.0	6.0	6.3	6.0	6.3	6.7	6.3	6.3
IS-TF 269 SEL	4.3	7.7	5.7	1.8	3.7	6.3	6.0	5.7	6.3	7.0	6.3	6.3
IS-TF 276 M2	5.3	7.3	5.7	3.0	7.3	6.3	6.3	5.7	5.7	6.7	7.0	6.3
JS818	5.3	8.0	5.7	3.7	11.3	7.0	6.0	5.0	6.3	6.7	6.7	6.3
LTP-F5DPDR	5.0	5.7	5.7	4.7	9.3	6.0	6.0	5.7	6.7	7.0	6.3	6.3
PST-5DZP	5.0	7.3	6.3	1.5	4.0	6.0	6.7	6.0	5.7	6.7	6.7	6.3

PST-5EV2	4.7	6.7	5.7	4.0	8.0	6.0	6.3	6.3	6.0	7.0	6.0	6.3
RZ2	5.0	6.0	6.3	2.0	5.7	6.0	6.0	6.3	6.0	6.7	6.7	6.3
TD1	3.3	7.7	5.3	2.3	5.3	6.3	7.0	5.3	5.7	7.0	6.3	6.3
ATF 1704	5.3	6.0	6.0	1.7	5.0	5.3	6.0	6.3	6.3	6.3	7.0	6.2
IS-TF 282 M2	5.3	7.3	7.0	2.2	3.0	6.7	6.3	5.3	5.7	7.0	6.3	6.2
IS-TF 307 SEL	3.7	8.0	6.0	0.7	3.0	5.7	7.0	6.3	6.0	6.3	6.0	6.2
MET 1	4.7	6.0	5.3	9.7	13.7	5.7	5.7	5.7	6.3	7.0	7.0	6.2
PPG-TF-169	6.0	6.0	6.0	3.7	7.3	5.7	6.0	5.7	6.3	6.7	7.0	6.2
PSG-8BP2	6.0	6.0	5.3	9.8	5.3	5.3	6.3	6.7	6.3	6.7	6.0	6.2
PST-R5NW	5.0	6.0	4.7	1.5	3.0	6.0	6.7	6.0	6.0	6.7	6.0	6.2
Burl TF-2	5.7	6.0	5.3	0.3	2.0	6.0	6.0	5.3	6.0	6.7	7.0	6.2
IS-TF 285	4.0	7.3	6.0	1.5	6.3	6.0	6.7	6.0	6.0	6.3	6.0	6.2
PPG-TF-150	3.7	6.3	6.0	3.0	5.0	6.0	6.0	5.7	6.0	6.7	6.7	6.2
Annihilator	6.0	6.7	6.7	4.0	9.7	7.0	6.0	5.0	6.3	6.3	6.0	6.1
ATF 1612	4.0	6.7	6.0	0.7	2.7	6.0	6.3	5.3	5.7	6.7	6.7	6.1
CCR2	5.0	6.7	7.0	3.5	11.7	6.0	5.7	5.7	5.7	6.3	7.3	6.1
PSG-PO1	2.3	6.7	5.3	1.7	7.3	5.3	6.7	5.7	5.7	7.3	6.0	6.1
TY 10	5.3	7.3	5.3	2.3	6.7	6.3	6.0	5.7	5.0	7.0	6.7	6.1
IS-TF 308 SEL	4.7	7.3	6.3	1.7	2.7	6.3	6.3	5.3	5.7	6.7	6.0	6.1
JS819	5.3	7.7	6.3	1.3	5.3	6.3	6.7	5.7	6.0	6.0	5.7	6.1
ATF 1736	4.3	6.3	5.0	1.3	3.3	5.3	6.3	5.3	6.0	6.3	6.7	6.0
Burl TF-136	4.0	6.0	6.3	1.3	3.7	6.0	6.0	5.3	5.7	6.7	6.3	6.0
Firebird 4	4.3	7.0	5.7	1.2	6.0	5.7	7.0	5.7	5.0	6.3	6.3	6.0
JS825	4.0	7.0	5.3	1.3	3.0	6.3	6.3	5.3	6.3	6.3	5.3	6.0
PPG-TF-138	5.0	6.7	5.7	4.3	10.3	6.3	6.3	5.7	6.0	6.0	5.7	6.0
PSG-TT4	5.7	5.3	5.3	2.0	5.3	6.3	5.7	5.3	5.7	6.3	6.7	6.0
RAD-TF-89	4.3	7.3	5.7	3.7	7.3	5.3	6.0	5.0	5.7	7.0	7.0	6.0
Terrano	4.0	7.3	5.0	4.7	5.0	6.0	7.0	6.0	6.0	5.7	5.3	6.0
B23	3.3	7.0	6.3	3.5	7.7	5.3	6.0	5.0	5.7	6.7	7.0	5.9
Exp TF-09	6.0	7.0	5.0	2.3	7.3	6.3	5.7	5.7	5.7	6.3	6.0	5.9
GO-DFR	4.0	7.0	5.7	3.3	5.3	6.3	5.7	5.3	5.7	6.7	6.0	5.9
IS-TF 289	3.7	7.7	6.0	4.7	13.7	5.7	6.3	5.3	6.0	6.7	5.7	5.9
JS916	6.0	7.0	6.3	5.3	6.0	6.3	6.0	5.3	5.3	6.3	6.3	5.9

Comp. Res. SST	5.3	6.3	7.0	3.7	5.3	6.0	6.3	5.7	6.0	5.7	5.7	5.9
DZ1	2.7	6.7	6.0	5.5	4.0	5.7	6.7	6.0	5.7	6.0	5.3	5.9
PPG-TF-172	4.0	7.3	6.0	2.3	6.0	5.7	6.0	5.7	5.7	6.3	6.0	5.9
BAR Fa 121089	4.7	6.7	5.7	5.5	6.3	5.7	6.3	5.3	5.7	6.7	5.3	5.8
BAR Fa 121091	4.0	7.7	5.7	1.3	4.7	6.3	6.3	5.0	5.7	6.0	5.7	5.8
K12-05	3.0	8.0	6.0	1.0	5.3	5.3	6.0	5.3	5.7	6.3	6.3	5.8
PST-5BPO	4.7	6.0	5.0	7.0	14.3	5.7	5.7	5.3	5.7	6.0	6.3	5.8
Regenerate	4.0	7.0	6.3	4.5	12.7	5.7	5.7	5.3	5.3	6.3	6.3	5.8
RAD-TF-92	4.0	7.7	6.3	3.5	7.3	5.3	6.7	4.7	5.3	6.7	5.7	5.7
BAR Fa 121095	3.7	7.7	6.0	3.0	10.0	5.7	6.3	5.3	5.3	6.0	5.3	5.7
PSG-WE1	3.7	6.7	6.0	3.3	12.0	5.3	5.3	5.7	5.7	6.0	6.0	5.7
JS809	5.0	7.3	6.0	1.7	4.7	6.0	6.3	5.0	5.7	5.7	5.0	5.6
Catalyst	3.3	5.3	6.0	8.0	14.7	4.7	5.0	5.3	5.7	6.0	6.7	5.6
BAR Fa 120878	6.3	4.7	4.0	10.0	5.0	4.7	5.3	5.7	5.0	6.0	5.7	5.4
Marauder	5.7	6.0	7.0	5.7	7.0	5.3	5.3	5.0	5.3	5.7	5.0	5.3
PST-5GRB	4.3	5.0	7.3	2.0	6.0	5.3	5.0	5.0	5.0	5.7	5.3	5.2
Warhawk	5.7	6.7	6.7	4.7	4.7	6.0	5.3	4.3	5.0	5.3	5.3	5.2
Aquaduct	6.0	6.3	6.0	3.0	2.7	5.3	5.0	5.3	5.3	5.0	5.0	5.2
204 Res. Blk4	4.0	5.7	7.3	3.8	3.7	4.7	5.0	3.7	5.3	5.3	5.7	4.9
K12-13	3.3	8.0	6.7	2.2	13.0	4.3	5.3	5.0	5.0	5.0	4.7	4.9
Ky-31	7.0	2.0	3.0	3.3	3.0	3.0	3.0	3.0	2.7	3.0	3.0	2.9
$LSD_{0.05}$	1.89	0.83	1.17	ns†	ns	1.47	1.31	1.13	1.25	1.42	1.32	0.94
CV%	24.3	7.6	12.2	103.2	79.5	14.9	12.7	12.1	12.8	13.2	12.7	9.4

† ns, not significant, $p > 0.05$

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2014 COOPERATIVE TURFGRASS BREEDERS FIELD EVALUATION OF PERENNIAL RYEGRASS CULTIVARS

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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 2013 Perennial Ryegrass 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

One hundred-seven cultivars of perennial ryegrasses were established on September 27, 2013 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 27, 2013 and were fertilized at the time of seeding at the rate of 1 pound of nitrogen per 1,000 ft^2. Once seeding was completed, the plots were protected with a turf cover until germination was evident. Plots were treated in April 2014 with a pre-emergent crabgrass control (prodiamine) product. Tenacity was applied in two applications late May/early June 2014. Plots were fertilized at the rate of 1#N/m in May 2014. Broadleaf weed control was applied June 2014. Tenacity and Speedzone were applied again in September 2014. In October, plots were fertilized at the rate of 1#N/m. Plots were maintained at a mowing height of 2" height of cut and are mowed approximately 2 times per week. Irrigation was applied as needed.

Establishment ratings

Establishment ratings were made on October 22, 2013. Establishment ratings were based on a scale of 1-9. Ratings were based on percent germination and seedling vigor. A rating of 1 had the lowest percent germination/vigor and 9 the highest.

Quality ratings

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) beginning April 2014 through October 2014. 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

During 2014 growing season, ambient air temperatures and rainfall was consistent with normal spring conditions. However, rainfall mid-summer through October was limited and supplemental irrigation was applied as needed to the ryegrass plots. In general, the perennial ryegrasses persisted season-long without loss of color, due to the supplemental irrigation. Throughout the first growing season, there was no evidence of significant disease expression. Red thread was observed on some plots early fall.

Figure 1 - Cooperative Turfgrass Breeders Perennial Ryegrass Test, University of Connecticut

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Table 1 – Perennial Rye Grass, Cultivars and Sponsors					
PLOT	**CULTIVAR**	**SPONSOR**	**PLOT**	**CULTIVAR**	**SPONSOR**
1	PPG-PR 196	Peak Genetics	45	Monsieur	DLF
2	APR2687	NexGen	46	PST-2ED1	PST
3	PSG-21-10	PSG	47	PST-2BD1	PST
4	Thrive	DLF	48	APR2154	NexGen
5	PST-2SHRP	PST	49	APR2397	NexGen
6	Linn	PSG	50	APR2320	NexGen
7	DLF-PR-569	DLF	51	DLF-PR-561	DLF
8	PST-2FIND-13	PST	52	Brightstar SLT	PST
9	PSG-HLTY	PSG	53	PST-3IP	PST
10	PST-Gray Fox	PST	54	APR2659	NexGen
11	DLF-PR-575	DLF	55	DLF-PR-521	DLF
12	DLF-PR-523	DLF	56	PST-2MG7	PST
13	DLF-PR-583	DLF	57	APR2394	NexGen
14	PPG-PR 197	Peak Genetics	58	PSG-20-10	PSG
15	PR-09-6	PSG	59	Silver Dollar	PST
16	DLF-PR-579	DLF	60	PPG-PR 229	Peak Genetics
17	Penguin	NexGen	61	Harrier	PSG
18	Homerun	Peak Genetics	62	Fiesta 4	PSG
19	GSI-3-12	PSG	63	Apple GL	Peak Genetics
20	APR2790	NexGen	64	APR2540	NexGen
21	PS 10	Peak Genetics	65	DSL5B1	PSG
22	Aspire	DLF	66	APR2554	NexGen
23	PST-2SURV	PST	67	Allstar 3	DLF
24	PSG-HLY	PSG	68	APR2524	NexGen
25	4JPR	PSG	69	Soprano	NexGen
26	PPG-PR 234	Peak Genetics	70	PPG-PR 171	Peak Genetics
27	PPG-PR 228	Peak Genetics	71	DLF-PR-578	DLF
28	APR2680	NexGen	72	PPG-PR 222	Rutgers
29	Gator 3	DLF	73	APR2385	NexGen
30	Pop	NexGen	74	PPG-PR 227	Peak Genetics
31	PPG-PR 231	Peak Genetics	75	APR2662	NexGen
32	APR2344	NexGen	76	Diligent	DLF
33	Manhattan 6 GLR	PST	77	PPG-PR 168	Peak Genetics
34	PST-2RDY	PST	78	Banfield	DLF
35	PST-2LTD	PST	79	DLF-PR-565	DLF
36	PST-2PDA	PST	80	APR2688	NexGen
37	PST-2MPX1	PST	81	PST-2A2	PST
38	Stamina	DLF	82	DLF-PR-553	DLF
39	PSG-HLT	PSG	83	PST-2A12	PST
40	PST-2TPR	PST	84	APR2399	NexGen
41	DLF-PR-580	DLF	85	DLF-PR-564	DLF
42	DLF-PR-563	DLF	86	PPG-PR 232	Peak Genetics
43	PST-2ETS	PST	87	PST-224	PST
44	Esquire	DLF	88	PST-2TFC	PST

Table 1 – Perennial Rye Grass, Cultivars and Sponsors cont.

PLOT	CULTIVAR	SPONSOR	PLOT	CULTIVAR	SPONSOR
89	DLF-PR-537	DLF	99	APR2237	NexGen
90	APR2445	NexGen	100	Line Drive GLS	NexGen
91	DLF-PR-562	DLF	101	PS 9	Peak Genetics
92	PST-2CITM	PST	102	PST-2REB	PST
93	PSG1037-12K	PSG	103	APR2477	NexGen
94	PPG-PR 172	Rutgers	104	Karma	PSG
95	APR2104	NexGen	105	APR2679	NexGen
96	PST-2BDT	PST	106	PST-3MP3	PST
97	PPG-PR 167	Peak Genetics	107	Bandalore	DLF
98	Zoom	PSG			

Table 2 - Turfgrass Quality Ratings

CULTIVAR	AVERAGE QUALITY RATING 2104	CULTIVAR	AVERAGE QUALITY RATING 2014
PPG-PR-196	5.72	Manhattan 6 GLR	5.24
APR2687	5.14	PST-2RDY	5.33
PST-21-10	5.67	PST-2LTD	5.09
Thrive	5.19	PST-2PDA	6.00
PST-2SHRP	5.24	PST-2MPX1	5.43
Linn	4.76	Stamina	6.09
DLF-PR-569	5.57	PSG-HLT	5.52
PST-2FIND-13	5.81	PST-2TPR	5.81
PSG-HLTY	5.38	DLF-PR-580	5.29
PST-Gray Fox	5.48	DLF-PR-563	5.81
DLF-PR-575	5.38	PST-2ETS	5.52
DLF-PR-523	5.43	Esquire	5.76
DLF-PR-583	5.76	Monsieur	6.00
PPG-PR-197	5.24	PST-2ED1	5.19
PR-09-6	5.19	PST-2BD1	5.04
DLF-PR-579	5.34	APR2154	5.48
Penguin	5.90	APR2397	5.76
Homerun	5.91	APR2320	5.67
GSI-3-12	4.86	DLF-PR-561	4.95
APR2790	6.14	Brightstar SLT	5.91
PS 10	6.00	PST-3IP	4.81
Aspire	6.00	APR2659	6.19
PST-2-SURV	4.91	DLF-PR-521	4.91
PST-HLY	5.67	PST-2MG7	4.81
4JPR	5.67	APR2394	5.33
PPG-PR-234	5.76	PSG-20-10	5.52
PPG-PR-228	6.14	Silver Dollar	5.14
APR2680	**5.86**	PPG-PR-229	6.14
Gator 3	5.19	Harrier	5.34
Pop	5.19	Fiesta 4	5.91
PPG-PR-231	6.00	Apple GL	6.00
APR2344	4.81	APR2540	5.71

Table 2 - Turfgrass Quality Ratings cont.

CULTIVAR	AVERAGE QUALITY RATING 2104	CULTIVAR	AVERAGE QUALITY RATING 2014
DSL5B1	4.71	APR2445	5.14
APR2554	6.29	DLF-PR-562	6.00
Allstar 3	5.10	PST-2CITM	5.62
APR2524	5.76	PSG1037-12K	6.24
Soprano	5.76	PPG-PR-172	6.29
PPG-PR-171	6.00	APR2104	6.57
DLF-PR-578	5.00	PST-2BDT	5.52
PPG-PR-222	6.19	PPG-PR-167	6.10
APR2385	5.48	Zoom	6.14
PPG-PR-227	6.38	APR2237	5.76
APR2662	6.48	Line Drive GLS	6.24
Diligent	5.95	PS 9	6.10
PPG-PR-168	5.28	PST-2REB	5.86
Banfield	5.29	APR2477	5.67
DLF-PR-565	5.67	Karma	6.38
APR2688	5.76	APR2679	6.43
PST-2A2	5.57	PST-3MP3	5.52
DLF-PR-553	5.62	Bandalore	6.09
PST-2A12	5.28	**GRAND MEAN**	**5.65**
APR2399	5.91	**CV%**	**9.42**
DLF-PR-564	5.76	**$LSD_{0.05}$**	**0.72**
PPG-PR-232	5.90	**MIN. MEAN**	**4.71**
PST-224	5.57	**MAX. MEAN**	**6.57**
PST-2TFC	5.86	**MIN. MEAN**	**4.71**
DLF-PR-537	6.00	**MAX. MEAN**	**6.57**

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DEVELOPMENT OF SHORT GROWTH MUTANTS OF PERENNIAL RYEGRASS POTENTIALLY USEFUL FOR LOW MAINTENANCE APPLICATIONS

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INTRODUCTION

Perennial ryegrass (PRG; *Lolium perenne* L.) also known as English ryegrass is an important cool-season grass grown as a forage crop in pastures and as turfgrass in lawns, athletic fields and golf courses (Pearson et al., 2011). PRG is commonly used in residential and commercial lawns and maintained at optimum mowing height of 5-9 cm (Turgeon, 2005). Short-growth PRG mutants can reduce mowing frequency and may also be useful in fairways and tees where low mowing heights (i.e. $\leq$ 2.54 cm) are desirable. Water requirement of cool-season perennial ryegrass is also quite high (Liu and Jiang, 2010). Therefore there is an increasing demand for short-growth turf with reduced mowing, irrigation and fertilizer requirements, due to increased energy costs and limited water resources (Ma et al., 2008).

Short-growth PRG cultivars can be developed through hybridization, transgenic and mutation breeding techniques. Hybridization breeding is based on the existing natural variation due to spontaneous mutations, while mutation breeding allows for creating variations not existent in the natural population (Ahloowalia and Maluszynski, 2001). Short-growth PRG has been developed by using RNA interference (RNAi) and genetic transformation techniques (Ma et al., 2008). It was reported that the mutant plants exhibited 50% reduction in growth compared to the wild-type plants after 90 days of growth in the greenhouse (Ma et al., 2008). Nonetheless, it is difficult to commercialize a transgenic cultivar due to regulatory issues and public mistrust of transgenic plants (Zapiola et al., 2008). Hence, mutation breeding methodologies provide an excellent tool to develop economically important turfgrass mutants. These techniques involve the usage of gamma-rays, X-rays, fast neutrons, ethyl methanesulfonate (EMS) and sodium azide to induce variations. Induced mutations have been utilized to improve major crops such as wheat, rice, barley, cotton, peanuts and beans (Ahloowalia and Maluszynski, 2001). This method has resulted in the development and release of more than 1800 cultivars in 50 countries (Maluszynski et al., 1995). Turfgrasses and forage grasses with changes in several morphological traits have also been generated using radiation-induced mutations (Krishna et al., 1984). According to the published reports, 10 turfgrass cultivars developed through irradiation mutagenesis were released for commercial use (FAO/IAEA database 2006). Dwarfism is the most frequent mutant character observed among the irradiated plants (Lu et al., 2009). Short-growth mutants were developed in bermudagrass (Lu et al., 2009); St. Augustinegrass (Busey, 1980; Li et al., 2010) and centipedegrass (Dickens et al., 1981) through gamma irradiation and the mutants displayed significant growth retardation and improved drought resistance (Busey, 1980; Lu et al., 2009).

The main objectives of this study were to develop short-growth mutants of PRG from ‘Fiesta 4’ seeds, using EMS, gamma-ray radiation and fast neutrons, and further characterize them under field conditions.

MATERIALS & METHODS

Seed material. ‘Fiesta 4’ PRG seeds were purchased, from the Chas. C. Hart Seed Co. Wethersfield, CT.

Gamma-ray irradiation screen. Seeds were soaked in tap water for 24 h and then the wet seeds were irradiated with gamma-rays from a Cobalt-60 source, with dosages of 0, 2.5, 5.0, 7.5, 10.0, 15.0 and 20.0 kilorads (kr) at the University of Massachusetts, gamma cave facility, Lowell, MA. Each treatment had 3 replicates with 1200 seeds per replicate. After the seeds were irradiated, they were germinated on moist paper towels (spread in growth trays) in an incubator at a temperature of 23 ± 2 °C under 35-45 $\mu mol \cdot m^{-2} \cdot s^{-1}$ light provided by white fluorescent tube lamps over a 16h photoperiod. To determine the optimum dose for LD_{50} (survival rate of 50%), germination observations were taken on the 21st day of the experiment. Germination percentages were reported as an average over three replicates.

EMS concentration screen. The EMS mutagenesis protocol developed by Kim et al., (2006) for *Arabidopsis* was followed with some modifications. Approximately 1200 ‘Fiesta 4’ seeds per replicate were soaked in 100 mM phosphate buffer (pH 7.5) for 24 h at room temperature. Then the supernatant buffer was discarded and 200 ml of freshly prepared 100 mM phosphate buffer solution containing EMS at 0, 0.2, 0.4, 0.6, 0.8 or 1.0 M, was added to each replicate and incubated on a shaker for 16 h. Each treatment had 3 replicates. After EMS treatment, seeds were washed two times in 200 ml of 3% sodium thiosulfate buffer for 20 min at room temperature with gentle shaking, followed by three washes in 200 ml of distilled water. The mutagen treated seeds were air-dried for 12 h, and then were germinated on moist paper towels (spread in growth trays) in an incubator. Culture conditions were same as those used for gamma-ray irradiation screen. To determine the optimum concentration for LD_{50} (survival rate of 50%), observations were recorded on the 21st day of culture. Data on germination were reported as a mean of three replicates for each treatment.

After the preliminary study, 10 kg of ‘Fiesta 4’ seeds were irradiated with 9.0 kr dose of gamma rays, while another 10 kg of seeds were treated with 0.8 M EMS based on the aforementioned procedures. Also, 5 kg of seeds were irradiated with 1.0 kr dose of fast neutrons (Van Harten, 1998), at the

University of Massachusetts irradiation facility, Lowell, MA. The mutagen treated M1 seeds (1st mutant generation seeds) were air-dried for 12 h and stored at 4 °C until further use.

Field planting and harvesting of M2 (2nd mutant generation) seeds. Mutagen treated seeds were hand-broadcasted at a rate of 1.5 kg per 100 m^2 to grow the M1 plants (the seedlings and adult plants developed from M1 seeds) for M2 seed production (the seeds which develop on M1 plants) at the University of Connecticut, Plant Science Research and Education Facility. At the end of fruit ripening phase, the M2 generation seeds were harvested, air-dried at room temperature and stored at 4 °C until further use.

Identification of short-growth mutants based on growth rate or their responses to GA. Wild-type 'Fiesta 4', EMS M2, gamma M2 and fast neutron M2 populations were soaked in 289 µM gibberellic acid (GA_3) solution for 2h. After soaking, the supernatant solution was removed and the seeds were cold-treated for 14 days at 4 °C. GA_3 concentration was selected based on a preliminary study conducted to obtain uniform germination of 'Fiesta 4' seeds. The cold treated seeds were then germinated on moist paper towels in growth trays, maintained in an incubator at a temperature of 25 ± 2 °C with 16 h of light. After 3 weeks of growth, seedlings were transferred to plug trays containing promix potting soil (Premier Horticulture Inc; PA). Seedlings were allowed to grow for 3 months in a greenhouse at a temperature of 20-25 °C under natural light. Plants were fertilized every 14 days with a 0.12% solution of 20-20-20, and irrigated as per requirement. After 3 months, short-growth mutants were selected based on growth rate or their responses to GA (can germinate only when GA is present).

Morphological characterization of mutant plant lines. A number of mutant lines exhibiting short-growth characteristics were selected from M2 generation. When sufficient plant materials were obtained through vegetative propagation, a field trial was conducted for 6 lines. Wild-type 'Fiesta 4' (WT) was used as a control. Transplanting of 3-inch plugs (with 8-10 tillers) was done in September, 2011. The field test employed randomized design with three replicates. The spacing between two plants in a row and between 2 rows was 30 cm. All the plants were watered as per requirement until they were established in the field. Measurements were taken in June 2012 (at maturity stage), on ten randomly picked tillers from each replicate for leaf blade length, leaf blade width and internode length. Top three leaves and internodes on the ten tillers were measured and mean values were calculated for each replicate. Canopy height and root length were measured for three replicates. Data were reported as a mean of 3 replicates for each plant line.

Evaluation of tolerance to low mowing height: In the fall of 2011, a mixture of Victory II Chewings Fescue and Jasper II Creeping Red Fescue seeds was hand-broadcasted at a rate of 4-6 lbs per 1000 sq. ft. at the University of Connecticut, Plant Science Research and Education Facility. In the spring 2012, 11 x 22 inch sections where removed from an established Fescue sod turf plot were removed and eight-month-old vegetatively propagated Gamma-17 mutant and wild-type sod strips (11 x 22 inch) were randomly planted in the 28 x 56 cm cut out sections. Each test line was planted in triplicate. Spacing between two sod strips in a row and between rows was 30 cm. All the plants were watered as needed until established in the field. Upon establishment, mowing heights for Gamma-17 mutant and wild-type sod strips were gradually lowered to 1 inch from 3 inches. The mowing was done twice per week with a John Deer JS60 rotary push mower.

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

Gamma-ray dose and EMS concentration effects on seed germination. Untreated 'Fiesta 4' seeds germinated by the 3rd day; whereas germination in gamma irradiated seeds was delayed 1 and 2 days by gamma rates ≤ 7.5 and ≥ 10.0 kr, respectively. Germination data was collected on the 21st day of the experiment. Germination decreased as gamma-ray dosage increased (Table 1). Germination of 7.5 kr and 10.0 kr gamma irradiated seeds was reduced by 39.96% and 58.68%, respectively, compared to the untreated seeds (Table 1). Published reports indicate that in mutation breeding experiments, a mutagen dose which causes 50% reduction in seed germination percentage compared to the untreated seeds is thought to be an adequate dose for producing a maximum number of desirable mutations (Li et al., 2010; Van Harten, 1998). Therefore, a 9.0 kr dose was selected to treat 'Fiesta 4' seeds with gamma-rays for subsequent irradiation experiments to screen for short-growth mutants. EMS also delayed the germination of seeds by 2 days. There were no significant differences among the seeds treated with 0, 0.2 and 0.4 M EMS (Table 2). However, at higher concentrations (i.e. 0.6 M and 0.8 M), seed germination was reduced by 13.79% and 53.67% compared to the control (Table 2). At the highest concentration (1.0 M) only 0.17% of seeds germinated after 21 days (Table 2). Based on these data, 'Fiesta 4' seeds in subsequent experiments were treated with 0.8 M EMS to generate short-growth mutants.

Morphological characteristics of the mutants in a field condition. The data from field study shows that the FN-4, FN-5 and Gamma-17 mutants had significantly lower canopy heights (87%, 72% and 35% reduction respectively, compared to WT), significantly shorter leaf blades (63%, 56% and 45%, respectively, shorter than WT) and significantly shorter internodes (80%, 74% and 51%, respectively, shorter when compared with WT) (Table 3; Fig. 1 and 2). All the three mutants had significantly narrower leaves (50%, 9% and 19%, respectively, when compared with WT). FN-5 and Gamma-17 had significantly longer roots (11% and 9% longer than WT) (Table 3). Similarly, the EMS mutants GAD-1, GAD-2 and EMS-4 displayed desirable turf characteristics compared to the wild-type. They had significantly lower canopy heights (27%, 31% and 26% reduction respectively, than WT), significantly shorter leaf blades (39%, 49% and 23%, respectively, shorter when compared with WT) (Table 4; Fig. 3 and 4). Their leaf blade widths were reduced by 15%, 19% and 15%, respectively (Table 4). However, only GAD-1 had significantly shorter internodes (45% shorter) when compared with WT. GAD-2 mutant had 7% longer roots than WT; while GAD-1 and EMS-4 mutants had similar root lengths as the WT (Fig. 3 and 4). Published reports indicate that the compact turfgrass lines improve turf quality, require low maintenance under greenhouse and field conditions (Hanna et al., 1997; Hanna and Elsner, 1999; Reynolds et al., 2009). Because of their short-growth characteristics, all the six mutants included in this study will need mowing less frequently and their requirements for water and fertilizers should also be reduced. Further evaluation is in progress to characterize the performance of these plants under drought, low fertilizer and other conditions.

In field tests of tolerance to low mowing height (1-inch), Gamma-17 displayed significantly higher turf density, better leaf texture and turf quality than wild type in 2012, 2013 and 2014. The turf density of Gamma-17 was close to the high-density level while that of wild type controls remained at the medium-density level at the 1 inch moving height. The turf quality of Gamma-17 approached the best possible quality while the wild type was slightly above the acceptable level. Also, the fact that the leaves of Gamma-17 plants are narrower than those of wild type plants also improved the morphological appearance of the Gamma-17 under low mowing height conditions (Fig. 5). Gamma-17 had shorter internodes than the wild type controls, with more leaves retained on the stems at the low mowing height.

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Table 1: Effect of gamma-ray dose on the germination of 'Fiesta 4' perennial ryegrass seeds.

Gamma-ray dose[z] (kr)	Germination rate[y] (% ± SE)
0	92.39 ± 2.02 a[x]
2.5	78.93 ± 0.71 b
5.0	70.03 ± 1.52 c
7.5	55.47 ± 1.61 d
10.0	38.17 ± 1.03 e
15.0	24.37 ± 1.45 f
20.0	19.10 ± 0.15 g

kr = kilorad; SE = standard error.
[z]Each dosage treatment had three replicates with 1200 seeds per replicate.
[y]Germination data were recorded on the 21st day of experiment. Germination rates were calculated by dividing the number of seeds germinated by the number of seeds treated.
[x]Values followed by the same letter were not significantly different from each other according to the LSD (P=0.05).

Table 2: Effect of EMS concentration on the germination of 'Fiesta 4' perennial ryegrass seeds.

Concentration of EMS (M)[z]	Germination rate[y] (% ± SE)
0	92.60 ± 1.33 a[x]
0.2	90.37 ± 0.58 a
0.4	89.17 ± 0.44 a
0.6	79.83 ± 0.75 b
0.8	42.90 ± 0.52 c
1.0	0.17 ± 0 d

EMS = ethyl methanesulfonate; SE = standard error.
[z]Each EMS treatment had three replicates with 1200 seeds per replicate.
[y]Germination data were recorded on the 21st day of experiment. Germination rates were calculated by dividing the number of seeds germinated by the number of seeds treated.
[x]Values followed by the same letter were not significantly different from each other according to the LSD (P=0.05).

Table 3: Morphological characteristics of gamma-ray and fast neutron induced short-growth mutants in comparison to the wild-type 'Fiesta 4' perennial ryegrass.

Genotype	CH[z] (cm ± SE)	RL[z] (cm ± SE)	LL[z] (cm ± SE)	LW[z] (cm ± SE)	IL[z] (cm ± SE)
Wild-type	68.33 ± 0.33 a[y]	33.00 ± 0.57 b[y]	13.07 ± 0.15 a[y]	0.32 ± 0 a[y]	7.71 ± 1.13 a[y]
FN-4	9.00 ± 0.57 d	22.67 ± 0.33 c	4.74 ± 0.35 d	0.16 ± 0 d	1.56 ± 0.28 b
FN-5	19.33 ± 0.33 c	36.67 ± 1.33 a	5.80 ± 0.21 c	0.29 ± 0 b	1.98 ± 0.40 b
Gamma-17	44.33 ± 1.85 b	36.00 ± 0.58 a	7.16 ± 0.27 b	0.26 ± 0 c	3.79 ± 0.79 b

SE = standard error; CH = canopy height; RL = root length; LL = leaf blade length; LW = leaf blade width; IL = internode length.
[z]Each value represents the mean of three replicates. Measurements were taken in June 2012 (at maturity stage), on ten randomly picked tillers from each replicate for leaf blade length, leaf blade width and internode length.
[y]Values followed by the same letter were not significantly different from each other according to the LSD (P=0.05).

Table 4: Morphological characteristics of ethyl methanesulfonate induced short-growth mutants in comparison to the wild-type ‘Fiesta 4’ perennial ryegrass.

Genotype	CH^z (cm ± SE)	RL^z (cm ± SE)	LL^z (cm ± SE)	LW^z (cm ± SE)	IL^z (cm ± SE)
Wild-type	68.33 ± 0.33 a^y	33.00 ± 0.57 b^y	13.07 ± 0.15 a^y	0.32 ± 0 a^y	7.71 ± 1.13 a^y
GAD-1	50.00 ± 0 b	31.33 ± 0.33 b	7.93 ± 0.50 c	0.27 ± 0 b	4.24 ± 1.06 b
GAD-2	47.00 ± 0.57 c	35.33 ± 1.33 a	6.61 ± 0.34 d	0.26 ± 0 b	4.64 ± 0.75 ab
EMS-4	50.33 ± 1.45 b	32.00 ± 0.58 b	10.00 ± 0.36 b	0.27 ± 0 b	5.05 ± 0.57 ab

SE = standard error; CH = canopy height; RL = root length; LL = leaf blade length; LW = leaf blade width;
IL = internode length.
^{z}Each value represents the mean of three replicates. Measurements were taken in June 2012 (at maturity stage), on ten randomly picked tillers from each replicate for leaf blade length, leaf blade width and 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 canopy height and root length of field-grown wild-type ‘Fiesta 4’ perennial ryegrass (left) and Gamma-17 mutant (right).

Fig. 2: Comparison of canopy height and rootlength of field-grown wild-type ‘Fiesta 4’ perennial ryegrass (left) and FN-5 mutant (right).

Fig. 3: Comparison of canopy height and root length of field-grown wild-type ‘Fiesta 4’ perennial ryegrass (left) and EMS-4 mutant (right).

Fig. 4: Comparison of canopy height and root length of field-grown wild-type ‘Fiesta 4’ perennial ryegrass (left) and GAD-2 mutant (right).

Fig. 5: M1 Gamma-17 (right) showed healthy growth and color to low mowing height (2.5 cm) while the WT control (left) did not survive well under the field conditions.

RELATING TURFGRASS GROWTH AND QUALITY TO FREQUENTLY MEASURED SOIL NITRATE

Geng, X., K. Guillard, and T.F. Morris. 2014. Relating turfgrass growth and quality to frequently measured soil nitrate. Crop Sci. 54:366–382. doi: 10.2135/cropsci2013.03.0145

ABSTRACT

Currently, there is no soil-based N test used to guide N fertilizer recommendations for turfgrass. This study was conducted across 3 yr in Connecticut to determine if frequent measurement of soil nitrate–N (NO_3–N) could be used to estimate color, density, clippings yield, clippings total N concentration, and clippings N uptake in Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.) lawns. Randomized complete block field experiments were set out on the two species with nine N rates. Soil cores and clippings were collected at 2-wk intervals from May through October and analyzed for concentrations of NO_3–N and total N, respectively. Turfgrass color was measured with chlorophyll and normalized difference vegetative index meters, and shoot count density was measured after the last sampling. Significant ($p < 0.001$) Cate-Nelson, linear-plateau, and quadratic-plateau models were observed for all relative measures of turfgrass growth and quality as a function of soil NO_3–N concentrations. The critical soil NO_3–N concentrations for the three models that indicated the beginning of a plateau response or marked the Cate-Nelson change point between likely or unlikely response ranged from 3.7 and 18.0 mg kg^{-1} for Kentucky bluegrass and from 2.5 and 10.1 mg kg^{-1} for tall fescue. Probability plots indicated a high likelihood of acceptable turfgrass responses at the lower range of the critical concentrations suggested by the Cate-Nelson model. These results suggest that frequent measurement of soil NO_3–N may help to guide N fertilization of Kentucky bluegrass and tall fescue when managed as lawns.

TURFGRASS GROWTH AND COLOR CORRELATED TO SPRING ILLINOIS SOIL N TEST AND SOIL PERMANGANATE-OXIDIZABLE CARBON CONCENTRATIONS

Geng, X., K. Guillard, and T.F. Morris. 2014. Turfgrass growth and color correlated to spring Illinois soil N test and soil permanganate-oxidizable carbon concentrations. Crop Sci. 54:383–400.
doi: 10.2135/cropsci2013.06.0426

ABSTRACT

The Illinois soil N test (ISNT) and soil permanganate-oxidizable C (POXC) concentrations have been used to estimate mineralization potential of agricultural soils, assess soil quality, distinguish differences between crop management treatments, and to predict crop response to N fertilization. However, it is not known if these measures are correlated to growth and color quality responses of cool-season turfgrasses. This study was conducted across five yrs (2008-2012) in Connecticut, USA to determine if a single spring measurement of ISNT-N and POXC concentrations could be used to estimate color and growth responses of Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.) lawns. Randomized complete block field experiments were set out on the two species with varying rates of an organic fertilizer. Soil samples were collected in early May of each year and analyzed for concentrations of ISNT-N and POXC. Turfgrass color, clippings yield, clippings total N concentration, and clippings total N uptake were measured from May through October. Turfgrass responses showed consistent positive linear responses ($p<0.05$) as a function of ISNT-N and POXC. Across species and years, ISNT-N and POXC were generally greater under tall fescue than under Kentucky bluegrass. A single spring measurement of soil ISNT-N and POXC shows promise in categorizing Kentucky bluegrass and tall fescues lawns as to their likelihood of N fertilization response. The data suggest a low probability of meaningful Kentucky bluegrass and tall fescues lawn responses to N fertilization when spring ISNT-N and POXC concentrations exceed 250 mg kg^{-1} and 1300 mg kg^{-1}, respectively.

DEFINING SUFFICIENCY LEVELS OF NITROGEN IN COOL-SEASON TURFGRASS LAWNS USING MACY'S CONCEPT

Geng, X., K. Guillard, S.S. Mangiafico, and T.F. Morris. 2014. Defining sufficiency levels of nitrogen in cool-season turfgrass lawns using Macy's concept. Crop Sci. 54:1844–1858.
doi: 10.2135/cropsci2013.11.0737

ABSTRACT

Few correlation or calibration studies have been conducted to determine or validate sufficiency levels of N concentrations in the clippings of turfgrass for color and growth responses. In a series of field experiments conducted across six consecutive growing seasons (2007–2012) in Connecticut, clipping samples of Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.) lawns were used to estimate yields and then analyzed for N concentrations. Chlorophyll and normalized difference vegetative index (NDVI) meters were used to quantify turf color before sampling. Macy's concept of three nutritional zones of plant tissue nutrient concentration was used to identify minimum and critical concentrations of N in the clippings that define sufficiency ranges for color and growth responses, in addition to luxury consumption. Averaged across all variables and seasons (spring, summer, and fall), the sufficiency ranges of N concentration in the clippings were estimated to be 32 to 46 g kg^{-1} for Kentucky bluegrass, and 28 to 42 g kg^{-1} for tall fescue. Differences in minimum and critical concentrations among seasons and between species were thought to be due to demand-driven nutrient uptake. Luxury consumption of N was observed in both species. When used in context with local conditions, tissue analysis for N concentrations in cool-season turfgrass clippings can provide an objective basis for guiding N fertilization.

FALL VERDURE SAP NITRATE-N CONCENTRATIONS AS A PREDICTOR OF COOL-SEASON TURFGRASS LAWN COLOR RESPONSE IN THE FALL AND FOLLOWING SPRING

Miele, K.M, K. Guillard, and T.F. Morris. 2014. Fall verdure sap nitrate-N concentrations as a predictor of cool-season turfgrass lawn color response in the fall and following spring. *In* ASA-CSSA-SSSA Abstracts, Madison, WI. Presentation 119–6. https://scisoc.confex.com/scisoc/2014am/webprogram/Paper89055.html

ABSTRACT

In northern climates, fall fertilization of cool-season turfgrasses with N has become the standard practice to maintain turfgrass color and density into the fall, increase root carbohydrate concentrations for stress tolerance, and optimize spring green-up after winter. However, there are no routine tests that guide fall N fertilization for these purposes. The objective of this study was to determine if relationships exist between fall sap nitrate-N concentrations in the verdure of a cool-season turfgrass lawn mixture and turf color during the fall and following spring. The study was set out as two randomized complete block design experiments with three replicates, and conducted across 3 consecutive fall-spring periods (2010–11, 2011–12, and 2012–13) on a turfgrass lawn consisting of 35% Kentucky bluegrass (*Poa pratensis*), 30% perennial ryegrass (*Lolium perenne*), and 35% creeping red fescue (*Festuca rubra*). Treatments in each experiment were 13 N application rates (from 0 to 196 kg N ha^{-1}) applied as urea. N was applied in September for the first blocked experiment, and in October for the second blocked experiment. Turf color and verdure sap nitrate concentrations were measured weekly in October (on the September-fertilized plots) and in November (on the October-fertilized plots) with an NDVI meter and a Cardy nitrate meter, respectively. NDVI response as a function of sap nitrate-N concentration was modeled with linear plateau models. The results suggest that fall and spring turf color is significantly correlated to fall verdure sap nitrate-N concentrations, with NDVI readings plateauing at concentrations between 200 and 300 mg nitrate-N L^{-1}. Sap verdure nitrate-N concentrations increased through the weekly November sampling, indicating that the turfgrass plants stored increasingly more nitrate as growth slowed with the onset of dormancy. These results suggest that sap nitrate-N concentrations in the verdure show promise as a guide for fall N fertilization of cool-season turfgrass.

USE OF HERBIVORE-INDUCED PLANT VOLATILES AS SEARCH CUES BY *TIPHIA VERNALIS* AND *TIPHIA POPILLIAVORA* TO LOCATE THEIR BELOW-GROUND SCARABAEID HOSTS

Obeysekara, P.T., A. Legrand and G. Lavigne. 2014. Use of herbivore-induced plant volatiles as search cues by *Tiphia vernalis* and *Tiphia popilliavora* to locate their below-ground scarabaeid hosts. Entomologia Experimentalis et Applicata 150:74–85.
http://onlinelibrary.wiley.com/enhanced/doi/10.1111/eea.12138/

ABSTRACT

Japanese beetle, *Popillia japonica* Newman, and oriental beetle, *Anomala orientalis* (Waterhouse) (both Coleoptera: Scarabaeidae) are considered invasive species and have been reported as key pests of urban landscapes in the Northeastern USA. *Tiphia vernalis* Rohwer and *Tiphia popilliavora* Rohwer (Hymenoptera: Tiphiidae) were introduced as biocontrol agents against these beetles. These parasitic wasps burrow into the soil and search for grubs. When a host is found, the wasp attaches an egg in a location that is specific for the wasp species. It is unknown if these wasps can detect patches of concealed hosts from a distance above ground and what role, if any, herbivore-induced plant volatiles play in their host location. This study evaluated the responses of female *T. vernalis* and *T. popilliavora* to grub-infested and healthy plants in Y-tube olfactometer bioassays. Also the effect of root herbivory on the composition of turfgrass (Poaceae) volatile profiles was investigated by collecting volatiles from healthy and grub-infested grasses. *Tiphia* wasps were highly attracted to volatiles emitted by grub-infested tall fescue (*Festuca arundinacea* Schreb.) and Kentucky bluegrass (*Poa pratensis* L.) over healthy grasses. In contrast, wasps did not exhibit a significant preference for grub-infested perennial ryegrass (*Lolium perenne* L.) as compared with the control plants. The terpene levels emitted by grub-infested Kentucky bluegrass and tall fescue were greater than that of control plants. Low levels of terpenes were observed for both test and control perennial ryegrass. The elevated levels of terpenes emitted by grub-infested Kentucky bluegrass and tall fescue coincided with the attractiveness to the tiphiid wasps. Here, we provide evidence that plant exposure to root-feeding insects *P. japonica* and *A. orientalis* resulted in an increase in terpenoid levels in turfgrasses, which strongly attracts their above-ground parasitoids.

ANALYSIS OF TIPHIA PARASITOIDS PREOVIPOSITIONAL BEHAVIORS AND OF THEIR SCARAB HOST DEFENSIVE RESPONSES

Obeysekara, P.T., and A. Legrand. 2014. Analysis of Tiphia parasitoids preovipositional behaviors and of their scarab host defensive responses. Biological Control 69: 97-106.
http://www.sciencedirect.com/science/article/pii/S1049964413002740

ABSTRACT

Tiphia vernalis Rohwer and *Tiphia popilliavora* Rohwer were introduced as biocontrol agents against Japanese beetles (*Popillia japonica* Newman) and oriental beetles (*Anomala orientalis* Waterhouse). Studies have shown that under field conditions, *T. vernalis* parasitize Japanese beetles more often than oriental beetles. This study was done to understand how tiphiid wasps handle the two different host species and the influence of host defensive behaviors on the oviposition process of tiphiid wasps. The preovipositional behaviors performed by Tiphia wasps included: stinging, examining, moving soil, kneading, host feeding, and host scraping. The frequency, sequence, and total time spent on each behavior before oviposition were scored and compared between two host species. The sequence and frequency of preovipositional behaviors performed by both *Tiphia* wasps did not show a difference between the two host species. However, female *T. vernalis* spent significantly longer time trying to sting oriental beetles than Japanese beetles in order to paralyze them. The time *T. popilliavora* spent on prestinging behaviors did not show a difference between Japanese and oriental beetles. The defensive behaviors performed by Japanese and oriental beetle grubs included: vigorous movements, rubbing their abdomen or head against the wasp's abdomen, and biting at the attacking wasp. The frequency and total time spent on each defensive behavior was scored and compared between two host species. Overwintered, third instar oriental beetle grubs spent significantly longer time on defensive behaviors when they were attacked by *T. vernalis* which likely cause wasps to spend longer time trying to sting oriental beetle grubs. The active host resistance gained through behavioral defenses could make oriental beetle grubs less susceptible to *T. vernalis* attack than Japanese beetle grubs, especially under field conditions. Younger grubs attacked by *T. popilliavora* did not exhibit these differences.

THE INFLUENCE OF HOST SPECIES AND LOCATION IN THE HOST DETECTION ABILITY OF TIPHIID (HYMENOPTERA:TIPHIIDAE) PARASITOIDS

Obeysekara, P.T. and A. Legrand. 2014. The influence of host species and location in the host detection ability of Tiphiid (Hymenoptera:Tiphiidae) parasitoids. Environmental Entomology 43: 1594-1602.
http://ee.oxfordjournals.org/content/43/6/1594

ABSTRACT

Tiphia vernalis Rohwer and *Tiphia popilliavora* Rohwer are ectoparasitoids of root-feeding larvae of the Japanese beetle, *Popillia japonica* Newman, and oriental beetles, *Anomala orientalis* Waterhouse (Coleoptera: Scarabaeidae). Little is known about the influence of host species and location in the host detection ability of tiphiid wasps. In this study, we examined the response of female *T. popilliavora* wasps, an understudied *Tiphia* species, to potential host stimuli using dual choice tests in an observation chamber filled with soil.*T. popilliavora* wasps were able to successfully discriminate the trails containing body odor or frass of *P. japonica* grubs from trails without cues. Frass trails of *P. japonica* grubs elicited stronger responses than body odor trails. We also examined the preference of host cues by tiphiid wasps using dual choice behavioral assays. Both *T. vernalis and T. popilliavora* wasps did not show preference toward trails that either contained *P. japonica* or *A. orientalis* cues. In addition, we also determined the detection of host cues by tiphiid wasps in a dual-choice test for cues presented at varying soil depths. Wasps were able to successfully discriminate between the Y-tube arms with and without cues when the cues of *P. japonica* were buried at a depth of 2 cm. In contrast, both *Tiphia* species were unable to distinguish between the Y-tube arms with and without cues when the cues were buried at a depth of 5 cm. Thus, our findings suggest that once *Tiphia* wasps land on the ground, they can detect the presence of their specific hosts, just below the soil surface by exploiting the kairomones present in grub body odor trails and frass and once the wasps are in the soil, they use the same cues to direct themselves to the host grubs.

SEASONAL NITROGEN FERTILIZATION PROGRAMS AND PLANT GROWTH REGULATOR EFFECTS ON ANTHRACNOSE SEVERITY OF ANNUAL BLUEGRASS PUTTING GREEN TURF

Chen, X., and J.C. Inguagiato. 2014. Seasonal nitrogen fertilization oprograms and plant growth regulator effects on anthracnose severity of annual bluegrass putting green turf. *In* ASA-CSSA-SSSA Abstracts, Madison, WI. Presentation 122–5. https://scisoc.confex.com/scisoc/2014am/webprogram/Paper87831.html

ABSTRACT

Anthracnose (caused by *Colletotrichum cereale* sensu lato Crouch, Clarke, and Hillman) is a detrimental disease of annual bluegrass (ABG; *Poa annua* L.) putting greens. Ethephon and trinexapac-ethyl applied together for seedhead and vegetative control can reduce anthracnose severity, although this effect has been inconsistent in previous research. Moderate nitrogen fertilization can improve ABG tolerance to anthracnose. However, the influence of seasonal N programming on the ability of plant growth regulators to reduce anthracnose is not well understood. A two year field study was established in 2013 to evaluate potential interactions between seasonal nitrogen fertilization programs, ethephon (ET), and trinexapac-ethyl (TE) application interval on anthracnose severity of ABG putting green turf. Nitrogen treatments included spring or fall applications of 48.8 kg ha^{-1}, or a split application of 12.2 and 36.6 kg ha^{-1} applied spring and fall respectively. Ethephon was applied at 0 or 3.81 kg a.i. ha^{-1} twice in April. Trinexapac-ethyl treatment intervals consisted of none, 14 day interval, or every 200 growing degree days (GDD) base 0°C from mid-Apr through July 2013 and August 2014, applied at 0.05 kg a.i. ha^{-1}. Surprisingly, N had little effect on anthracnose severity during 2013. However, spring N treatments consistently reduced disease severity compared to fall only treatments from late June through early August 2014. Ethephon, initially reduced anthracnose severity, although had no effect later in the 2013 season. Ethephon treated turf consistently had reduced anthracnose severity throughout 2014. Trinexapac-ethyl consistently reduced anthracnose severity regardless of application interval in both years. However, TE applied every 200 GDD reduced disease severity more than TE every 14-d during July and August. No consistent interactions were observed. Results to date suggest spring rather than fall N fertilization, ET, and TE applied based on GDD model can reduce anthracnose on annual bluegrass putting green turf.

THE VINEYARD CLUB: A CASE STUDY OF PESTICIDE-FREE TURFGRASS MANAGEMENT

Inguagiato, J.; Carlson, J. 2014. Phytopathology. November. 104(11S): p. S3.143.

ABSTRACT

Organic turfgrass management is not commonly practiced on golf courses where diseases can damage turf surfaces and disrupt play. The Vineyard Golf Club was mandated by the local permitting agencies on the Island of Martha's Vineyard, MA to be organically managed. They defined organic as being managed without the benefit of synthetically derived pesticides. When The Vineyard Golf Club (VGC) opened for play in May of 2002, Dollar Spot (caused by Sclerotinia homoeocarpa F.T. Bennett) was the most common disease of fairway and putting green turf on the course. Management of this disease focuses on the use of plant defense inducing products (i.e., Civitas), frequent applications of biological control products (e.g., Ecoguard and Rhapsody) and fertility to encourage rapid recovery of disease symptoms. Success of organic practices is also achieved through communications with the members. VGC members take pride in the organic management program and tolerate temporary reductions in turf quality on certain areas of the course. This presentation will highlight the organic management program as it has evolved through the last 12 years.

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

Campbell, J.H., J.J. Henderson, V.H. Wallace, J.C. Inguagiato, and A. Minniti. 2014. Optimizing pre-germination techniques for three turfgrass species: Creeping bentgrass, Kentucky bluegrass and perennial ryegrass. *In* ASA-CSSA-SSSA Abstracts, Madison, WI. Presentation 287–7.
https://scisoc.confex.com/scisoc/2014am/webprogram/Paper89480.html

ABSTRACT

Many intensively trafficked areas such as athletic fields and golf courses require constant overseeding. Rapid seed germination and subsequent development are critical to managing these high wear areas. The objectives of this research were to determine the effect of water aeration, soaking duration, and water temperature on the mean germination time (MGT) and percent germination of three turfgrass species; Kentucky bluegrass (*Poa pratensis*, KBG), perennial ryegrass (*Lolium perenne*, PRG) and creeping bentgrass (*Agrostis stonlonifera*, CBG). Two separate studies were conducted. The first was designed as a 2x3x4 factorial with an untreated control. Treatments were arranged in a split plot design with aeration/no aeration as the main plot split by species and soaking duration (8, 24, 48, and 72 hours) with an untreated control. Treatments were replicated three times within three runs completed at 20°C in a growth chamber. The second experiment was a 3x3x3 factorial nested, split plot with an untreated control. This experiment examined the effect of soaking duration (8, 24, and 48 hours) and water temperature (4, 20, 30°C) on seed germination for the three species. A total of three runs were completed, each consisting of three treatment replications. Water aeration had little effect on treatments across turfgrass species, except PRG. Therefore, aeration 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, seed should be aerated and soaked for 8h. These results indicate that soaking duration and water temperature were not critical factors for PGR as there was no benefit to longer soaking durations or varying water temperatures.