University of Connecticut

College of Agriculture & Natural Resources

2010 Annual Turfgrass Research Report

Cover photo: John Inguagiato, Assistant Professor of Turfgrass Pathology, discusses control and management of annual bluegrass putting green diseases at the 2010 UConn Turfgrass Field Day.

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2010 Annual Turfgrass Research Report Summary

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

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

This report is divided into various sections and includes original research results in the fields of pest control (pathology and entomology), athletic field and golf turf maintenance, cultivar evaluation, fertility and nutrient management, and turfgrass ecology. Additionally, abstracts and citations of scientific publications and presentations published in 2010 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.

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The University of Connecticut Turf Group

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PREVENTIVE ANTHRACNOSE CONTROL IN A MIXED ANNUAL BLUEGRASS AND CREEPING BENTGRSS PUTTING GREEN TURF WITH VARIOUS FUNGICIDES, 2010

John Inguagiato and Robert Blake

Department of Plant Science and Landscape Architecture
University of Connecticut

INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. Recent research has identified management practices that can reduce anthracnose severity. However, cultural practices alone are unlikely to provide complete control of this disease, particularly at sites with a history of anthracnose. Therefore, an integrated disease management program utilizing cultural and chemical controls is required to avoid turf loss. The objective of this study was to evaluate the efficacy of currently available and experimental fungicides for preventive control of anthracnose on a golf course putting green.

MATERIALS & METHODS

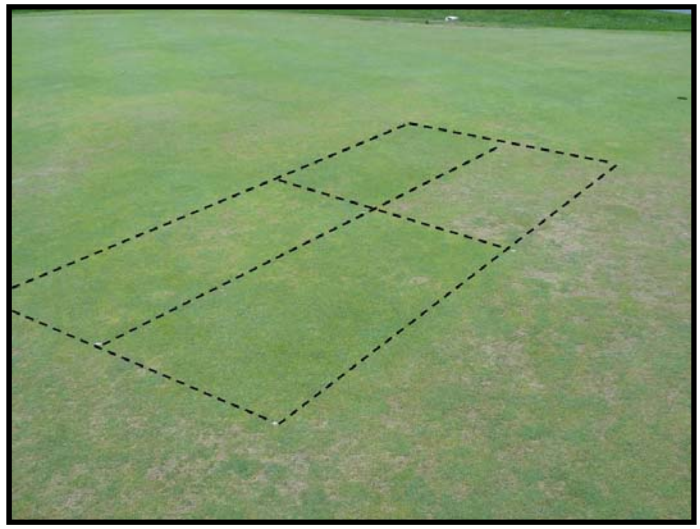
A field study was conducted on a putting green with a history of anthracnose at Burning Tree Country Club in Greenwich, CT. Turf was comprised of annual bluegrass (*Poa annua*) and approximately 20% creeping bentgrass (*Agrostis stolonifera*) grown on a native soil with an accumulated sand topdressing layer. Limited nitrogen fertility was applied during the trial to encourage anthracnose development.

Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. Treatments were initiated prior to disease development from 24 May through 16 August. All materials 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.

Anthracnose was assessed as a percentage of the plot area blighted by *C. cereale*. 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 1 equaled no discoloration and 2 represented the minimum acceptable level. Algae severity was assessed on a 1 to 9 scale where 1 equaled no algae, 3 equaled an acceptable level of algae severity, and 9 equaled turf completely covered by algae. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS

Anthracnose developed throughout the study area from a natural infestation in early-July. Disease pressure was high throughout July and August resulting in 22.5 to 43.8% plot area blighted in untreated turf during that time (Table 1). Further disease development in untreated turf was limited in August, despite continued favorable disease conditions, due to



the presence of creeping bentgrass within the plots which was unaffected by *C. cereale*.

Most treatments reduced anthracnose compared to untreated, particularly during July (Table 1). However, only a few resulted in good disease control (i.e., ≤ 5%) throughout the trial. These included DPX-LEM17-76 + Daconil Ultrex, LEM17+CTL, Daconil Ultrex + QP Fosetyl-Al, Daconil Ultrex + QP Fosetyl-Al + Foursome and the Syngenta program. Unacceptable disease control resulted from application of the low rate of DPX-LEM17-76 and Bayer program #2 containing Interface (trifloxystrobin + iprodione).

Algae developed throughout the trial area on 16 August. On that date, the experimental compound LEM17+CTL and all other treatments and rotational programs (Bayer program #1 and Syngenta) containing chlorothalonil provided near complete algae control (Table 2). Algae was slightly reduced in turf treated with the Bayer program #2, although all other treatments did not differ from untreated.

Slight phytotoxcicty, in the form of stunted blue-gray colored turf was observed on 21 June following the second application of Primo MAXX in the Syngenta program (Table 2). Thereafter, no signs of phytotoxicity were observed in the trial.

Turf quality was primarily influenced by anthracnose severity. No quality differences were observed between treatments prior to disease development. Later in the trial only treatments providing good anthracnose control maintained acceptable turf quality (Table 3).

DISCUSSION

High disease pressure provided a stringent assessment of fungicide efficacy in this trial. These data support previous work indicating that the addition of chlorothalonil to tank mixes or rotational programs generally results in improved anthracnose control. This effect was evident in turf treated with DPX-LEM17-76 + Daconil Ultrex compared to the experimental applied alone. Bayer rotational program #2 was slightly less effective than Bayer program #1 presumably due to the substitution of Daconil Ultrex for Interface (trifloxystrobin + iprodione) in the former. Strobilurins can provide effective anthracnose control; however, resistance of *C. cereale* to this class of fungicides has been documented. Previous work at this site suggests this population of *C. cereale* is insensitive to strobilurin fungicides. When anthracnose is active, strobilurins should only be applied in combination with a fungicide with an alternate mode of action effective in controlling this disease (i.e., chlorothalonil, polyoxin-D, fludioxonil, DMI).

ACKNOWLEDGEMENTS

The UCONN Turfgrass Science Program would like to express our appreciation to Michael Barton, CGCS, his staff and Burning Tree Country Club for their cooperation in conducting this research.

Table 1. Anthracnose severity in a mixed annual bluegrass and creeping bentgrass putting green treated preventively with fungicides in Greenwich, CT during 2010.

Treatment Rate per 1000 ft^{-2}	Int.[z]	Anthracnose severity 6 Jul	22 Jul	2 Aug	16 Aug	7 Sep
		---------------------- % plot area blighted ----------------------				
DPX-LEM17-76…........0.3 oz + Daconil Ultrex…......3.25 oz	14-d	1.3 b[v]	4.3 b	2.5 b	2.3 d	2.3 c
DPX-LEM17-76…...….0.3 oz + Banner MAXX…....1.0 fl oz	14-d	1.8 b	10.0 b	4.0 b	3.8 cd	3.1 c
LEM17+CTL..............3.1fl oz	14-d	2.0 b	7.8 b	3.5 b	1.9 d	1.5 c
DPX-LEM17-76…...….0.3 oz	14-d	2.5 b	12.0 b	11.5 b	13.3 bc	9.0 bc
DPX-LEM17-76.........….0.5 oz	14-d	3.0 b	8.8 b	11.8 b	7.3 bcd	7.5 bc
Bayer Program #1	Pgm. [y]	1.5 b	9.5 b	7.6 b	7.5 bcd	7.5 bc
Chipco Signature...….4.0 oz						
Triton FLO…….......0.5 fl oz						
Daconil Ultrex........…3.2 oz						
Bayer Program #2	Pgm. [x]	1.8 b	10.0 b	7.8 b	15.3 b	15.0 b
Chipco Signature...….4.0 oz						
Triton FLO……..…0.5 fl oz						
Interface……..............3.0 oz						
Syngenta Program	Pgm. [w]	3.8 b	6.8 b	4.5 b	4.5 cd	2.9 c
A16422A.................3.6 fl oz						
Primo MAXX........0.15 fl oz						
A14658D................3.0 fl oz						
Renown..................4.5 fl oz						
Concert....................5.0 fl oz						
Daconil Ultrex................3.2 oz + Chipco Signature.........4.0 oz	14-d	0.8 b	8.0 b	4.0 b	6.5 bcd	6.5 bc
Daconil Ultrex................3.2 oz + Fosetyl-Al……......…4.0 oz	14-d	1.0 b	4.8 b	1.3 b	1.1 d	1.8 c
Daconil Ultrex................3.2 oz + Fosetyl-Al……......…4.0 oz + Foresome…...……..0.4 fl oz	14-d	0.3 b	3.0 b	1.5 b	0.8 d	4.0 c
Untreated	--	22.5 a	43.8 a	43.3 a	40.0 a	25.3 a
ANOVA: Treatment (P > F)		0.0001	0.0005	0.0001	0.0001	0.0004
Days after treatment	14-d	15	16	11	14	22
	Pgm.	15	16	11	14	22

[z] Applications were made on 24 May, 7 and 21 June, 6 and 22 July, and 2 and 16 August.

[y] Chipco Signature was applied every 14-d; Triton FLO was applied on 24 May, 21 June, 22 July, and 16 August; Daconil Ultrex was applied on 7 June, 6 July, and 2 August.

[x] Chipco Signature was applied every 14-d; Triton FLO was applied on 24 May, 21 June, 22 July, and 16 August; Interface was applied on 7 June, 6 July, and 2 August.

[w] Materials were applied on each date as follows: 24 May: A16422A and Primo MAXX; 7 June: Renown and Primo MAXX; 21 June: A16422A and Primo MAXX; 6 July: Renown and Primo MAXX; 22 July: Concert and Primo MAXX; 2 August: Renown, A14658D and Primo MAXX; and 16 August: A16422A, A14658D and Primo MAXX.

[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 in a mixed annual bluegrass and creeping bentgrass putting green treated preventively with fungicides in Greenwich, CT during 2010.

Treatment Rate per 1000 ft^{-2}	Int.[z]	Turf quality							
		24 May	7 Jun	21 Jun	6 Jul	22 Jul	2 Aug	16 Aug	7 Sep
		------------------- 1 – 9; 6 = min. acceptable -------------------							
DPX-LEM17-76………..0.3 oz	14-d	7.3	7.5	7.3	6.3	6.8	6.3 abc [v]	6.5 ab	6.3 ab
+ Daconil Ultrex……...3.25 oz									
DPX-LEM17-76……..…0.3 oz	14-d	7.3	6.3	7.0	6.8	6.0	6.0 abc	4.8 cd	5.5 ab
+ Banner MAXX…....1.0 fl oz									
LEM17+CTL..............3.1fl oz	14-d	7.0	6.0	7.3	7.5	6.8	7.0 ab	6.3 abc	7.0 a
DPX-LEM17-76……..…0.3 oz	14-d	7.0	6.8	6.5	5.8	5.8	5.5 bc	4.5 de	5.0 bc
DPX-LEM17-76........…0.5 oz	14-d	6.8	6.8	6.8	5.8	5.3	5.5 bc	4.8 cd	5.5 ab
Bayer Program #1	Pgm. [y]	7.5	5.8	7.5	7.3	6.8	6.5 abc	4.8 cd	5.0 bc
Chipco Signature...…4.0 oz									
Triton FLO……......0.5 fl oz									
Daconil Ultrex........…3.2 oz									
Bayer Program #2	Pgm. [x]	7.3	6.3	7.5	5.8	5.0	4.5 cd	4.3 de	3.5 c
Chipco Signature...…4.0 oz									
Triton FLO……..…0.5 fl oz									
Interface……..............3.0 oz									
Syngenta Program	Pgm. [w]	7.3	6.0	6.5	5.5	5.8	5.8 bc	5.0 bcd	5.3 abc
A16422A................3.6 fl oz									
Primo MAXX........0.15 fl oz									
A14658D................3.0 fl oz									
Renown..................4.5 fl oz									
Concert...................5.0 fl oz									
Daconil Ultrex...............3.2 oz	14-d	7.0	7.0	7.8	6.3	5.8	7.5 ab	6.3 abc	5.5 ab
+ Chipco Signature.........4.0 oz									
Daconil Ultrex...............3.2 oz	14-d	7.0	6.0	7.8	7.8	7.0	7.5 ab	7.0 a	6.3 ab
+ Fosetyl-Al……......…4.0 oz									
Daconil Ultrex...............3.2 oz	14-d	7.3	7.0	8.3	7.8	6.8	8.0 a	6.8 a	5.5 ab
+ Fosetyl-Al……......…4.0 oz									
+ Foresome…...……..0.4 fl oz									
Untreated	--	7.3	8.0	7.0	4.0	2.8	2.5 d	3.0 e	3.5 c
ANOVA: Treatment (P > F)		0.998	0.186	0.351	0.103	0.059	0.001	0.0001	0.024
Days after treatment	14-d	initial	14	14	15	16	11	14	22
	Pgm.	initial	14	14	15	16	11	14	22

[z] Applications were made on 24 May, 7 and 21 June, 6 and 22 July, and 2 and 16 August.

[y] Chipco Signature was applied every 14-d; Triton FLO was applied on 24 May, 21 June, 22 July, and 16 August; Daconil Ultrex was applied on 7 June, 6 July, and 2 August.

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

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Table 3. Phytotoxicity in a mixed annual bluegrass and creeping bentgrass putting green treated preventively with fungicides in Greenwich, CT during 2010.

Treatment Rate per 1000 ft^{-2}	Int.[z]	Phytotoxicity						Algae
		7 Jun	21 Jun	6 Jul	22 Jul	2 Aug	16 Aug	16 Aug
		------------------- 1 – 5; 2 = min. acceptable -------------------						1 - 9
DPX-LEM17-76…........0.3 oz + Daconil Ultrex…......3.25 oz	14-d	1.0	1.0 b[v]	1.0	1.0	1.0	1.0	1.0 c
DPX-LEM17-76…...….0.3 oz + Banner MAXX…....1.0 fl oz	14-d	1.0	1.3 b	1.0	1.0	1.0	1.0	5.3 a
LEM17+CTL..............3.1fl oz	14-d	1.0	1.0 b	1.0	1.0	1.0	1.0	1.5 bc
DPX-LEM17-76…...….0.3 oz	14-d	1.0	1.0 b	1.0	1.0	1.0	1.0	4.8 a
DPX-LEM17-76.......….0.5 oz	14-d	1.0	1.0 b	1.0	1.0	1.0	1.0	5.0 a
Bayer Program #1 Chipco Signature...….4.0 oz Triton FLO……......0.5 fl oz Daconil Ultrex........…3.2 oz	Pgm.[y]	1.3	1.0 b	1.0	1.0	1.0	1.0	2.0 bc
Bayer Program #2 Chipco Signature...….4.0 oz Triton FLO……...…0.5 fl oz Interface.….…............3.0 oz	Pgm.[x]	1.0	1.3 b	1.0	1.0	1.0	1.0	2.5 b
Syngenta Program A16422A................3.6 fl oz Primo MAXX........0.15 fl oz A14658D................3.0 fl oz Renown..................4.5 fl oz Concert...................5.0 fl oz	Pgm.[w]	1.3	2.0 a	1.0	1.0	1.0	1.0	1.3 c
Daconil Ultrex...............3.2 oz + Chipco Signature.........4.0 oz	14-d	1.3	1.0 b	1.0	1.0	1.0	1.0	1.3 c
Daconil Ultrex...............3.2 oz + Fosetyl-Al.……......…4.0 oz	14-d	1.3	1.0 b	1.0	1.0	1.0	1.0	1.0 c
Daconil Ultrex...............3.2 oz + Fosetyl-Al.……......…4.0 oz + Foresome…...……..0.4 fl oz	14-d	1.0	1.0 b	1.0	1.0	1.0	1.0	1.3 c
Untreated	--	1.0	1.0 b	1.0	1.0	1.0	1.0	5.0 a
ANOVA: Treatment ($P > F$)		0.684	0.0001	1.0	1.0	1.0	1.0	0.0001
Days after treatment	14-d	14	14	15	16	11	14	14
	Pgm.	14	14	15	16	11	14	14

[z] Applications were made on 24 May, 7 and 21 June, 6 and 22 July, and 2 and 16 August.
[y] Chipco Signature was applied every 14-d; Triton FLO was applied on 24 May, 21 June, 22 July, and 16 August; Daconil Ultrex was applied on 7 June, 6 July, and 2 August.
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[v] Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

BROWN PATCH CONTROL IN COLONIAL BENTGRSS FAIRWAY TURF WITH VARIOUS FUNGICIDES, 2010

John Inguagiato and Robert Blake

Department of Plant Science and Landscape Architecture
University of Connecticut

INTRODUCTION

Brown patch (caused by *Rhizoctonia solani*) commonly affects high maintenance turfgrasses during summer months. This disease can be particularly severe on colonial bentgrass fairway turf. Repeat applications of effective fungicides are generally required to prevent unacceptable thinning of the turf canopy. The objective of this study was to evaluate the efficacy of current and experimental fungicides and organic nitrogen sources for early curative and preventive brown patch control in fairway turf.

MATERIALS & METHODS

A field study was conducted on an 'Alister' 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.

Treatments consisted of currently available and experimental fungicides applied individually or in rotational programs and organic and synthetic fertilizers. Fertilizer treatments were applied at a rate of 0.14 lbs N $1000\text{-}ft^{-2}$ and watered with 0.1-inch immediately following application. Treatments were initiated as an early curative application on 10 June. Thereafter, compounds were applied on a 14- (10 and 22 June and 8 and 24 July) or 21-day (10 June and 1 and 24 July) interval using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 1 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Brown patch was assessed as a percentage of the plot area blighted by *R. 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 1 was equal to no discoloration and 2 represented the minimum acceptable level. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS

Brown patch developed within the trial area prior to the initiation of treatments, during an early onset of favorable conditions on 8 June. An evaluation of brown patch at this time indicated no significant differences were present within the trial area prior to the initiation of treatments (Table 1). Following initial treatment applications on 10 June brown patch severity decreased to 0% in nearly all plots by 22 June (14 DAT). No differences in early curative control were observed due to limited disease occurrence at the time of initial application. After 22 July, treatment effects were assessed as preventive brown patch control.

Environmental conditions favorable for brown patch during July resulted in 18% turf area blighted in untreated turf by 27 July (Table 1). Nearly all treatments provided acceptable control (≤ 10%), reducing disease compared to untreated turf on this date. However, organic (TB 6-0-0 + LC 1-1-1) and synthetic nitrogen fertilizers did not reduce brown patch on this date, with the later enhancing disease compared to untreated and organic fertilizer treated turf. Similar results were observed on 6 August, although turf treated with QP TM, QP Ipro, UC-10-1 (3.2 oz) and QP Chlorothalonil 720SFT (1.84 oz) provided unacceptable level of control by this date.

Following the final application on 24 July, brown patch severity was evaluated on 13 August (20 DAT) to assess residual treatment effects during high disease pressure. Most treatments continued to reduce disease compared to untreated, which contained 71% plot area blighted on this date. However, acceptable control was only observed in turf treated with DPX-LEM17-76, Insignia, Honor, Renown, tank mixes including Interface and various formulations of chlorothalonil at the high rate (3.2 oz). QP Ipro applied alone had no effect on brown patch on this date, but reduced the disease when tank mixed with Foursome. Organic and synthetic N fertilizer sources also had no effect on brown patch at this time.

Turf quality was generally good among all treatments prior to disease development (Table 2). However, a few notable differences were apparent on 8 July when disease severity was low. Quality of turf treated with QP TM and QP Ipro was improved when these materials were tank mixed with Foursome (green pigmented tracker dye). Higher rates (3.2 oz) of various cholorothalonil formulations generally had better quality than the low rate application of the same materials. Treatments containing strobilurin fungicides (e.g., Renown, Honor, Interface) or the experimental DPX-LEM 17-76 tended to have very good turf quality. Conversely, quality of TB 6-0-0 + LC 1-1-1 and 46-0-0 was reduced on this date due to a slight phototoxic affect (Table 3) and brown patch, respectively.

Phytotoxic effects of treatments on turf were limited, and none were observed to be unacceptable throughout the duration of the trial (Table 3).

DISCUSSION

Brown patch development was severe during late-July and August in the trial, providing for a rigorous assessment of treatment efficacy. A number of treatments provided excellent or good brown patch control up to 20 days after application. The best treatments for brown patch control and turf quality tended to be pre-mixes or tank mixes containing a strobilurin fungicide, or the experimental fungicide DPX-LEM17-76. Numerical differences suggested that higher rates (3.2 oz) of chlorothalonil were required to suppress disease longer than 14 days, however statistical separation was not possible likely due to distribution of disease in the trial area. No differences were observed between chlorothalonil formulations within a given application rate.

As expected, brown patch was severe in nitrogen fertilizer treated turf. Nitrogen applied at 0.14 lbs 1000 ft^{-2} as 46-0-0 increased disease in mid to late July, whereas no increase was seen in turf treated with an equivalent amount of N derived from organic sources (TB 6-0-0 + LC 1-1-1) at this same time. No difference was observed between these N sources and untreated at the peak of the epidemic in August.

Table 1. Brown patch severity in an 'Alister' colonial bentgrass fairway turf treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Treatment	Rate per 1000 ft^{-2}	Int.[z]	Plot area blighted							
			9 Jun	16 Jun	22 Jun	8 Jul	14 Jul	27 Jul	6 Aug	13 Aug
			%							
QP TM	2.0 fl oz	14-d	1.7	1.0	0.0	1.3	1.0 bcd[x]	2.8 c	11.8 b	28.5 d
QP TM	2.0 fl oz	14-d	0.0	0.0	0.0	0.3	0.5 cd	1.3 c	7.8 b	22.0 d-g
+ Foursome	0.4 fl oz									
QP IPRO	4.0 fl oz	14-d	0.0	0.7	0.0	0.0	0.0 d	0.3 c	10.3 b	52.3 bc
QP IPRO	4.0 fl oz	14-d	0.0	0.0	0.0	0.0	0.0 d	0.3 c	3.0 b	24.5 def
+ Foursome	0.4 fl oz									
UC-10-1	1.84 oz	14-d	0.3	0.3	0.0	1.8	0.5 cd	5.8 c	7.3 b	30.0 cd
UC-10-1	3.2 oz	14-d	2.7	2.3	0.8	3.3	0.0 d	8.0 c	18.8 b	23.8 def
QP Chlorothalonil DF	1.84 oz	14-d	0.3	0.0	0.0	0.0	0.5 cd	2.3 c	8.0 b	23.3 def
QP Chlorothalonil DF	3.2 oz	14-d	0.0	0.7	0.0	0.0	0.0 d	0.0 c	2.3 b	8.3 d-g
Chlorothalonil 720 SFT	1.84 oz	14-d	1.3	0.7	0.0	1.3	1.3 bcd	7.8 c	14.3 b	25.0 de
Chlorothalonil 720 SFT	3.2 oz	14-d	0.7	0.0	0.8	0.0	0.0 d	0.8 c	4.5 b	11.0 d-g
Echo Ultimate	1.84 oz	14-d	1.7	0.7	1.3	1.0	0.5 cd	6.0 c	6.5 b	20.3 d-g
Echo Ultimate	3.2 oz	14-d	0.0	0.3	0.0	0.0	0.0 d	0.0 c	0.3 b	3.8 efg
Daconil Ultrex	1.84 oz	14-d	0.0	0.3	0.0	0.3	0.0 d	7.5 c	8.3 b	18.0 d-g
Daconil Ultrex	3.2 oz	14-d	6.3	3.3	0.0	0.0	0.0 d	2.3 c	1.3 b	3.0 efg
TB 6-0-0	29.5 fl oz	21-d	2.3	1.7	1.0	0.5	3.0 b	21.5 b	62.3 a	88.3 a
+ LC 1-1-1	14.75 fl oz									
DPX-LEM17-76	0.3 oz	21-d	0.3	0.3	0.0	0.3	0.3 cd	0.0 c	0.8 b	3.3 efg
DPX-LEM17-76	0.5 oz	21-d	3.3	1.7	0.0	0.0	0.0 d	0.0 c	0.0 b	1.5 fg
Insignia SC	0.54 fl oz	14-d	0.0	0.0	0.0	0.0	0.0 d	0.0 c	0.0 b	0.0 g
Honor	0.83 oz	14-d	0.7	0.3	0.0	0.0	0.0 d	0.3 c	0.0 b	0.0 g
Renown	2.5 fl oz	14-d	11.3	5.0	0.0	0.0	0.0 d	0.0 c	0.0 b	0.0 g
Chipco Signature	4.0 oz	Pgm.[y]	2.7	0.7	0.0	0.0	0.0 d	0.0 c	1.3 b	8.3 d-g
Daconil Ultrex	3.2 oz									
Interface	3.0 fl oz									
Chipco Signature	4.0 oz	Pgm.[y]	0.0	0.0	0.0	0.0	0.0 d	0.0 c	0.3 b	3.8 efg
Daconil Ultrex	3.2 oz									
Interface	4.0 fl oz									
46-0-0	5.04 oz	21-d	0.3	0.0	0.0	2.0	5.5 a	32.3 a	61.3 a	88.8 a
untreated		--	0.0	0.0	0.0	0.5	2.3 bc	18.3 b	47.5 a	70.8 ab
ANOVA: Treatment (P > F)			0.474	0.641	0.474	0.360	0.0009	0.0001	0.0001	0.0001
Days after treatment		14-d	-1	6	14	14	6	3	13	20
		21-d	-1	6	14	7	13	3	13	20
		Pgm.	-1	6	14	14	6	3	13	20

[z] Applications were made every 14 days on 10 and 22 June and 8 and 24 July, or every 21 days on 10 June and 1 and 24 July.

[y] Chipco Signature was applied every 14 d, Interface was applied on 10 June and 8 July, and Daconil Ultrex was applied on 22 June and 24 July.

[x] 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. Turf quality in an 'Alister' colonial bentgrass fairway turf treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Treatment	Rate per 1000 ft^{-2}	Int.[z]	Turf quality 22 Jun	2 Jul	8 Jul	14 Jul	27 Jul	13 Aug
			-------------------- 1 – 9; 6 = min. acceptable --------------------					
QP TM	2.0 fl oz	14-d	8.0 abc [x]	8.8	8.0 cd	7.0 fgh	7.0 b-e	4.3 gh
QP TM + Foursome	2.0 fl oz + 0.4 fl oz	14-d	8.5a	9.0	8.8 ab	8.5 abc	8.3 ab	4.5 g
QP IPRO	4.0 fl oz	14-d	8.0 abc	8.8	7.8 de	7.0 fgh	8.0 abc	3.8 ghi
QP IPRO + Foursome	4.0 fl oz + 0.4 fl oz	14-d	8.3 ab	9.0	9.0 a	8.8 ab	9.0 a	4.5g
UC-10-1	1.84 oz	14-d	8.0 abc	8.8	8.3 bcd	7.3 efg	6.5 de	4.5 g
UC-10-1	3.2 oz	14-d	7.5 cd	8.5	8.0 cd	8.3 a-d	7.0 b-e	6.0 ef
QP Chlorothalonil DF	1.84 oz	14-d	7.5 cd	9.0	8.5 abc	8.3 a-d	7.0 b-e	4.5 g
QP Chlorothalonil DF	3.2 oz	14-d	8.0 abc	9.0	8.8 ab	8.0 b-e	8.5 a	6.5 de
Chlorothalonil 720 SFT	1.84 oz	14-d	7.5 cd	8.8	8.0 cd	7.3 efg	6.0 ef	4.8 fg
Chlorothalonil 720 SFT	3.2 oz	14-d	7.8 bcd	8.8	9.0 a	7.8 c-f	8.3 ab	6.0 ef
Echo Ultimate	1.84 oz	14-d	8.0 abc	9.0	7.8 de	7.8 c-f	6.5 de	4.5 g
Echo Ultimate	3.2 oz	14-d	7.8 bcd	8.8	8.5 abc	8.5 abc	8.5 a	6.8 cde
Daconil Ultrex	1.84 oz	14-d	8.5 a	9.0	8.3 bcd	8.3 a-d	6.8 cde	4.5 g
Daconil Ultrex	3.2 oz	14-d	8.3 ab	9.0	9.0 a	8.5 abc	7.8 a-d	7.0 cde
TB 6-0-0 + LC 1-1-1	29.5 fl oz + 14.75 fl oz	21-d	7.3 d	8.5	7.3 e	6.3 h	4.3 g	2.0 j
DPX-LEM17-76	0.3 oz	21-d	7.8 bcd	9.0	8.5 abc	8.8 ab	8.0 abc	6.8 cde
DPX-LEM17-76	0.5 oz	21-d	8.3 ab	9.0	9.0 a	8.8 ab	8.8 a	7.5 bcd
Insignia SC	0.54 fl oz	14-d	8.0 abc	8.8	8.5 abc	7.5 d-g	8.8 a	9.0 a
Honor	0.83 oz	14-d	8.0 abc	9.0	9.0 a	9.0 a	8.5 a	8.5 ab
Renown	2.5 fl oz	14-d	7.8 bcd	9.0	8.8 ab	8.5 abc	8.3 ab	8.0 abc
Chipco Signature / Daconil Ultrex / Interface	4.0 oz / 3.2 oz / 3.0 fl oz	Pgm. [y]	8.5 a	9.0	9.0 a	9.0 a	9.0 a	7.0 cde
Chipco Signature / Daconil Ultrex / Interface	4.0 oz / 3.2 oz / 4.0 fl oz	Pgm. [y]	8.5 a	9.0	8.8 ab	9.0 a	8.8 a	8.0 abc
46-0-0	5.04 oz	21-d	8.0 abc	8.8	7.8 de	6.8 gh	4.3 g	2.5 ij
untreated		--	8.0 abc	8.8	8.3 bcd	6.8 gh	4.8 fg	3.0 hij
ANOVA: Treatment (P > F)			0.001	0.609	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	14	10	16	6	3	20
		21-d	14	1	7	13	3	20
		Pgm.	14	10	16	6	3	20

[z] Applications were made every 14 days on 21 May, 2 and 17 June and 1 July, or every 21 days on 21 May, 10 June and 1 July. Additional applications of Concert and various materials within the rotational program were made on 16 and 30 July and 6 and 11 August.

[y] Chipco Signature was applied every 14 d, Interface was applied on 10 June and 8 July, and Daconil Ultrex was applied on 22 June and 24 July.

[x] 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 in an 'Alister' colonial bentgrass fairway turf treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Treatment Rate per 1000 ft^{-2}	Int.[z]	Phytotoxicity				
		22 Jun	2 Jul	8 Jul	14 Jul	27 Jul
		--------------- 1 – 5; 2 = min. acceptable ---------------				
QP TM…………………2.0 fl oz	14-d	1.0	1.0	1.3 bc [x]	1.3 bc	1.0
QP TM…………………2.0 fl oz + Foursome……………0.4 fl oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
QP IPRO………………..4.0 fl oz	14-d	1.0	1.0	1.3 bc	1.8 a	1.0
QP IPRO……….........4.0 fl oz + Foursome……………0.4 fl oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
UC-10-1……….………..1.84 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
UC-10-1……….……...…..3.2 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
QP Chlorothalonil DF…...1.84 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
QP Chlorothalonil DF…......3.2 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
Chlorothalonil 720 SFT….1.84 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
Chlorothalonil 720 SFT…...3.2 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
Echo Ultimate……….…..1.84 oz	14-d	1.0	1.0	1.0 c	1.3 bc	1.0
Echo Ultimate……………..3.2 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
Daconil Ultrex……….......1.84 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
Daconil Ultrex………...….3.2 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
TB 6-0-0………..……..29.5 fl oz + LC 1-1-1……….…..14.75 fl oz	21-d	1.0	1.0	1.8 a	1.5 ab	1.0
DPX-LEM17-76…….…….0.3 oz	21-d	1.0	1.0	1.0 c	1.0 c	1.0
DPX-LEM17-76………..….0.5 oz	21-d	1.0	1.0	1.0 c	1.0 c	1.0
Insignia SC…………….0.54 fl oz	14-d	1.0	1.0	1.0 c	1.3 bc	1.0
Honor…………………..……0.83 oz	14-d	1.0	1.0	1.0 c	1.0 c	1.0
Renown………...……….2.5 fl oz	14-d	1.0	1.0	1.0 c	1.3 bc	1.0
Chipco Signature……...…..4.0 oz Daconil Ultrex…………….3.2 oz Interface…………...……3.0 fl oz	Pgm. [y]	1.0	1.0	1.0 c	1.0 c	1.0
Chipco Signature…...……..4.0 oz Daconil Ultrex…………….3.2 oz Interface…………...……4.0 fl oz	Pgm. [y]	1.0	1.0	1.0 c	1.0 c	1.0
46-0-0……………......….5.04 oz	21-d	1.0	1.0	1.0 c	1.0 c	1.0
untreated	--	1.0	1.0	1.5 ab	1.5 ab	1.0
ANOVA: Treatment (P > F)		1.0	1.0	0.0001	0.004	1.0
Days after treatment	14-d	14	10	16	6	3
	21-d	14	1	7	13	3
	Pgm.	14	10	16	6	3

[z] Applications were made every 14 days on 21 May, 2 and 17 June and 1 July, or every 21 days on 21 May, 10 June and 1 July. Additional applications of Concert and various materials within the rotational program were made on 16 and 30 July and 6 and 11 August.

[y] Chipco Signature was applied every 14 d, Interface was applied on 10 June and 8 July, and Daconil Ultrex was applied on 22 June and 24 July.

[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 IN CREEPING BENTGRSS FAIRWAY TURF WITH VARIOUS FUNGICIDES, 2010

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INTRODUCTION

Dollar spot (caused by *Sclerotinia homoeocarpa*) is one of the most common diseases affecting golf course fairways throughout New England. An integrated approach employing cultural practices (e.g., increased nitrogen fertility, dew removal and proper irrigation) and preventive fungicide applications is typically required to provide season-long control of this disease. The objectives of this study were to evaluate the efficacy of various preventively and curatively applied fungicides and nitrogen sources on dollar spot control in 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. The site was irrigated as necessary to avoid drought stress.

Treatments consisted of currently available and experimental fungicides applied individually or in rotational programs, and organic and synthetic fertilizers. Fertilizer treatments were applied at a rate of 0.14 lbs N 1000-ft^{-2} and irrigated with 0.1-inch of water immediately following application. Initial treatment applications were made on 21 May prior to disease developing in the trial area. Repeat applications were made on 14 or 21 day intervals (dates listed in Tables 1 – 4) until 1 July except for Concert and the Syngenta rotational program containing Concert (Table 5), which continued until 11 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 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 was assessed as a count of individual disease foci within each plot from 27 May to 15 July, and as a percentage of the plot area blighted by *S. homoeocarpa* once disease severity increased from 17 June to 13 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 1 was equal to no discoloration and 2 represented the minimum acceptable level. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS

Dollar spot developed from a natural infestation on 27 May, six days after the initial treatment (Table 1). Disease continued to develop throughout the trial, becoming unacceptable (≥ 5% plot area blighted) by 1 July in untreated plots, and reaching 24% by 13 August (Tables 1 & 2). Most treatments provided control of dollar spot during the onset of disease in early-June, however little to no dollar spot control was observed in turf treated with QP TM, TB 6-0-0 + LC 1-1-1 and 46-0-0 (Table 1). Excellent dollar spot control (≤ 1%) was observed 14 days after the last application in turf treated with Interface, Tartan, Iprodione Pro, DPX-LEM17-76, Concert, Concert rotational program, QP Ipro, QP Myclobutanil 20 T&O, QP Propiconazole 14.3, QP Chlorothalonil 720SFT and Banner MAXX (Table 2) on 15 July. By the last observation date (43 DAT) only DMI fungicides (Tartan, Concert, Concert rotational program, QP Myclobutanil, QP Propiconizole 14.3 and Banner MAXX) and the 5.0 fl oz rate of Interface (trifloxystrobin & iprodione) provided excellent dollar spot control. Chlorothalonil treatments generally resulted in acceptable disease control until 1 August (31 DAT). Differences between chlorothalonil formulations were limited, although UC-10-1 applied at 1.84 oz was typically less effective than other formulations at the same rate (Table 2).

Emerald and Honor were applied curatively on 25 June and 6 August. A slight increase in dollar spot was observed in both treatments 3 DAT in June and August. However, Honor reduced disease 6 DAT compared to pre-treatment levels on both occasions, and Emerald had a similar effect in August. Further disease reductions were observed in both treatments on 15 July, 20 DAT.

Phytotoxic effects in the form of stunted, bluish-gray turf were periodically observed in turf treated with DMI fungicides (Table 3). These effects were generally not considered to be unacceptable, except in QP Myclobutanil 20 T&O treated turf on 15 July. When slight phytotoxcicity was observed, the addition of Foursome aided in masking these effects (Table 3).

Turf quality was high in all plots prior to dollar spot development (Table 4). Once dollar spot increased, quality in affected plots rapidly fell below acceptable levels (i.e., <6). Another factor effecting quality ratings was the addition of green pigmented materials (Stress Guard, Foursome and A14658D) in pre-mixes or as tank mix partners. Treatments containing Stress Guard (Interface, Tartan) commonly had exceptionally high turf quality. Similarly, tank mixing Foursome with QP Ipro, QP Myclobutanil 20 T&O and QP Propiconizole 14.3 improved quality on nearly all observations compared to each treatment applied alone. The experimental material A14658D applied within the Concert rotational program on 30 July and 11 August improved quality of that treatment compared to Concert by 13 August.

DISCUSSION

Dollar spot developed to a moderate level in the trial providing a good evaluation of fungicide efficacy. The most effective treatments generally were those containing a DMI fungicide or the active ingredient iprodione. Incomplete control of dollar spot resulted from a single curative application of Emerald or Honor. A follow-up application would likely have improved the level of control observed. It was also noted that approximately 6 days were required before noticeable recovery from symptoms occurred.

QP TM had no effect on dollar spot in this trial. It is possible that resistance to this material has developed at the site resulting in poor control in this trial. When using single-site mode of action fungicides, these materials should be rotated or tank mixed with multi-site materials to minimize the risk of resistance.

Dollar spot is known to be enhanced when N fertility is limiting. Additionally, some organic derived N sources have been observed to enhance dollar spot suppression. In this trial TB 6-0-0 + LC 1-1-1, an organic derived fertilizer, and urea (46-0-0) applied at equivalent N rates had no effect on dollar spot, and were no different from each other throughout the trial.

Table 1. Dollar spot incidence in a ‘Putter’ creeping bentgrass fairway turf treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Treatment Rate per 1000 ft^{-2}	Int.[z]	Dollar spot incidence[y] 27 May	9 Jun	17 Jun	24 Jun	28 Jun	1 Jul	15 Jul
		---------------------------- number of foci 18 ft^{-2}	----------------------------					
Interface…………………..3.0 fl oz	21-d	0.8	0.0 g [w]	0.0 g	0.0 e	0.3 f	0.5 gh	0.0 g
Interface…………………..…4.0 fl oz	21-d	0.8	0.0 g	0.0 g	0.0 e	0.0 f	0.8 gh	0.0 g
Interface…………………..…5.0 fl oz	21-d	0.0	0.0 g	0.0 g	0.0 e	0.0 f	0.0 h	0.0 g
Interface…………………..…6.0 fl oz	21-d	0.0	0.0 g	0.0 g	0.0 e	0.0 f	0.0 h	0.0 g
Tartan………………...…...1.5 fl oz	21-d	0.3	0.0 g	0.0 g	0.0 e	0.3 f	0.5 gh	0.0 g
Iprodione Pro………...…...4.0 fl oz	21-d	0.5	0.3 g	0.0 g	0.0 e	1.5 ef	1.5 fgh	0.0 g
DPX-LEM17-76…………….0.3 oz	21-d	0.5	0.0 g	0.0 g	0.0 e	3.8 ef	8.3 fgh	6.5 efg
DPX-LEM17-76…………….0.5 oz	21-d	6.3	0.3 g	0.0 g	0.0 e	0.5 f	2.3 fgh	0.5 fg
Emerald…………………....0.18 oz	Cur. [y]	0.8	11.5 abc	20.5 ab	34.8 a	49.3 a	42.8 abc	31.0 de
Honor…………………….…….1.1 oz	Cur.	0.5	11.5 abc	19.8 abc	28.8 abc	37.8 a-d	29.5 cde	13.8 efg
Concert…………….....…….4.5 fl oz	14-d	0.3	0.0 g	0.0 g	0.0 e	0.0 f	0.0 h	0.0 g
Concert…………….....…….4.5 fl oz	Prg. [x]	0.3	0.3 g	0.0 g	0.0 e	0.5 f	0.0 h	0.0 g
A14658D……………......3.0 fl oz	Prg.							
Primo MAXX……...…..0.25 fl oz	Prg.							
A16422A……….....……2.3 fl oz	Prg.							
Headway…………......…1.5 fl oz	Prg.							
TB 6-0-0……….....……….29.5 fl oz	21-d	1.0	12.0 ab	14.0 b-e	27.5 abc	46.3 ab	54.0 a	75.8 b
+ LC 1-1-1……………..14.75 fl oz	21-d							
46-0-0…………………......….5.04 oz	21-d	0.3	8.3 a-d	15.3 a-d	22.8 bc	32.5 cd	42.5 abc	75.5 b
QP TM………………....….2.0 fl oz	14-d	1.0	8.3 a-d	13.0 cde	24.0 bc	37.8 a-d	41.3 abc	74.5 b
QP TM………………....….2.0 fl oz	14-d	0.3	8.3 a-d	13.5 cde	21.3 c	36.3 bcd	41.3 abc	70.0 bc
+ Foursome……………….0.4 fl oz								
QP IPRO………….........4.0 fl oz	14-d	0.3	0.3 g	0.0 g	0.0 e	0.0 f	0.0 h	0.3 fg
QP IPRO…………...…...4.0 fl oz	14-d	0.3	0.0 g	0.0 g	0.0 e	0.0 f	0.0 h	0.0 g
+ Foursome……………….0.4 fl oz								
QP Myclobutanil 20 T&O..2.4 fl oz	14-d	1.0	0.8 g	0.5 g	0.3 e	0.5 f	0.0 h	0.0 g
QP Myclobutanil 20 T&O..2.4 fl oz	14-d	0.0	0.0 g	0.0 g	0.0 e	0.0 f	0.0 h	0.0 g
+ Foursome……………….0.4 fl oz								
Propiconazole 14.3……..…2.0 fl oz	14-d	0.3	0.0 g	0.0 g	0.0 e	0.0 f	0.0 h	0.0 g
Propiconazole 14.3……….2.0 fl oz	14-d	0.5	0.3 g	0.0 g	0.0 e	0.0 f	0.0 h	0.0 g
+ Foursome……………….0.4 fl oz								
UC-10-1………..…………..1.84 oz	14-d	1.3	7.0 b-f	7.8 ef	11.0 d	30.8 d	47.8 ab	71.5 bc
UC-10-1………...……...…..3.2 oz	14-d	0.3	3.0 efg	5.0 fg	1.5 e	13.8 e	31.3 bcd	47.3 cd
QP Chlorothalonil DF……..1.84 oz	14-d	0.8	3.3 d-g	2.3 fg	2.0 e	10.8 ef	18.8 def	40.8 d
QP Chlorothalonil DF…........3.2 oz	14-d	0.5	0.0 g	0.3 g	0.3 e	5.5 ef	13.5 e-h	29.8 de
Chlorothalonil 720 SFT..….1.84 oz	14-d	0.0	2.3 fg	1.3 fg	0.3 e	8.3 ef	17.8 d-g	29.5 de
Chlorothalonil 720 SFT…......3.2 oz	14-d	0.5	1.0 g	0.3 g	0.5 e	2.8 ef	5.5 fgh	12.3efg
Echo Ultimate…………..…..1.84 oz	14-d	0.5	2.3 fg	1.3 fg	1.0 e	8.3 ef	14.5 d-h	30.0 de
Echo Ultimate………....…..3.2 oz	14-d	0.3	0.3 g	0.3 g	0.0 e	1.3 ef	5.0 fgh	15.0 efg
Daconil Ultrex……..…..…...1.84 oz	14-d	0.3	2.5 efg	2.8 fg	2.0 e	9.3 ef	13.8 e-h	26.3 de
Daconil Ultrex……………....3.2 oz	14-d	0.8	6.5 c-f	4.0 fg	1.5 e	7.3 ef	15.0 d-h	25.0 def
Banner MAXX………..…..2.0 fl oz	21-d	0.3	0.3 g	0.3 g	0.0 e	0.0 f	0.0 h	0.0 g
untreated	--	0.3	7.5 a-e	12.8 de	22.5 bc	35.5 bcd	47.3 ab	85.8 ab
untreated	--	0.8	12.5 a	21.5 a	30.3 ab	45.3 abc	52.8 a	101.0 a
ANOVA: Treatment (P > F)		0.179	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment	14-d	6	2	15	7	11	14	14
	21-d	6	19	7	14	18	21	14
	Cur.	--	--	--	--	3	6	20
	Pgm.	6	2	15	7	11	14	14

[z] Applications were made every 14 days on 21 May, 2 and 17 June and 1 July, or every 21 days on 21 May, 10 June and 1 July. Additional applications of Concert and various materials within the rotational program were made on 16 and 30 July and 6 and 11 August.

[y] Curative applications were made on 25 June and 6 August.

[x] Program details are provided in Table 5.

[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 2. Dollar spot severity in a 'Putter' creeping bentgrass fairway turf treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Treatment	Rate per 1000 ft^{-2}	Int.[z]	Plot area blighted							
			17 Jun	24 Jun	28 Jun	1 Jul	15 Jul	1 Aug	9 Aug	13 Aug
			%							
Interface	3.0 fl oz	21-d	0.0 e[w]	0.0 c	0.0 f	0.0 f	0.0 h	0.3 jk	1.0 ij	1.8 ijk
Interface	4.0 fl oz	21-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.1 jk	1.8g-j	2.3 h-k
Interface	5.0 fl oz	21-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	0.8 ij	1.5 ijk
Interface	6.0 fl oz	21-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	0.1 j	0.5 ijk
Tartan	1.5 fl oz	21-d	0.0 e	0.0 c	0.0 f	0.1 f	0.0 h	0.0 k	0.6 j	0.5ijk
Iprodione Pro	4.0 fl oz	21-d	0.0 e	0.0 c	0.0 f	0.1 f	0.0 h	0.8 ijk	2.0 f-j	3.0 f-k
DPX-LEM17-76	0.3 oz	21-d	0.0 e	0.0 c	0.3 f	0.6 ef	0.4 gh	2.0 h-k	3.3 e-j	3.5 e-k
DPX-LEM17-76	0.5 oz	21-d	0.0 e	0.0 c	0.0 f	0.4 ef	0.0 h	1.0 ijk	1.8 g-j	1.9 ijk
Emerald	0.18 oz	Cur.[y]	1.4 a	3.0 a	4.0 ab	4.0 bc	2.8 def	3.8 ghi	5.0 d-j	2.8 g-k
Honor	1.1 oz	Cur.	1.4 a	3.0 a	4.3 ab	2.5 cd	1.5 e-h	3.5 g-j	4.3 d-j	2.3 h-k
Concert	4.5 fl oz	14-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.1 jk	0.0 j	0.3 jk
Concert	4.5 fl oz	Prg.[x]	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	0.1 j	0.0 k
A14658D	3.0 fl oz	Prg.								
Primo MAXX	0.25 fl oz	Prg.								
A16422A	2.3 fl oz	Prg.								
Headway	1.5 fl oz	Prg.								
TB 6-0-0	29.5 fl oz	21-d	1.1 ab	2.5 ab	4.0 ab	5.3 ab	7.0 b	11.8 b	15.0 ab	16.8 b
+ LC 1-1-1	14.75 fl oz	21-d								
46-0-0	5.04 oz	21-d	0.8 bc	2.5 ab	3.3 bcd	4.5 b	7.0 b	10.5 bcd	13.5 bc	18.0 b
QP TM	2.0 fl oz	14-d	0.8 bc	2.8 ab	3.5 abc	4.8 b	7.3 b	10.0 bcd	13.0 bc	12.8 bc
QP TM	2.0 fl oz	14-d	0.6 cd	2.0 b	2.8 cd	3.8 bc	5.8 bc	8.3 cde	8.5 cd	10.0 cd
+ Foursome	0.4 fl oz									
QP IPRO	4.0 fl oz	14-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	1.5 hij	2.3 h-k
QP IPRO	4.0 fl oz	14-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.3 k	2.0 f-j	3.3 f-k
+ Foursome	0.4 fl oz									
QP Myclobutanil 20 T&O	2.4 fl oz	14-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.1 jk	0.9 ij	0.3 jk
QP Myclobutanil 20 T&O	2.4 fl oz	14-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	0.4 j	0.8 ijk
+ Foursome	0.4 fl oz									
Propiconazole 14.3	2.0 fl oz	14-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	0.0 j	0.1 k
Propiconazole 14.3	2.0 fl oz	14-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	0.3 j	0.0 k
+ Foursome	0.4 fl oz									
UC-10-1	1.84 oz	14-d	0.3 de	0.6 c	2.1 de	4.0 bc	6.5 b	11.5 bc	14.3 ab	17.8 b
UC-10-1	3.2 oz	14-d	0.1 e	0.0 c	1.1 ef	2.8 cd	4.0 cd	7.5 def	6.5 d-h	8.5 c-f
QP Chlorothalonil DF	1.84 oz	14-d	0.1 e	0.1 c	0.8 f	1.8 de	3.3 de	6.0 efg	6.8 d-g	9.5 cd
QP Chlorothalonil DF	3.2 oz	14-d	0.0 e	0.0 c	0.4 f	0.9 ef	1.8 e-h	5.8 efg	6.5 d-h	7.5 c-h
Chlorothalonil 720 SFT	1.84 oz	14-d	0.0 e	0.0 c	0.8 f	1.5 def	3.3 de	5.8 efg	7.8 de	9.0 cde
Chlorothalonil 720 SFT	3.2 oz	14-d	0.0 e	0.0 c	0.1 f	0.4 ef	0.9 fgh	4.0 ghi	4.8 d-j	5.8 d-j
Echo Ultimate	1.84 oz	14-d	0.0 e	0.0 c	0.6 f	1.5 def	2.8def	6.0 efg	7.0 def	8.0 c-g
Echo Ultimate	3.2 oz	14-d	0.0 e	0.0 c	0.3 f	0.5 ef	1.3 fgh	4.0 ghi	4.3 d-j	5.5 d-k
Daconil Ultrex	1.84 oz	14-d	0.0 e	0.0 c	0.6 f	1.3 def	2.8 def	4.8 fgh	5.8 d-i	6.0 d-i
Daconil Ultrex	3.2 oz	14-d	0.3 de	0.0 c	0.3 f	1.4 def	2.1d-g	6.5 efg	7.3 de	7.6 c-h
Banner MAXX	2.0 fl oz	21-d	0.0 e	0.0 c	0.0 f	0.0 f	0.0 h	0.0 k	0.4 j	0.1 k
untreated		--	1.0 abc	2.8 ab	3.3 bcd	5.3 ab	7.5 b	17.8 a	16.8 ab	23.8 a
untreated		--	1.1 ab	2.8 ab	4.5 a	6.5 a	9.8 a	17.3 a	19.3 a	24.3 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	15	7	11	14	14	31	39	43
		21-d	7	14	18	21	14	31	39	43
		Cur.	--	--	3	6	20	37	3	7
		Pgm.	15	7	11	14	14	2	10	2

[z] Applications were made every 14 days on 21 May, 2 and 17 June and 1 July, or every 21 days on 21 May, 10 June and 1 July. Additional applications of Concert and various materials within the rotational program were made on 16 and 30 July and 6 and 11 August.

[y] Curative applications were made on 25 June and 6 August.

[x] Program details are provided in Table 5.

[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).

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Table 3. Phytotoxicity in a 'Putter' creeping bentgrass fairway turf treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Treatment Rate per 1000 ft^{-2}	Int.[z]	Phytotoxicity						
		27 May	17 Jun	24 Jun	1 Jul	15 Jul	1 Aug	13 Aug
		--------------------------- 1 – 5; 2 = min. acceptable ---------------------------						
Interface…………………..…..3.0 fl oz	21-d	1.0 c [w]	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Interface…………………..…..4.0 fl oz	21-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.3 b	1.0
Interface…………………..…..5.0 fl oz	21-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Interface…………………..…..6.0 fl oz	21-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Tartan………………...…...1.5 fl oz	21-d	1.3 bc	1.0 c	1.0	1.0	1.5 cd	2.0 a	1.0
Iprodione Pro……….....…...4.0 fl oz	21-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
DPX-LEM17-76…………….0.3 oz	21-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
DPX-LEM17-76…………….0.5 oz	21-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Emerald…………………....0.18 oz	Cur. [y]	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Honor……………………..…….1.1 oz	Cur.	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Concert……………...…….4.5 fl oz	14-d	1.0 c	1.0 c	1.0	1.0	1.5 cd	2.0 a	1.0
Concert……………...…….4.5 fl oz	Prg. [x]	1.3 bc	2.0 a	2.0	1.0	2.0 b	1.0 b	1.0
A14658D……………......3.0 fl oz	Prg.							
Primo MAXX……...…..0.25 fl oz	Prg.							
A16422A………...….….2.3 fl oz	Prg.							
Headway……………....….1.5 fl oz	Prg.							
TB 6-0-0………...……….29.5 fl oz	21-d	1.5 b	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
+ LC 1-1-1……………..14.75 fl oz	21-d							
46-0-0………………......….5.04 oz	21-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
QP TM………………...….2.0 fl oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
QP TM………………...….2.0 fl oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
+ Foursome……………….0.4 fl oz								
QP IPRO…………….........4.0 fl oz	14-d	1.3 bc	1.0 c	1.0	1.0	1.3 de	1.0 b	1.0
QP IPRO……………...…...4.0 fl oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
+ Foursome……………….0.4 fl oz								
QP Myclobutanil 20 T&O..2.4 fl oz	14-d	2.0 a	1.3 b	1.0	1.0	2.5 a	1.8 a	1.0
QP Myclobutanil 20 T&O..2.4 fl oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.3 b	1.0
+ Foursome……………….0.4 fl oz								
Propiconazole 14.3……..…2.0 fl oz	14-d	1.3 bc	1.3 b	1.0	1.0	1.8 bc	1.8 a	1.0
Propiconazole 14.3……….2.0 fl oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.8 a	1.0
+ Foursome……………….0.4 fl oz								
UC-10-1………..………….1.84 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
UC-10-1………..………..….3.2 oz	14-d	1.0 c	1.3 b	1.0	1.0	1.0 e	1.0 b	1.0
QP Chlorothalonil DF……..1.84 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
QP Chlorothalonil DF…........3.2 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Chlorothalonil 720 SFT..…..1.84 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Chlorothalonil 720 SFT…......3.2 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Echo Ultimate…………….…..1.84 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Echo Ultimate…………...…..3.2 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Daconil Ultrex………..…...1.84 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Daconil Ultrex…………...…..3.2 oz	14-d	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
Banner MAXX………..…..2.0 fl oz	21-d	1.0 c	1.3 b	1.0	1.0	1.3 de	1.3 b	1.0
untreated	--	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
untreated	--	1.0 c	1.0 c	1.0	1.0	1.0 e	1.0 b	1.0
ANOVA: Treatment (P > F)		0.0001	0.0001	1.0	1.0	0.0001	0.0001	1.0
Days after treatment	14-d	6	15	7	14	14	31	43
	21-d	6	7	14	21	14	31	43
	Cur.	--	--	--	6	20	37	7
	Pgm.	6	15	7	14	14	2	14

[z] Applications were made every 14 days on 21 May, 2 and 17 June and 1 July, or every 21 days on 21 May, 10 June and 1 July. Additional applications of Concert and various materials within the rotational program were made on 16 and 30 July and 6 and 11 August.

[y] Curative applications were made on 25 June and 6 August.

[x] Program details are provided in Table 5.

[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 4. Turf quality in a 'Putter' creeping bentgrass fairway turf treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Treatment Rate per 1000 ft^{-2}	Int.[z]	Turf quality 27 May	17 Jun	24 Jun	1 Jul	15 Jul	1 Aug	13 Aug
		--------------------------- 1 – 9; 6 = min. acceptable ---------------------------						
Interface…………………..….3.0 fl oz	21-d	8.5 ab [w]	8.3 a-d	8.5 abc	8.5abc	8.0 b-e	7.8 abc	6.3 cde
Interface…………………..….4.0 fl oz	21-d	8.8 a	8.5 abc	8.5 abc	8.5 abc	8.5 abc	7.8 abc	6.5 b-e
Interface…………………..….5.0 fl oz	21-d	8.3 abc	8.8 ab	9.0 a	8.8 ab	8.3 a-d	8.3 a	6.8 cde
Interface…………………..….6.0 fl oz	21-d	8.5 ab	9.0 a	9.0 a	8.8 ab	9.0 a	8.3 a	7.8 a
Tartan………………...…...1.5 fl oz	21-d	8 a-d	8.0 b-e	8.5 abc	8.0 bcd	7.0 f-i	6.5 def	6.8 bcd
Iprodione Pro………...…...4.0 fl oz	21-d	7.8 bcd	7.3 e-h	8.5 abc	8.0 bcd	7.5 d-g	6.8 cde	6.3 cde
DPX-LEM17-76…………….0.3 oz	21-d	8.5 ab	8.0 b-e	9.0 a	7.5 def	7.8 c-f	6.5 def	5.8 efg
DPX-LEM17-76…………….0.5 oz	21-d	8.0 a-d	7.5 d-g	8.0 b-e	8.0 bcd	8.8 ab	7.8 abc	6.5 b-e
Emerald…………………....0.18 oz	Cur. [y]	8.0 a-d	5.8 j	6.0 gh	5.8 j-m	5.8 jkl	5.5 fgh	6.0 def
Honor……………………..…….1.1 oz	Cur.	8.5 ab	6.3 ij	5.5 h	6.3 h-k	6.8 ghi	5.5fgh	6.5 b-e
Concert……………...…….4.5 fl oz	14-d	7.8 bcd	7.8 c-f	7.8 cde	7.8 cde	7.0 f-i	6.0 efg	6.5 b-e
Concert……………...…….4.5 fl oz	Prg. [x]	7.5 cde	7.3 e-h	7.3 ef	7.3 d-g	7.3 e-h	7.0 b-e	7.0 abc
A14658D……………....3.0 fl oz	Prg.							
Primo MAXX……..…..0.25 fl oz	Prg.							
A16422A………...…….2.3 fl oz	Prg.							
Headway…………....….1.5 fl oz	Prg.							
TB 6-0-0………...……….29.5 fl oz	21-d	7.5 cde	6.8 ghi	5.8 h	5.5 klm	3.8 p	3.8 klm	3.8 jkl
+ LC 1-1-1……………..14.75 fl oz	21-d							
46-0-0………………......….5.04 oz	21-d	8.8 a	6.8 ghi	6.0 gh	5.8 j-m	4.0 op	4.3 i-m	3.5 kl
QP TM………………....….2.0 fl oz	14-d	7.8 bcd	6.5 hij	5.8 h	5.5 klm	4.3 nop	4.0 j-m	4.3 ijk
QP TM………………....….2.0 fl oz	14-d	8.5 ab	7.0 f-i	6.8 fg	5.8 j-m	4.8 mno	4.5 h-l	4.5 hij
+ Foursome……………….0.4 fl oz								
QP IPRO………….........4.0 fl oz	14-d	7.8 bcd	7.5 d-g	7.8 cde	6.8 f-i	7.3 e-h	6.8 cde	5.8 efg
QP IPRO……………..…...4.0 fl oz	14-d	8.8 a	8.8 ab	9.0 a	9.0 a	8.8 ab	8.0 ab	6.3 cde
+ Foursome……………….0.4 fl oz								
QP Myclobutanil 20 T&O..2.4 fl oz	14-d	6.8 a	6.8 ghi	7.5 def	7.3 d-g	6.5 hij	6.8 cde	6.8 bcd
QP Myclobutanil 20 T&O..2.4 fl oz	14-d	8.5 ab	8.8 ab	8.8 ab	8.8 ab	9.0 a	8.0 ab	7.0 abc
+ Foursome……………….0.4 fl oz								
Propiconazole 14.3……..…2.0 fl oz	14-d	7.3 de	7.0 f-i	7.3 ef	7.0 e-h	7.3 e-h	7.0 b-e	6.5 b-e
Propiconazole 14.3……….2.0 fl oz	14-d	8.3 abc	8.8 ab	8.8 ab	8.8 ab	8.8 ab	7.5 a-d	7.3 ab
+ Foursome……………….0.4 fl oz								
UC-10-1………..…………..1.84 oz	14-d	8.0 a-d	7.3 e-h	7.3 ef	6.0 i-l	5.0 lmn	3.8 klm	3.8 jkl
UC-10-1………..………..…..3.2 oz	14-d	8.3 abc	7.3 e-h	8.0 b-e	6.5 g-j	5.3 lm	4.8 h-k	4.8 hi
QP Chlorothalonil DF……..1.84 oz	14-d	7.8 bcd	7.3 e-h	7.3 ef	6.8 f-i	5.5 klm	4.8 h-k	4.5 hij
QP Chlorothalonil DF…........3.2 oz	14-d	7.8 bcd	8.3 a-d	8.5 abc	7.3 d-g	6.3 ijk	5.0 g-j	5.0 ghi
Chlorothalonil 720 SFT..…..1.84 oz	14-d	8.0 a-d	7.3 e-h	8.5 abc	7.0 e-h	5.8 jkl	4.8 h-k	4.5 hij
Chlorothalonil 720 SFT….....3.2 oz	14-d	7.8 bcd	7.8 c-f	8.3 a-d	7.8 cde	7.0 f-i	5.5 fgh	5.3 fgh
Echo Ultimate…………..…..1.84 oz	14-d	8.5 ab	7.5 d-g	8.0 b-e	7.0 e-h	5.5 klm	5.0 g-j	4.5 hij
Echo Ultimate…………....…3.2 oz	14-d	8.0 a-d	7.5 d-g	8.5 abc	7.8 cde	6.3 ijk	5.5 fgh	5.3 fgh
Daconil Ultrex…………..…..1.84 oz	14-d	8.3 abc	7.8 c-f	8.3 a-d	7.3 d-g	5.5 klm	4.8 h-k	5.0 ghi
Daconil Ultrex…………....…3.2 oz	14-d	7.8 bcd	7.5 d-g	8.0 b-e	7.0 e-h	6.3 ijk	5.3 ghi	5.0 ghi
Banner MAXX………..…..2.0 fl oz	21-d	7.8 bcd	6.8 ghi	7.8 cde	7.3 d-g	7.3 e-h	7.3 a-d	6.8 bcd
untreated	--	8.0 a-d	6.5 hij	6.0 gh	5.3 lm	3.8 p	3.3 m	3.3 l
untreated	--	7.8 bcd	6.3 ij	5.5 h	5.0 m	3.5 p	3.5 lm	3.5 kl
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment	14-d	6	15	7	14	14	31	43
	21-d	6	7	14	21	14	31	43
	Cur.	--	--	--	6	20	37	7
	Pgm.	6	15	7	14	14	2	14

[z] Applications were made every 14 days on 21 May, 2 and 17 June and 1 July, or every 21 days on 21 May, 10 June and 1 July. Additional applications of Concert and various materials within the rotational program were made on 16 and 30 July and 6 and 11 August.

[y] Curative applications were made on 25 June and 6 August.

[x] Program details are provided in Table 5.

[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 5. Syngenta dollar spot control program evaluated in a 'Putter' creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2010.

Application date	Treatment	Rate per 1000 ft^{-2}
21 May	Concert	4.0 fl oz
	+ Primo MAXX	0.2 fl oz
2 Jun	Concert	4.0 fl oz
	+ Primo MAXX	0.2 fl oz
17 Jun	A16422A	2.3 fl oz
	+ Primo MAXX	0.2 fl oz
1 Jul	Headway	1.39 fl oz
	+ Primo MAXX	0.2 fl oz
16 Jul	Headway	1.39 fl oz
	+ Primo MAXX	0.2 fl oz
30 Jul	A16422A	2.3 fl oz
	+ Primo MAXX	0.2 fl oz
	+ A14658D	3.0 fl oz
11 Aug	Concert	4.0 fl oz
	+ A14658D	3.0 fl oz
	+ Primo MAXX	0.2 fl oz

PREVENTIVE DOLLAR SPOT CONTROL IN A MIXED CREEPING BENTGRSS AND ANNUAL BLUEGRASS PUTTING GREEN TURF WITH VARIOUS FUNGICIDES, 2010

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INTRODUCTION

Dollar spot (caused by *Sclerotinia homoeocarpa*) is A common diseases affecting golf course putting greens throughout New England. An integrated approach employing cultural practices (e.g., increased nitrogen fertility, dew removal and proper irrigation) and preventive fungicide applications is typically required to provide season-long control of this disease. The objective of this study was to evaluate the efficacy of various fungicides applied preventively to control dollar spot on creeping bentgrass putting green turf.

MATERIALS & METHODS

A field study was conducted on a mixed 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*; < 10%) 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 0.130-inches. The site was irrigated as necessary to avoid drought stress.

Treatments consisted of various fungicides applied individually or as tank mixes and rotational programs. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. Treatments were initiated prior to dollar spot development on 21 May and continued until 16 July, except rotational programs containing Interface which were applied until 26 August. Specific application dates are provided in tables 1 – 3. 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.

Dollar spot was assessed as a count of individual disease foci within each plot from 30 June to 13 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 a 1 to 5 scale; where 1 was equal to no discoloration and 2 represented the minimum acceptable level. Algae severity was assessed on a 1 to 9 scale where 1 equaled no algae, 3 equaled an acceptable level of algae severity, and 9 equaled turf completely covered by algae. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS

Dollar spot pressure was very low likely due to temperatures exceeding optimum conditions for disease development during the trial. Therefore, no differences in dollar spot incidence were observed among the treatments evaluated in this trial (Tables 1).

Turf quality was generally good among all treatments throughout the trial except on 14 July when a severe infestation of algae occurred (Table 2). The greatest level of turf quality was generally observed in plots treated with materials containing the green pigmented Stress Guard (Reserve, Interface) or rotational programs containing Foursome, a green pigmented tracking dye (Table 2). No quality differences were observed between various rates or application intervals of Reserve or Interface throughout the trial. The presence of algae in the trial area significantly influenced quality ratings on 14 July. On this date, only treatments containing chlorothalonil maintained acceptable quality. By the last observation date (13 Aug) treatments last applied 28 days earlier had less effect on quality, although slight improvements were still observed in turf treated with Reserve, Insignia SC, Daconil Ultrex and the rotational program containing the growth regulator T-NEX. As expected, rotational programs lasting into August also continued to provide excellent turf quality on this date. None of the treatments resulted in phytotoxicity at the rates and intervals evaluated in this trial.

A severe algae infestation occurred uniformly throughout the trial on 14 July. Treatments containing the active ingredient chlorothalonil (Daconil Ultrex, Reserve, Concert, QP Chlorothalonil DF) provided complete control of algae (Table 1). Conversely, algae severity was greater in turf treated with Insignia SC compared to untreated. No algae differences were observed among remaining treatments.

DISCUSSION

Due to low disease pressure in the trial conclusions regarding the efficacy of materials tested are not possible at this time. However, many treatments improved turf quality compared to untreated turf in the absence of disease. Moreover, no phytotoxic effects were observed despite repeated DMI applications during prolonged high temperatures in 2010. Higher rates of DMI's would likely result in adverse effects on quality, but the rates and intervals evaluated in this trial did not appear to have a negative effect on creeping bentgrass growth.

Table 1. Dollar spot incidence and algae severity in a mixed 'Penn-A4' creeping bentgrass and annual bluegrass turf maintained at 0.130 inches treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010

Treatment Rate per 1000 ft^{-2}	Application schedule[z]	Dollar spot incidence				Algae severity
		30 Jun	14 Jul	1 Aug	13 Aug	14 Jul
		-------- number of foci per 18 ft^{-2} --------				---- 1 – 9 ----
Reserve………...……..2.5 fl oz	ABCDEFGHI	0.0	0.0	0.0	0.0	1.0 c[y]
Reserve…………....…3.2 fl oz	ACEGI	0.0	0.0	0.0	0.3	1.0 c
Reserve…………...…3.5 fl oz	ACEGI	0.0	0.0	0.0	0.3	1.0 c
Concert…………...…..5.5 fl oz	ACEGI	0.0	0.0	0.0	0.3	1.0 c
Interface…………...…3.0 fl oz	ACEGI	0.0	0.0	0.0	1.0	4.5 ab
Interface…….…..……4.0 fl oz	ACEGI	0.3	0.0	0.3	0.8	4.5 ab
Interface……….…...…5.0 fl oz	ACEGI	0.0	0.0	0.0	0.0	4.8 ab
Iprodione Pro…..……..4.0 fl oz	ACEGI	0.5	0.0	0.0	0.5	4.0 b
Emerald……….……....0.13 oz	ACEGI	0.3	0.0	0.0	0.3	4.3 ab
Honor……………….…0.83 oz	ACEGI	0.3	0.0	0.0	0.3	4.8 ab
+ Iprodione Pro…...….4.0 fl oz						
Chipco Signature……….4.0 oz	ACEGIKMO	0.0	0.0	0.0	0.0	1.0 c
Triton FLO……...…0.5 fl oz	AE					
Daconil Ultrex……..…3.2 oz	CGK					
Interface……………3.0 fl oz	IM					
Tartan…………...…1.5 fl oz	O					
Chipco Signature…...…..4.0 oz	ACEGIKMO	0.0	0.0	0.0	0.5	1.0 c
Interface…...........…3.0 fl oz	A					
Interface………...…4.0 fl oz	M					
Daconil Ultrex……......3.2 oz	CGK					
Triton FLO………....0.5 fl oz	E					
Tartan……………..…..1.5 fl oz	IO					
Emerald……………..…0.18 oz	ACEGI	0.0	0.0	0.3	0.0	4.5 ab
Insignia SC…………..…0.7 fl oz	ACEGI	0.0	0.0	1.0	0.0	5.5 a
Fosetyl-Al……………....4.0 oz	AEGI	0.0	0.0	0.0	0.3	1.0 c
Propiconazole 14.3...1.0 fl oz	A					
Foresome………..……0.4 fl oz	ACEGI					
Disarm……………0.18 fl oz	C					
TM/C……….......……4.0 oz	E					
Chlorothalonil DF...….3.2 oz	G					
Myclobutanil…...…..1.2 fl oz	I					
Fosetyl-Al………......…4.0 oz	ACEGI	0.0	0.0	0.0	0.3	1.0 c
Propiconazole 14.3....1.0 fl oz	A					
Foresome…….……..0.4 fl oz	ACEGI					
Disarm……....……0.18 fl oz	C					
TM/C……………......…4.0 oz	E					
Chlorothalonil DF….....3.2 oz	G					
Myclobutanil……....1.2 fl oz	I					
T-NEX…………..0.125 fl oz	ACEGI					
Daconil Ultrex……...…..3.2 oz	ACEGI	0.0	0.0	0.3	0.5	1.0 c
Compass…...............…..0.1 oz	ACEGI	0.0	0.0	0.0	0.5	4.0 b
Banner MAXX……….0.5 fl oz	ACEGI	0.0	0.0	0.0	0.3	4.3 ab
Untreated	--	0.0	0.0	0.3	0.8	3.5 b
ANOVA: Treatment (P > F)		0.128	1.0	0.620	0.688	0.0001
Days after treatment	ABCDEFGHI	5	6	16	28	6
	ACEGI	15	13	16	28	13
	Pgm.	15	13	2	2	13

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 21 May, B = 27 May, C = 2 June, D = 11 June, E = 15 June, F = 25 June, G = 1 July, H = 8 July, I = 16 July, K = 30 July, M = 11 August, O = 26 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 (α = 0.05).

Table 2. Turf quality in a mixed 'Penn-A4' creeping bentgrass and annual bluegrass turf maintained at 0.130 inches treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010

Treatment	Rate per 1000 ft^{-2}	Application schedule[z]	Turf quality					
			27 May	16 Jun	30 Jun	14 Jul	1 Aug	13 Aug
			---------------------- 1 – 9; 6 = min. acceptable ----------------------					
Reserve	2.5 fl oz	ABCDEFGHI	7.3 b-e[y]	7.8 abc	8.8 a	7.5 bc	8.3 abc	7.5 a-d
Reserve	3.2 fl oz	ACEGI	7.5 a-d	7.5 a-d	8.3 ab	7.5 bc	8.3 abc	7.8 abc
Reserve	3.5 fl oz	ACEGI	7.3 b-e	7.0 b-e	8.3 ab	6.5 cd	7.8 a-d	7.8 abc
Concert	5.5 fl oz	ACEGI	6.3 e	6.3 ef	7.3 c-f	5.8 de	6.8 def	6.0 d
Interface	3.0 fl oz	ACEGI	7.8 abc	8.0 ab	7.8 bcd	4.5 efg	6.8 def	6.0 d
Interface	4.0 fl oz	ACEGI	7.5 a-d	8.3 a	8.0 abc	4.5 efg	7.5 b-e	6.8 bcd
Interface	5.0 fl oz	ACEGI	8.3 ab	8.0 ab	7.8 bcd	5.3 def	7.8 a-d	6.8 bcd
Iprodione Pro	4.0 fl oz	ACEGI	6.8 cde	5.8 f	6.5 fg	4.3 fg	7.0 c-f	7.0 bcd
Emerald	0.13 oz	ACEGI	7.3 b-e	6.8 c-f	7.5 b-e	4.5 efg	7.5 b-e	7.0 bcd
Honor	0.83 oz	ACEGI	6.8 cde	6.5 def	6.8 efg	4.0 fg	6.8 def	6.5 cd
+ Iprodione Pro	4.0 fl oz							
Chipco Signature	4.0 oz	ACEGIKMO	7.8 abc	7.8 abc	8.3 ab	8.0 ab	8.8 ab	9.0 a
Triton FLO	0.5 fl oz	AE						
Daconil Ultrex	3.2 oz	CGK						
Interface	3.0 fl oz	IM						
Tartan	1.5 fl oz	O						
Chipco Signature	4.0 oz	ACEGIKMO	8.3 ab	8.0 ab	8.8 a	8.8 ab	8.5 ab	8.3 ab
Interface	3.0 fl oz	A						
Interface	4.0 fl oz	M						
Daconil Ultrex	3.2 oz	CGK						
Triton FLO	0.5 fl oz	E						
Tartan	1.5 fl oz	IO						
Emerald	0.18 oz	ACEGI	6.8 cde	6.0 ef	7.0 d-g	4.0 fg	6.5 def	6.5 cd
Insignia SC	0.7 fl oz	ACEGI	6.8 cde	7.0 b-e	7.5 b-e	4.0 fg	7.8 a-d	7.5 a-d
Fosetyl-Al	4.0 oz	AEGI	8.5 a	8.5 a	8.8 a	9.0 a	8.8 ab	6.5 cd
Propiconazole 14.3	1.0 fl oz	A						
Foresome	0.4 fl oz	ACEGI						
Disarm	0.18 fl oz	C						
TM/C	4.0 oz	E						
Chlorothalonil DF	3.2 oz	G						
Myclobutanil	1.2 fl oz	I						
Fosetyl-Al	4.0 oz	ACEGI	8.5 a	8.5 a	8.8 a	8.8 ab	9.0 a	7.8 abc
Propiconazole 14.3	1.0 fl oz	A						
Foresome	0.4 fl oz	ACEGI						
Disarm	0.18 fl oz	C						
TM/C	4.0 oz	E						
Chlorothalonil DF	3.2 oz	G						
Myclobutanil	1.2 fl oz	I						
T-NEX	0.125 fl oz	ACEGI						
Daconil Ultrex	3.2 oz	ACEGI	7 cde	6.5 def	7.8 bcd	6.3 cd	8.3 abc	7.5 a-d
Compass	0.1 oz	ACEGI	7.3 b-e	6.8 c-f	6.8 efg	3.8 g	6.3 ef	6.5 cd
Banner MAXX	0.5 fl oz	ACEGI	7.3 b-e	6.3 ef	6.3 g	3.8 g	6.8 def	6.3 cd
Untreated		--	6.5 de	5.8 f	6.3 g	4.3 fg	6.0 f	6.3 cd
ANOVA: Treatment (P > F)			0.0002	0.0001	0.0001	0.0001	0.0001	0.022
Days after treatment		ABCDEFGHI	6	1	5	6	16	28
		ACEGI	6	1	15	13	16	28
		Pgm.	6	1	15	13	2	2

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 21 May, B = 27 May, C = 2 June, D = 11 June, E = 15 June, F = 25 June, G = 1 July, H = 8 July, I = 16 July, K = 30 July, M = 11 August, O = 26 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 (α = 0.05).

Table 3. Phytotoxicity in a mixed 'Penn-A4' creeping bentgrass and annual bluegrass turf maintained at 0.130 inches treated preventively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2010

Treatment Rate per 1000 ft^{-2}	Application schedule[z]	Phytotoxicity 27 May	16 Jun	30 Jun	13 Aug
		----------- 1 – 5; 2 = min. acceptable -----------			
Reserve……….……2.5 fl oz	ABCDEFGHI	1.0	1.0	1.0	1.0
Reserve…………....…3.2 fl oz	ACEGI	1.0	1.0	1.0	1.0
Reserve…………....…3.5 fl oz	ACEGI	1.0	1.0	1.0	1.0
Concert………….…...5.5 fl oz	ACEGI	1.0	1.0	1.0	1.0
Interface…………....…3.0 fl oz	ACEGI	1.0	1.0	1.0	1.0
Interface………..……4.0 fl oz	ACEGI	1.0	1.0	1.0	1.0
Interface…………...…5.0 fl oz	ACEGI	1.0	1.0	1.0	1.0
Iprodione Pro…….……4.0 fl oz	ACEGI	1.0	1.0	1.0	1.0
Emerald……….……....0.13 oz	ACEGI	1.0	1.0	1.0	1.0
Honor………………….…0.83 oz	ACEGI	1.0	1.0	1.0	1.0
+ Iprodione Pro…...….4.0 fl oz					
Chipco Signature……….4.0 oz	ACEGIKMO	1.0	1.0	1.0	1.0
Triton FLO……...…0.5 fl oz	AE				
Daconil Ultrex……..…3.2 oz	CGK				
Interface……………3.0 fl oz	IM				
Tartan…………...…1.5 fl oz	O				
Chipco Signature…...…..4.0 oz	ACEGIKMO	1.0	1.0	1.0	1.0
Interface…..........…3.0 fl oz	A				
Interface………...…4.0 fl oz	M				
Daconil Ultrex……......3.2 oz	CGK				
Triton FLO………....0.5 fl oz	E				
Tartan……………..…..1.5 fl oz	IO				
Emerald…………….…0.18 oz	ACEGI	1.0	1.0	1.0	1.0
Insignia SC………..….0.7 fl oz	ACEGI	1.0	1.0	1.0	1.0
Fosetyl-Al……………....4.0 oz	AEGI	1.0	1.0	1.0	1.0
Propiconazole 14.3...1.0 fl oz	A				
Foresome…….…….0.4 fl oz	ACEGI				
Disarm……………0.18 fl oz	C				
TM/C……….......……4.0 oz	E				
Chlorothalonil DF...….3.2 oz	G				
Myclobutanil…...…..1.2 fl oz	I				
Fosetyl-Al……….....….4.0 oz	ACEGI	1.0	1.0	1.0	1.0
Propiconazole 14.3....1.0 fl oz	A				
Foresome…….……..0.4 fl oz	ACEGI				
Disarm……....……0.18 fl oz	C				
TM/C……………......…4.0 oz	E				
Chlorothalonil DF…......3.2 oz	G				
Myclobutanil……......1.2 fl oz	I				
T-NEX…………..0.125 fl oz	ACEGI				
Daconil Ultrex……...…..3.2 oz	ACEGI	1.0	1.0	1.0	1.0
Compass…...................….0.1 oz	ACEGI	1.0	1.0	1.0	1.0
Banner MAXX……….0.5 fl oz	ACEGI	1.0	1.0	1.0	1.0
Untreated	--	1.0	1.0	1.0	1.0
ANOVA: Treatment (P > F)		1.0	1.0	1.0	1.0
Days after treatment	ABCDEFGHI	6	1	5	28
	ACEGI	6	1	15	28
	Pgm.	6	1	15	2

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 21 May, B = 27 May, C = 2 June, D = 11 June, E = 15 June, F = 25 June, G = 1 July, H = 8 July, I = 16 July, K = 30 July, M = 11 August, O = 26 August.

PREVENTIVE TAKE-ALL PATCH CONTROL IN FAIRWAY TURF WITH VARIOUS FUNGICIDES, 2010

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INTRODUCTION

Take-all patch is a problematic disease of recently established bentgrass turf. The fungus causing take-all patch (*Gaeumannomyces graminis* var. *avenae*) infects roots, stolons and tillers during cool, wet conditions in the Spring and Fall. Take-all can be difficult to control because symptoms are often observed weeks after infection has occurred. Preventive fungicide applications and cultural practices are typically required to achieve acceptable disease control. However, few trials have provided data on the efficacy of preventive fungicide applications due to in the inconsistent or non-uniform appearance of the disease in the field. The objective of this trial was to evaluate the efficacy of preventive applications of currently available and experimental fungicides for control of take-all patch.

MATERIALS & METHODS

A field trial was conducted on a fairway with a history of take-all patch at Wintonbury Hills Golf Course in Bloomfield, CT during 2010. The trial area was comprised of a creeping bentgrass (*Agrostis stolonifera*) turf. Management of the area was typical of fairway turf in New England, although no fungicides were applied prior to, or during the trial.

Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. Initial treatments were made prior to symptom development on 14 April with subsequent applications on 5 and 26 May (21 d interval) except A14658A which was only applied on the last two application dates. Materials were applied in two consecutive passes over the plot area with a single AI9508E flat fan nozzle calibrated to deliver 2 gal water 1000-ft^{-2} at 40 psi; the two passes resulting in a total carrier volume of 4 gal water 1000-ft^{-2}.

Take-all patch incidence was assessed visually as a percentage of the plot area blighted. However, take-all patch incidence was low and inconsistent throughout the trial area. Moreover, identification of disease symptoms was complicated by turf decline due to environmental stress (i.e., drought and heat) in the trial area. Thus, turf decline during the trial is reported as plot area damaged by take-all patch and environmental stress. Severity ratings are reported on a scale of 1 to 5, where 1 was equal to no visible turf decline, and 5 equal to patches of necrotic turf containing no green foliage. These ratings also reflect the influence of environmental stress in addition to take-all patch on turf decline.

Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the highest quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 1 equaled no discoloration and 2 represented the minimum acceptable level.

Turf color was evaluated as grass color index based on reflectance of red, green and blue wavelengths using a FieldScout TCM 500 Turf Color Meter (Spectrum Technologies, Inc.) on 14 April. Thereafter, differences in turf canopy reflectance were evaluated as normalized difference vegetative index values (NDVI) using a FieldScout TCM 500 NDVI Turf Color Meter (Spectrum Technologies, Inc.). Regardless of reflectance method, three measurements were taken on dry, asymptomatic turf per plot and the mean value was analyzed and reported. Canopy temperature was determined using an infrared thermometer. Two measurements were taken per plot and averaged for comparison among treatments.

All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS

No differences in take-all patch incidence and severity were observed among the treatments evaluated in this trial (Tables 1 & 2). Despite a history of take-all patch at this site, disease was limited in distribution and intensity in the trial area. Moreover, environmental conditions unfavorable for turfgrass growth also appeared to cause turf to decline within the trial area; making an accurate assessment of take-all patch incidence and severity difficult.

Symptoms appeared initially on 26 May as wilted and/or slightly bronzed turf occurring in sporadic patches within the trial area. However, low disease incidence and limited distribution prevented treatment differences from being detected on this date (Table 1). Recovery of initial symptoms had occurred by 14 June following an extended period of rainfall. By late June, the onset of high temperatures and drought stress appeared to be contributing to turf decline, in addition to take-all patch, within portions of the trial area. An increase in the incidence and severity of turf decline within treated plots was apparent by the last two observation dates of the trial. Considerable numeric differences were observed among treatments on these two dates, although the failure to detect significant treatment differences suggests that abiotic stress (i.e., environment and traffic) likely had a considerable effect on turf at this time.

Turf quality was generally good among all treatments prior to turf decline in late-June and July (Table 3). Turf treated with Reserve, Heritage TL and Triton FLO tended to have the highest turf quality ratings from May to mid-June (Table 3). Conversely, quality of turf treated with various rates of A9898A applied alone or in combination with other materials was reduced compared to untreated turf on 5 May (Table 3). This was primarily due the phytotoxic effect of this material (Table 4) resulting in a grayish blue-green appearance with a coarse, stunted growth habit. Despite the noticeable change in turfgrass appearance, quality was acceptable throughout the trial, except at the high rate of A9898A on 29 July when turf appeared to be declining due to abiotic stress. A similar, yet less severe, phytotoxic response was also observed periodically in turf treated with A12910C, A18124A, Reserve (4.5 fl oz), Concert, Triton FLO and Bayleton. However, the effect subsided by 30 June (35 days after treatment).

Normalized difference vegetative index values did not differ among treatments on most dates throughout the trial, except on 5 May (Table 5). On this date, turf treated with A17386A, A18124A, Reserve (4.5 fl oz) and Triton FLO had higher NDVI values than most treatments in the trial, and also tended to have better turf quality. However, the relationship between NDVI and turf quality was less apparent on the remaining evaluation dates in this trial. Potential NDVI differences among treatments may be better resolved in future trials by increasing the number of readings per plot (e.g., 10 readings per plot) to obtain a more representative sample.

Canopy temperatures taken from plots during the trial did not indicate any significant treatment differences (Table 6). Similarly, increasing the number of readings per plot would likely improve identification of potential treatment differences.

DISCUSSION

Due to limited disease pressure in the trial conclusions regarding the efficacy of materials tested are not possible at this time. Future studies conducted at inoculated locations would likely improve the predictability of disease incidence and results obtained. The phytotoxic effect of some of the materials tested reduced turf quality (although still acceptable) at the rates and interval tested in this trial. Evaluating these materials (e.g., A9898A) at extended application intervals may be helpful in optimizing application parameters for disease control and turf quality. This may be particularly important if these materials are applied to turf already treated with plant growth regulators.

ACKNOWLEDGEMENTS

The UCONN Turfgrass Science Program would like to express our appreciation to Mark Mansur, his staff at Wintonbury Hills Golf Course for their cooperation in conducting this research.

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Table 1. Turf decline in creeping bentgrass fairway turf treated preventively with fungicides at Wintonbury Hills Golf Course in Bloomfield, CT during 2010.

Treatment	Rate per 1000 ft^{-2}	Int.[z]	Plot area damaged[y] 26-May	14-Jun	30-Jun	29-Jul
			---------------------------- %	----------------------------		
A9898A………………….	0.96 fl oz	21-d	0.8	0.0	5.0	3.0
A9898A……….....…..……	0.96 fl oz					
+A14658A...…………….	6.0 fl oz	21-d	4.5	0.0	0.0	15.0
A9898A……….....…………	1.3 fl oz	21-d	1.3	0.0	0.0	16.3
A18281A……………..…...	2.0 fl oz	21-d	0.0	0.0	0.0	36.0
A17386B…………………...	0.37 oz	21-d	1.0	0.0	6.3	9.5
A12910C…………… …...	0.95 fl oz	21-d	0.0	0.0	0.3	8.0
A12910C………………..…..	0.95 fl oz					
+A14658A...………..… …	6.0 fl oz	21-d	0.5	0.0	1.3	1.0
A18124A………………….	4.0 fl oz	21-d	0.0	0.0	1.8	2.0
A18124A………………….	4.0 fl oz					
+A14658A……...……	6.0 fl oz	21-d	0.5	0.0	0.0	6.3
A9898A……….....…..……	0.96 fl oz					
+A13972A……………….	1.0 fl oz	21-d	1.0	0.0	0.5	7.0
Reserve……………….…....	3.2 fl oz	21-d	1.8	0.0	0.3	3.8
Reserve………….....……….	3.5 fl oz	21-d	0.8	0.0	8.8	18.3
Reserve……………....…….	4.5 fl oz	21-d	1.0	0.0	0.8	12.0
Concert………………...…...	5.5 fl oz	21-d	0.5	0.0	4.0	15.0
Heritage TL…………..……	2.0 fl oz	21-d	1.0	0.0	4.5	0.0
Triton FLO……………..….…	1.1 fl oz	21-d	1.0	0.0	3.8	1.5
Disarm………………....…	0.36 fl oz	21-d	0.3	0.0	6.3	4.3
Bayleton……………..…….	2.0 fl oz	21-d	0.3	0.0	3.0	4.5
untreated		--	2.0	0.0	3.3	2.3
untreated		--	0.0	0.0	1.0	12.5
ANOVA: Treatment (P > F)			0.596	1.0	0.442	0.246
Days after treatment			21	19	35	64

[z] Treatments were applied on 14 Apr., 5 and 26 May 2010; except A14658A which was only applied on 5 and 26 May.

[y] Turf decline resulting from biotic and abiotic stress was indistinguishable during field evaluations . Values reported represent the overall decline of turf due to take-all patch, drought, heat and traffic.

Table 2. Severity of turf decline in creeping bentgrass fairway turf treated preventively with fungicides at Wintonbury Hills Golf Course in Bloomfield, CT during 2010.

			Severity of turf decline[y]			
Treatment	Rate per 1000 ft^{-2}	Int. [z]	26-May	14-Jun	30-Jun	29-Jul
			---------------------------- 1 to 5	----------------------------		
A9898A………………….	0.96 fl oz	21-d	1.5	1.0	1.5	1.8
A9898A………..…..……	0.96 fl oz					
+A14658A...…………..….	6.0 fl oz	21-d	1.5	1.0	1.0	2.0
A9898A………...…………	1.3 fl oz	21-d	1.5	1.0	1.0	3.3
A18281A……………..…...	2.0 fl oz	21-d	1.3	1.0	1.3	4.0
A17386B…………………....	0.37 oz	21-d	1.3	1.0	2.3	3.3
A12910C…………… …...	0.95 fl oz	21-d	1.0	1.0	1.3	1.8
A12910C………………..…...	0.95 fl oz					
+A14658A...………..… …	6.0 fl oz	21-d	1.3	1.0	1.3	1.3
A18124A…………………	4.0 fl oz	21-d	1.3	1.0	1.3	1.5
A18124A…………………	4.0 fl oz					
+A14658A……..……	6.0 fl oz	21-d	1.5	1.0	1.0	1.8
A9898A………...…...……	0.96 fl oz					
+A13972A………………	1.0 fl oz	21-d	1.0	1.0	1.3	2.5
Reserve…………………..…...	3.2 fl oz	21-d	1.3	1.0	1.0	1.5
Reserve…………...……….	3.5 fl oz	21-d	1.3	1.0	2.3	2.8
Reserve……………...…….	4.5 fl oz	21-d	1.3	1.0	1.3	2.0
Concert………………..…...	5.5 fl oz	21-d	1.3	1.0	2.0	3.0
Heritage TL…………...……	2.0 fl oz	21-d	1.0	1.0	1.5	1.0
Triton FLO…………..…..…	1.1 fl oz	21-d	1.3	1.0	1.5	2.0
Disarm………………...…	0.36 fl oz	21-d	1.3	1.0	1.5	2.0
Bayleton……………….…….	2.0 fl oz	21-d	1.0	1.0	2.3	2.3
untreated		--	1.5	1.0	1.5	2.5
untreated		--	1.5	1.0	1.5	2.5
ANOVA: Treatment (P > F)			0.985	1.0	0.394	0.300
Days after treatment			21	19	35	64

[z] Treatments were applied on 14 Apr., 5 and 26 May 2010; except A14658A which was only applied on 5 and 26 May.

[y] Severity of decline was visually assessed on a 1 to 5 scale; where 1 represented no visible signs of turf decline and 5 represented patches of necrotic turf containing no green foliage.

Table 3. Turf quality influenced by preventive fungicide applications on a creeping bentgrass fairway at Wintonbury Hills Golf Course in Bloomfield, CT during 2010.

			Turf quality[y]					
Treatment	Rate per 1000 ft^{-2}	Int. [z]	14-Apr	5-May	26-May	14-Jun	30-Jun	29-Jul
			------------- 1-9; 9 = best, 5 = min. acceptable -------------					
A9898A	0.96 fl oz	21-d	7.3	6.5 fg [x]	7.3	6.8 cde	7.0 bcd	7.5
A9898A + A14658A	0.96 fl oz + 6.0 fl oz	21-d	7.3	6.3 g	6.0	6.5 de	7.5 abc	7.3
A9898A	1.3 fl oz	21-d	6.8	6.3 g	7.0	6.8 cde	7.3 a-d	5.3
A18281A	2.0 fl oz	21-d	6.5	7.3 def	7.8	7.8 abc	7.3 a-d	4.0
A17386B	0.37 oz	21-d	7.3	7.5 cde	8.0	7.3 a-e	6.5 cd	6.5
A12910C	0.95 fl oz	21-d	7.5	7.3 def	8.0	7.0 b-e	8.0 ab	7.0
A12910C + A14658A	0.95 fl oz + 6.0 fl oz	21-d	7.8	7.8 b-e	7.3	6.3 e	7.5abc	8.5
A18124A	4.0 fl oz	21-d	7.8	7.8 b-e	7.3	7.5 a-d	8.3 a	7.8
A18124A + A14658A	4.0 fl oz + 6.0 fl oz	21-d	7.0	7.0 efg	7.0	7.5 a-d	8.3 a	7.8
A9898A + A13972A	0.96 fl oz + 1.0 fl oz	21-d	6.8	7.0 efg	7.5	6.8 cde	7.0 bcd	6.5
Reserve	3.2 fl oz	21-d	7.8	8.3 abc	7.8	7.5 a-d	8.0 ab	7.3
Reserve	3.5 fl oz	21-d	7.3	8.0 bcd	7.8	8.3 a	6.8 cd	5.8
Reserve	4.5 fl oz	21-d	7.5	9 a	7.8	8.0 ab	6.8 cd	7.3
Concert	5.5 fl oz	21-d	6.3	7.3 def	7.8	8.0 ab	7.3 a-d	6.3
Heritage TL	2.0 fl oz	21-d	8.0	8.3 abc	8.0	8.0 ab	6.5 cd	8.5
Triton FLO	1.1 fl oz	21-d	7.5	8.5 ab	8.0	7.3 a-e	7.3 a-d	8.8
Disarm	0.36 fl oz	21-d	7	7.8 b-e	8.3	8.0 ab	6.8 cd	6.8
Bayleton	2.0 fl oz	21-d	7.5	7.0 efg	7.5	6.5 de	7.3 a-d	7.3
untreated		--	7.3	7.5 cde	7.5	7.0 b-e	6.5 cd	6.8
untreated		--	6.8	7.5 cde	8.0	7.3 a-e	6.3 d	6.3
ANOVA: Treatment (P > F)			0.583	0.0001	0.617	0.002	0.029	0.191
Days after treatment			initial	21	21	19	35	64

[z] Treatments were applied on 14 Apr., 5 and 26 May 2010; except A14658A which was only applied on 5 and 26 May.

[y] Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the highest quality turf and 6 was the minimum acceptable level.

[x] Means within each column followed by the same letter are not statistically different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

Table 4. Phytotoxcicity influenced by preventive fungicide applications on a creeping bentgrass fairway at Wintonbury Hills Golf Course in Bloomfield, CT during 2010.

Treatment	Rate per 1000 ft^{-2}	Int. [z]	Phytotoxcicity[y] 5-May	26-May	14-Jun	30-Jun
			------------ 1-5; 1 = none, 2 = min. acceptable -----------			
A9898A	0.96 fl oz	21-d	2.0 a [x]	2.0 a	1.8 ab	1.0
A9898A +A14658A	0.96 fl oz +6.0 fl oz	21-d	1.5 b	2.0 a	2.0 a	1.0
A9898A	1.3 fl oz	21-d	1.5 b	1.8 ab	2.0 a	1.5
A18281A	2.0 fl oz	21-d	1.0 c	1.0 c	1.0 d	1.0
A17386B	0.37 oz	21-d	1.0 c	1.0 c	1.0 d	1.3
A12910C	0.95 fl oz	21-d	1.0 c	1.3 bc	1.5 bc	1.0
A12910C +A14658A	0.95 fl oz +6.0 fl oz	21-d	1.0 c	1.5 abc	1.3 cd	1.0
A18124A	4.0 fl oz	21-d	1.3 bc	1.3 bc	1.5 bc	1.0
A18124A +A14658A	4.0 fl oz +6.0 fl oz	21-d	1.5 b	1.8 ab	1.5 bc	1.0
A9898A +A13972A	0.96 fl oz +1.0 fl oz	21-d	1.0 c	1.0 c	2.0 a	1.0
Reserve	3.2 fl oz	21-d	1.0 c	1.0 c	1.0 d	1.0
Reserve	3.5 fl oz	21-d	1.0 c	1.0 c	1.0 d	1.0
Reserve	4.5 fl oz	21-d	1.0 c	1.3 bc	1.0 d	1.0
Concert	5.5 fl oz	21-d	1.0 c	1.3 bc	1.0 d	1.0
Heritage TL	2.0 fl oz	21-d	1.0 c	1.0 c	1.0 d	1.0
Triton FLO	1.1 fl oz	21-d	1.0 c	1.3 bc	1.0 d	1.0
Disarm	0.36 fl oz	21-d	1.0 c	1.0 c	1.0 d	1.0
Bayleton	2.0 fl oz	21-d	1.3 bc	1.5 abc	1.0 d	1.0
untreated		--	1.0 c	1.0 c	1.0 d	1.0
untreated		--	1.0 c	1.0 c	1.3 cd	1.0
ANOVA: Treatment ($P > F$)			0.0001	0.004	0.0001	0.5348
Days after treatment			21	21	19	35

[z] Treatments were applied on 14 Apr., 5 and 26 May 2010; except A14658A which was only applied on 5 and 26 May.

[y] Phytotoxcicity was visually assessed on a 1 to 5 scale; where 1 represented no visible signs of phytotoxcicty and 2 was the minimum acceptable level.

[x] Means within each column followed by the same letter are not statistically different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

Table 5. Turfgrass color and normalized difference vegetative index (NDVI) values influenced by preventive fungicide applications on a creeping bentgrass fairway at Wintonbury Hills Golf Course in Bloomfield, CT during 2010.

Treatment	Rate per 1000 ft^{-2}	Int. [z]	Grass Color Index[y]	NDVI [x]			
			14-Apr	5-May	26-May	14-Jun	29-Jul
A9898A	0.96 fl oz	21-d	7.18	0.725 a-e [w]	0.745	0.748	0.749
A9898A +A14658A	0.96 fl oz +6.0 fl oz	21-d	6.85	0.716 de	0.752	0.743	0.743
A9898A	1.3 fl oz	21-d	7.13	0.714 e	0.741	0.757	0.695
A18281A	2.0 fl oz	21-d	6.68	0.728 a-e	0.762	0.772	0.665
A17386B	0.37 oz	21-d	6.95	0.733 abc	0.762	0.767	0.729
A12910C	0.95 fl oz	21-d	7.28	0.728 a-d	0.756	0.761	0.740
A12910C +A14658A	0.95 fl oz +6.0 fl oz	21-d	7.10	0.727 a-d	0.749	0.762	0.754
A18124A	4.0 fl oz	21-d	7.48	0.737 a	0.749	0.767	0.720
A18124A +A14658A	4.0 fl oz +6.0 fl oz	21-d	7.15	0.727 a-d	0.757	0.764	0.733
A9898A +A13972A	0.96 fl oz +1.0 fl oz	21-d	6.93	0.722cde	0.751	0.760	0.735
Reserve	3.2 fl oz	21-d	7.00	0.723 b-e	0.751	0.757	0.726
Reserve	3.5 fl oz	21-d	6.75	0.727 a-d	0.762	0.774	0.711
Reserve	4.5 fl oz	21-d	7.25	0.736 ab	0.754	0.760	0.733
Concert	5.5 fl oz	21-d	6.93	0.728 a-d	0.755	0.766	0.705
Heritage TL	2.0 fl oz	21-d	7.38	0.736 ab	0.756	0.769	0.759
Triton FLO	1.1 fl oz	21-d	7.25	0.738 a	0.752	0.759	0.766
Disarm	0.36 fl oz	21-d	7.25	0.722 cde	0.764	0.775	0.740
Bayleton	2.0 fl oz	21-d	7.25	0.726 a-e	0.757	0.755	0.739
untreated		--	7.03	0.725 a-e	0.746	0.764	0.762
untreated		--	7.08	0.718 de	0.755	0.770	0.706
ANOVA: Treatment (P > F)			0.294	0.020	0.586	0.082	0.227
Days after treatment			initial	21	21	19	64

[z] Treatments were applied on 14 Apr., 5 and 26 May 2010; except A14658A which was only applied on 5 and 26 May.

[y] Turfgrass color index values were obtained using a Turf Color Meter (Spectrum Technologies, Inc.). Values reported represent the mean of three individual readings taken per plot.

[x] Normalized difference vegetative index values were obtained with a FieldScout TCM 500 NDVI Turf Color Meter (Spectrum Technologies, Inc). Values reported represent the mean of three individual readings taken per plot.

[x] Means within each column followed by the same letter are not statistically different based on Fisher's protected least significant difference test (α = 0.05).

Table 6. Canopy temperature affected by preventive fungicide applications on a creeping bentgrass fairway at Wintonbury Hills Golf Course in Bloomfield, CT during 2010.

Treatment	Rate per 1000 ft^{-2}	Int.[z]	Canopy temperature[y] 26-May	14-Jun	30-Jun	29-Jul
			----- °F -----			
A9898A	0.96 fl oz	21-d	99.8	87.6	90.4	82.8
A9898A 0.96 fl oz +A14658A	6.0 fl oz	21-d	101.0	86.0	91.0	81.8
A9898A	1.3 fl oz	21-d	100.9	88.6	92.1	84.0
A18281A	2.0 fl oz	21-d	101.4	88.9	92.8	90.6
A17386B	0.37 oz	21-d	101.3	85.6	88.1	82.4
A12910C	0.95 fl oz	21-d	100.5	89.8	89.9	84.4
A12910C 0.95 fl oz +A14658A	6.0 fl oz	21-d	101.3	87.3	88.9	82.0
A18124A	4.0 fl oz	21-d	102.9	89.0	88.4	80.3
A18124A 4.0 fl oz +A14658A	6.0 fl oz	21-d	101.4	87.3	88.6	85.9
A9898A 0.96 fl oz +A13972A	1.0 fl oz	21-d	100.3	86.9	91.9	80.6
Reserve	3.2 fl oz	21-d	99.1	88.4	87.3	81.9
Reserve	3.5 fl oz	21-d	101.0	85.0	89.0	82.8
Reserve	4.5 fl oz	21-d	99.3	88.3	88.6	87.0
Concert	5.5 fl oz	21-d	101.8	88.3	91.3	84.1
Heritage TL	2.0 fl oz	21-d	101.1	88.1	88.4	80.4
Triton FLO	1.1 fl oz	21-d	100.0	89.9	90.4	81.9
Disarm	0.36 fl oz	21-d	98.6	87.6	88.9	80.3
Bayleton	2.0 fl oz	21-d	99.0	84.9	90.1	80.6
untreated		--	98.5	85.5	88.9	82.8
untreated		--	103.0	86.4	90.8	88.0
ANOVA: Treatment (P > F)			0.5628	0.2636	0.2324	0.2064
Days after treatment			21	19	35	64

[z] Treatments were applied on 14 Apr., 5 and 26 May 2010; except A14658A which was only applied on 5 and 26 May.

[y] Canopy temperature was determined using an infrared thermometer. Values reported are the mean of two readings taken per plot.

RATE RESPONSE AND COMPARISON OF PHOSPHONATE MATERIALS ON ALGAE DEVELOPMENT IN PUTTING GREEN TURF, 2010

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INTRODUCTION

Algae infestations on closely mown putting greens continue to be difficult to manage. Chlorothalonil is a fungicide that can be used to control algae. However, the label restricts the total amount of product that can be applied, and its use is prohibited in some regions of New England. Phosphonate fungicides and/or fertilizers may provide another option for controlling algae. In a 2006 study at the University of Connecticut, plots treated with Alude, and Alude + Insignia had very low levels (3 to 7%) of algae when compared to the untreated control plots (40%), although the purpose of the study was not to evaluate algae. The objectives of this study are to assess the effect of various phosphonatae materials and rates on algae development in putting green turf.

MATERIALS & METHODS

A field study was conducted in 2010 on ‘L-93’ creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was double cut five days wk^{-1} at a bench setting of 0.130-inches. Nitrogen was typically applied as urea at 0.1 lbs N 1000 ft^{-2} every 14 days during the study. Soil pH, phosphorous and potassium were maintained based on soil test results. The site was lightly irrigated two to three times each day^{-1} between 1100 and 1600 hrs from July through September to encourage algae development. Dollar spot was controlled with applications of vinclozolin (Curalan 50EG) or boscalid (Emerald 70WG), and brown patch with flutalonil (ProStar 70WP).

Treatments were arranged as a 4 by 6 factorial within a randomized complete block design with four blocks. Main effects were phosphonate materials and application rate. Phosphonate materials evaluated included Alude (commercial phosphite fungicide), Phosphite 30 (commercial phosphite fertilizer), or H_3PO_3/KOH, (technical grade potassium phosphite), which contain mono- and di-potassium salts of phosphorous acid, and lastly H_3PO_4/KOH (potassium phosphate) which is a common component of phosphorous fertilizers. The active ingredient phosphorous acid or phosphoric acid (H_3PO_x/KOH) was applied at 0.9, 1.8, 2.6, 3.5, 4.4, and 5.3 oz 1000 ft^{-2} for each material. Treatments were applied every 14 days from 20 May to 26 August 2010 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.

Stock solutions of H_3PO_3/KOH and H_3PO_4/KOH were prepared in the lab similar to the methods described by Cook et al. (2009) prior to each field application. Preparations of H_3PO_3/KOH were achieved by titrating a 1 M solution of phosphorous acid (H_3PO_3) with 10 M potassium hydroxide to obtain a final pH of 6.2. Similarly, H_3PO_4/KOH was prepared by combining 1 M phosphoric acid (H_3PO_4) with 10 M potassium hydroxide to a final pH of 6.2. Prepared and commercial materials were added to calculated volumes of diH_20 to obtain a total mixture volume of 750 mL.

Algae incidence was assessed visually as a percentage of the plot area blackened by filamentous blue-green algae (species unknown). Algae severity was also visually assessed on a scale of 1 to 9 where 1 = no algae observed and 9 = entire plot area blackened by algae. Data were subjected to an analysis of variance and means were separated using Fisher’s protected least significance difference test.

PRELIMINARY RESULTS & DISCUSSION

Algae developed in the study area by 9 September and persisted until early October. Algae incidence was moderately high (up to 27%) throughout the study in 2010. Phosphonate materials and application rate affected algae development under moderate pressure (Table 1). Algae incidence was less apparent in turf treated with the phosphites: Alude, Phosphite 30, and H_3PO_3. No differences in algae incidence were observed between phosphite materials throughout 2010. Algae development was most pronounced where H_3PO_4 was applied throughout the year.

Application rate affected algae incidence throughout 2010 (Table 1). Algae incidence declined linearly with increasing rate of H_3PO_X 1000 ft^{-2}regardless of phosphonate material. Comparison of treatment means indicated that no significant reduction in algae resulted from applying H_3PO_x at rates greater than 3.5 oz 1000 ft^{-2}.

Turf quality was reduced in turf treated with phosphites and phosphate in July and August due to turf discoloration and algae infestation, respectively (data not shown). Turf discoloration was particularly evident in turf treated with phosphites at rates exceeding 3.5 oz 1000 ft^{-2}.

These data suggest increased application rates of various phophonate materials suppress algae development in putting green turf. However, rates required to completely control algae may result in phytotoxicity and a decline of turf quality. Further evaluation is required to determine phosphite rates that suppress algae without reducing turf quality. Phosphites (i.e., Alude, Phosphite 30 and H_3PO_3/KOH) were more effective at reducing algae than potassium phosphate (H_3PO_4/KOH). These data support results from preliminary research which also found that the phosphite fungicide Alude provided control of algae in putting green turf (Kaminski, 2007). Moreover, this study suggests that equivalent quantities of potassium phosphite regardless of formulation (i.e., commercially available phosphite fungicide, phosphite fertilizer or technical grade laboratory preparation) have similar efficacy in controlling algae development. This study will be repeated in 2011 to confirm or refute these preliminary results.

REFERENCES

Cook, P.J., P.J. Landschoot, and M. Schlossberg. 2009. Suppression of Anthracnose Basal Rot and Improved Putting Green Quality with Phosphonate Fungicides. Int. Turfgrass Soc. Res. J. 11(Part 1): 181-194.

Kaminski, J.E. 2007. Improving Turfgrass Quality and Reducing Algae on a Shaded Golf Course Putting Green. p. 33-35. *In* Kaminski, J.E. (ed.) 2006 Turfgrass Research Report. Univ. of Connecticut, Storrs.

Table 1. Algae incidence and severity influenced by phosphonate materials and rates on a creeping bentgrass putting green turf in Storrs, CT on 29 July 2010.

	Algae Incidence [y]
Main effect	29-Jul
Phosphonate [z]	% turf area blackened
Alude	2.7 **b** [x]
Phosphite 30	2.3 **b**
H_3PO_3/KOH	2.2 **b**
H_3PO_4/KOH	23.0 **a**
Rate (oz H_3PO_X 1000 ft^{-2})	
0.9	13.8 **a**
1.8	8.7 **b**
2.6	7.3 **cb**
3.5	6.0 **cd**
4.4	4.9 **cd**
5.3	4.5 **d**
Source	
Phosphonate (P)	***
Rate (R)	***
P x R	NS
C.V., %	49.6

[z] Treatments were applied on a 14 day interval from 16 June to 24 September 2009 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.

[y] Algae incidence was assessed visually as a percentage of the plot area blackened by filamentous blue-green algae.

[x] Means within each column followed by the same letter are not statistically different at $P \leq 0.05$ based on Fisher's protected least significant difference test.

DETERMINING THE IMPORTANCE OF LEAF COMPOST TOPDRESSING WHEN MANAGING ATHLETIC FIELDS ORGANICALLY, MAY 2010 – DECEMBER 2010

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University of Connecticut

INTRODUCTION

Effective July 1, 2010, the state of Connecticut has banned the usage of all lawn care pesticides on athletic fields and general grounds at public and private schools grades pre-K through 8. Compost topdressing is currently considered a critical component to managing turfgrass without the use of pesticides. Howrever, the researched based information regarding compost topdressing on athletic fields is limited. Topdressing athletic fields with spent mushroom substrate (SPS) has been evaluated showing many positive impacts such as an increase in percent ground cover after wear, decreased bulk density, increased water retention, and decrease surface hardness (3). However, composts can vary greatly and no research based information exists regarding topdressing leaf composts on athletic fields. Additionally, research on compost topdressing applications to soils ranging in organic matter content is very limited. Therefore, the potential benefit or detriment to increasing the organic matter level in a soil that is already considered suitable (4-8%) is not well understood. The specific objectives of this study are to: 1) Determine the effects of leaf compost and sand topdressing incorporated with core cultivation on soil physical properties when applied to low and high organic matter soils, and 2) Evaluate the effects of leaf compost topdressing and sand topdressing incorporated with core cultivation on the traffic tolerance of Kentucky bluegrass.

MATERIALS & METHODS

This study is being conducted at the Plant Science Research and Education Facility at the University of Connecticut. The native sandy loam soil (A Horizon) was completely excavated to a 12” depth, screened to 1” and compacted back into the high organic matter (6% w/w) study area (Figure 1). A low organic matter sandy loam (<1% w/w) was trucked in and compacted into the low organic matter study area. Plot areas were sodded with washed Kentucky bluegrass (*Poa pratensis* L.) ‘25% Award, 25% America, 25% Alpine, and 25% Northstar’ on May 11, 2010. This experiment was arranged in a Latin rectangle with six replications and three treatments; 1) Leaf compost topdressing applied at ¼” in the spring and fall, (Table 1), 2) Sand topdressing applied at ¼” in the spring and fall (Table 2), and 3) No topdressing applied. Plot sizes are 10 ft wide by 10 ft long and treatments were mowed twice per week at a height of 2 inches.

Figure 1. Excavation of soil to a depth of 12”.

The first topdressing treatments were applied on June 16, 2010. All topdressing treatments were incorporated by core cultivating each plot in two directions using 5/8” hollow core tines on June 16, 2010. The no topdressing treatments were also core cultivated in two directions (Figure 2). The second topdressing treatments were applied on December 2, 2010.

Figure 2. a) Sand topdressing being applied to the low organic soil plot area. b) Compost topdressing being applied to the high organic soil plot area. c) Low organic soil plot area after the treatments were applied. d) Incorporation of treatments using a Ryan GreensAire II Aerator.

Nutrients were applied according to soil test recommendations and all treatments were fertilized equally. The overall fertilizer application for the season was 3.25 lbs N, 1.44 lbs P_20_5, 1.21 lbs K_20. Plots were irrigated following fertilizer applications. Lime was applied on May 25, 2010 at a rate of 25 lbs per 1000 ft^2 to both plot areas to increase soil pH.

Data collected in this study included turfgrass quality, color, percent cover, soil moisture, surface hardness, weed counts, and soil physical properties. Turfgrass quality was visually rated using a scale of 1 to 9, where 1 = brown/dead turf; 6 = minimum acceptable color/quality; and 9 = optimum quality or dark green color. Digital image analysis was utilized in assessing 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 (2). Color and quality data was collected on a biweekly basis. Traffic Simulation was conducted using a Cady Traffic Simulator, a modified walk-behind core cultivation unit (1). Traffic was applied three times per week for 12 weeks beginning on August 30, 2010 and ending in late November for a total of 24 traffic events. Surface hardness was measured using a Clegg impact tester. Data was collected once a month from September 2010 to November 2010. Soil moisture readings were measured using a portable Trime-FM TDR probe (5 cm). Weed count data was obtained for both crabgrass and broadleaf weeds. Counts were done visually beginning on September 13, 2010 and were completed monthly through November. Percent organic matter will be assessed in spring 2011 before treatments are applied. Undisturbed soil samples will be extracted to assess soil bulk density and percent organic matter.

RESULTS AND DISCUSSION

This study was initiated in May 2010 with the installation of the Kentucky bluegrass sod. Comprehensive data collection ensued in July 2010 and continued through November 2010. Parameters that were measured in the field during 2010 are discussed in the following sections.

Table 1. Characteristics of leaf compost.

Sample	Organic Matter	Moisture (%)	Soluble Salts (mmhos/cm)	pH	N (%)	P_20_5 (%)	K_20 (%)	C:N Ratio
Leaf Compost	26.3	46.4	0.92	7.3	0.88	0.330	0.44	15.40

Table 2. Particle size analysis of sand topdressing treatment.

	SOIL SEPARATE %			% RETAINED						
Treatment	Sand	Silt	Clay	No. 10 Gravel 2 mm	No. 18 VCS 1 mm	No. 35 CS 0.5 mm	No. 60 MS 0.25 mm	No. 100 FS 0.15 mm	No. 140 VFS 0.10 mm	No. 270 VFS 0.05 mm
Coarse Sand (AA Will Mat. 2mm)	99.5	0.0	0.4	0.1	11.0	31.5	42.0	13.0	1.6	0.4
USGA Rec. for Putting Green Const		$\leq$ 5%	$\leq$ 3%	$\leq$ 3% Gravel $\leq$ 10% Combined		$\geq$ 60%		$\leq$ 20%	$\leq$ 5%	

Turfgrass Color

The high organic matter soil produced significantly darker green turf than the low organic matter soil regardless of the treatment applied throughout the first growing season. The topdressing treatments had no effect on turfgrass color during the first year (Figure 3).

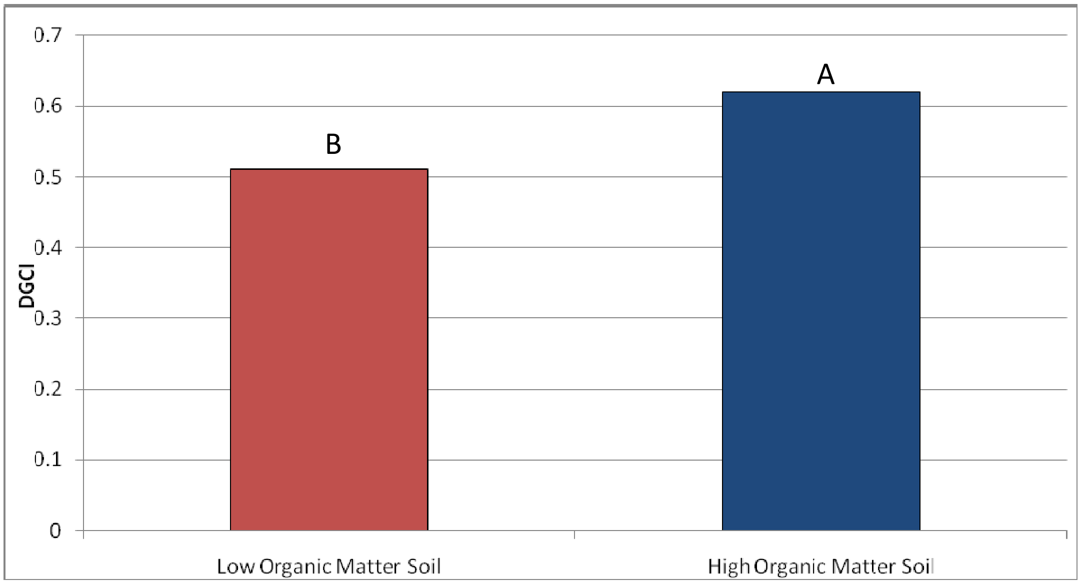

Figure 3. Soil type main effect on turfgrass color, November 2010. Turfgrass color was quantified using digital image analysis

Turfgrass Cover

Differences in percent cover were only observed in the low organic matter soil where the leaf compost retained greater cover than the untreated control following traffic (Figure 4).

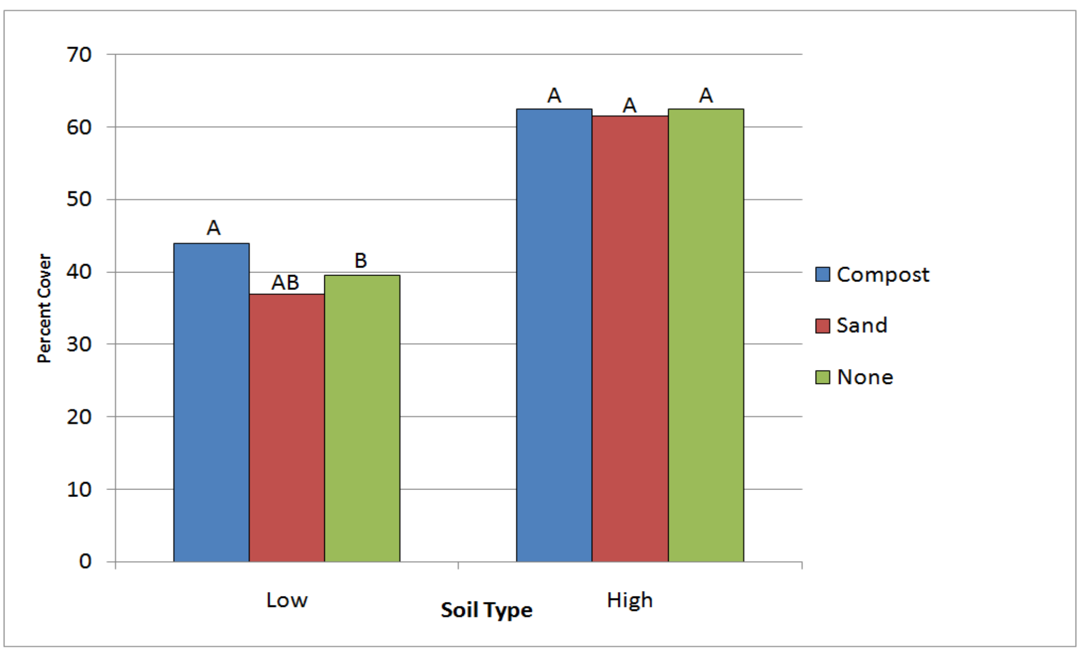

Figure 4. The effect of soil type and topdressing treatments on cover following traffic, November 2010.

Volumetric Soil Moisture

Leaf compost applied to the low organic matter soil also produced significant differences in volumetric soil moisture in the top 2" of the profile when compared to the sand or untreated control (Figure 5).

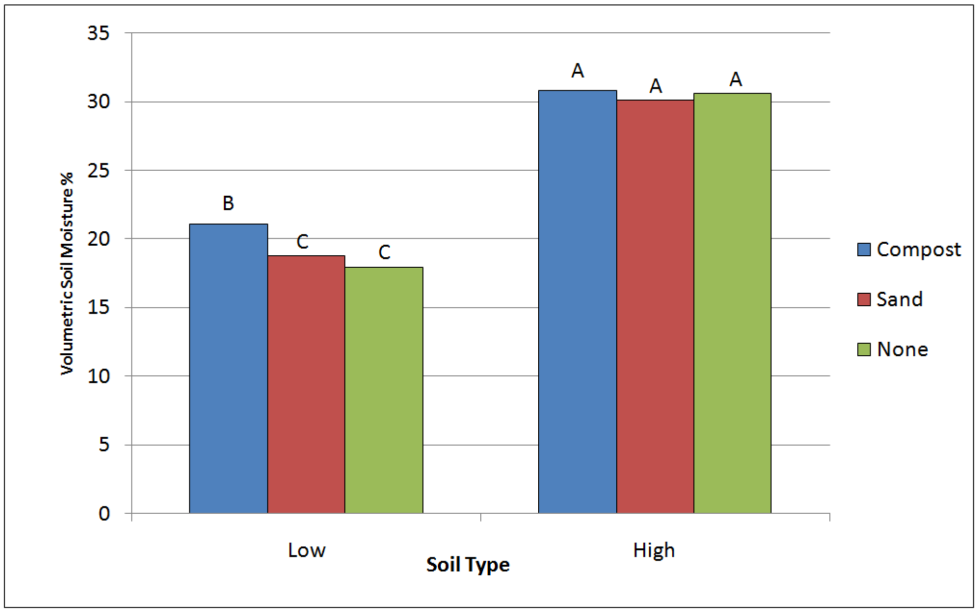

Figure 5. The effect of soil type and topdressing treatments on volumetric soil moisture, November 2010.

Surface Hardness

Differences in surface hardness were observed as an overall soil and treatment effect. The high organic matter soil had lower gmax values than the low organic matter soil (data not shown). Additionally, an overall treatment effect was observed with the leaf compost significantly reducing surface hardness compared to the untreated control (Figure 6).

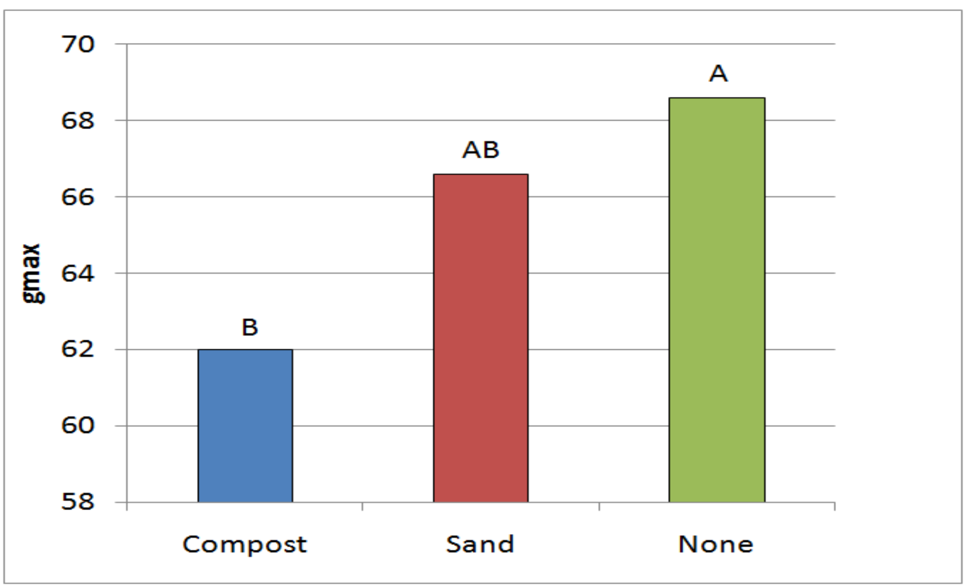

Figure 6. Topdressing treatments main effect on surface hardness, November 2010.

2011 and 2012 Growing Seasons

The first year of this study was focused on constructing the plot areas, properly establishing the Kentucky bluegrass, getting two applications of topdressing on the plots, and applying our first season of simulated football traffic. The second growing season (2011) will be an opportunity to begin to fully evaluate the potential effects from these topdressing treatments and core cultivation. Topdressing treatments applied in fall 2010 were split by core cultivation. This means each topdressing treatment (sand, leaf compost and the untreated control) was split into two subplots. Half of each plot was core cultivated in two directions and the other half received no core cultivation. This will help determine if there are any benefits or detriments to incorporating these topdressing materials utilizing core cultivation.

Summary to Date

Given the data to date, it is apparent that the high organic matter soil produced significantly darker green turf than the low organic matter soil regardless of the topdressing treatment applied. Leaf compost applications resulted in greater retention of cover following traffic in the low organic matter soil only, and Leaf compost applications resulted in greater moisture retention in the low organic matter soil only. The high organic matter soil produced lower surface hardness values than the low organic matter soil and leaf compost treatments had lower surface hardness values than the untreated control following traffic regardless of soil type.

Literature Cited

1. Henderson, J. J., J. L. Lanovaz, J. N. III Rogers, J. C. Sorochan, and J. T. Vanini. 2005. A new apparatus to simulate athletic field traffic: The cady traffic simulator. Agron. J. 97(4):p. 1153-1157.

2. Karcher, D.E., and M.D. Richardson. 2003. Quantifying turfgrass color using digital image analysis. Crop Sci. 43:943-951.

3. McNitt, A. S., D. M. Petrunak, and W. X. Uddin. 2004. Evaluation of spent mushroom substrate as a topdressing to established turf. Annu. Res. Rep. [Penn State]. p. [102-110].

PORTABLE ROADWAY SYSTEMS EVALUATED USING SIMULATED TRAFFIC ON PLAYING SURFACES FOR NON-SPORTING EVENTS

MAY 2010 – DECEMBER 2010

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INTRODUCTION

Many current sports venues routinely host non-sporting events that require vehicular traffic over playing surfaces to set up stages, seating and other event specific equipment. This presents a tremendous challenge to athletic field managers to protect the integrity of the playing surface often times during the season of play. Given the limited time for re-establishing turfgrass from seed, and the considerable cost associated with resodding, many athletic field managers and facility owners are seeking information about the most effective turf protection systems to minimize damage to the existing playing surface during set up, the actual event, and take down. Currently, independent research evaluating the various cover systems is lacking. The goal of this research is to generate independent, unbiased data to assist athletic field managers and facility operators in making informed decisions when selecting products to protect their fields during non-sporting events. The objectives of this research are to: 1) determine the impact of each cover system on turfgrass cover and color when used for multiple cover periods, 2) document changes in playing surface characteristics (surface hardness, traction, and displacement) following each cover period, and 3) evaluate the effects of roadway systems on soil physical properties.

MATERIALS AND METHODS

This study was initiated at the Plant Science Research and Education Facility at the University of Connecticut on a mixed stand of Kentucky bluegrass (*Poa pratensis* L.) and perennial ryegrass (*Lolium perenne* L.) in May 2010. This experiment was arranged in a 6 x 3 (cover type x cover period) factorial in a strip plot design with three replications. The main plots (cover period) were split by cover type. The five turf protection systems evaluated were 1) ¾” Plywood only (2 layers), 2) Enkamat Plus and ¾” Plywood (2 layers), 3) Enkamat Flatback and ¾” Plywood (2 layers), 4) Supa-Trac™ (Rola-Trak North America), 5) Terratrak Plus™ (CoverMaster, Inc.), and 6) and an uncovered treatment. The second factor, cover period, had three levels: 3, 6, and 9 days. An uncovered/untrafficked control was also included. Treatments were subjected to two traffic events; each consisted of 10 passes with a loaded dump truck (gross vehicle weight of rating of 20,000 lbs. (Fig. 1). Traffic events were conducted on the first and last day of each cover period. The first cover period lasted from June 26, 2010 to July 5, 2010. The second cover period lasted from August 10, 2010 to August 19, 2010. Plot sizes were 4 ft wide by 16 ft long and treatments were mowed three times per week at a height of 2 ¼ inches.

Fig. 1. Dump Truck GVWR = 20,000lbs

Data collection included turfgrass performance (turfgrass color, quality and percent cover) and playing surface characteristics (surface hardness, traction, and displacement). Displacement was measured using a custom designed apparatus that used five measuring pins spaced equally across the tire track to measure the depth of the rut produced by the dump truck. These reading were averaged across both tire tracks (Fig. 2).

Fig. 2. Displacement readings being taken using a custom designed apparatus

Turfgrass quality was done using a visual rating scale of 1 to 9, where 1=brown/dead turf; 6=minimum acceptable color/quality; and 9=optimum quality or dark green color. Turfgrass color was determined using Digital Image Analysis. Digital images were taken prior to covers being applied and then taken immediately following each cover period. Controlled light conditions were provided through the use of a light box. After all the covers were removed, light box photos were taken every 3 days for a period of two weeks. Photos were taken between the tire tracks on each plot. 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 (2). Plots were rated biweekly after each cover period. Surface hardness was measured using a Clegg Impact Tester.

Traction was measured using a Canaway Traction Device (1). Data was collected after each cover period ended. Soil physical properties were assessed at the end of the final cover period. Comprehensive data collection ensued in June 2010 and continued through September 2010. Color, percent cover, and displacement data following the first cover period only are discussed in the following sections.

TURFGRASS COLOR

Following the three day cover period, Terratrak Plus had darker green turfgrass color than Enkamat Flat w/plywood and Enkamat Plus w/ plywood. Following the 6 day cover period, Terratrak Plus and Supa-Trac, had darker green color than all the Plywood treatments. Terratrak Plus had the darkest green color following the 9 day cover period (Fig. 3).

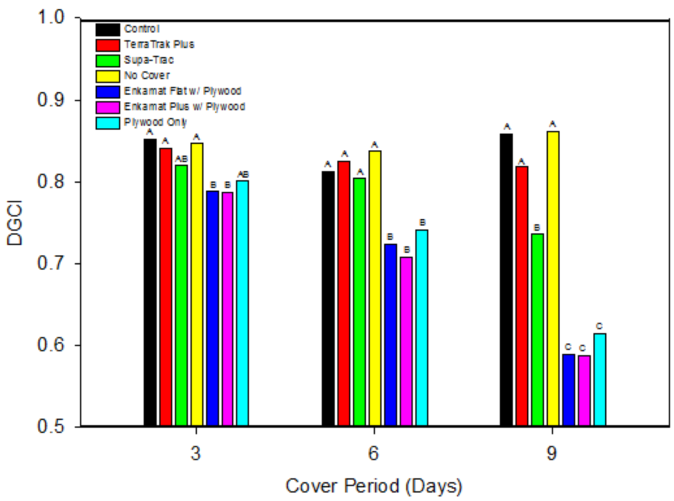

Fig. 3. The effect of cover type and cover duration on turfgrass color, June 2010. Turfgrass color was quantified using digital image analysis.

PERCENT COVER

There were no differences in percent cover between cover types following the three day cover period. Following the six and nine day cover periods, Terratrak Plus and Supa-Trac had higher percent cover than all the Plywood treatments. Terratrak Plus and Supa-Trac were not different from No cover w/ traffic (Fig. 4).

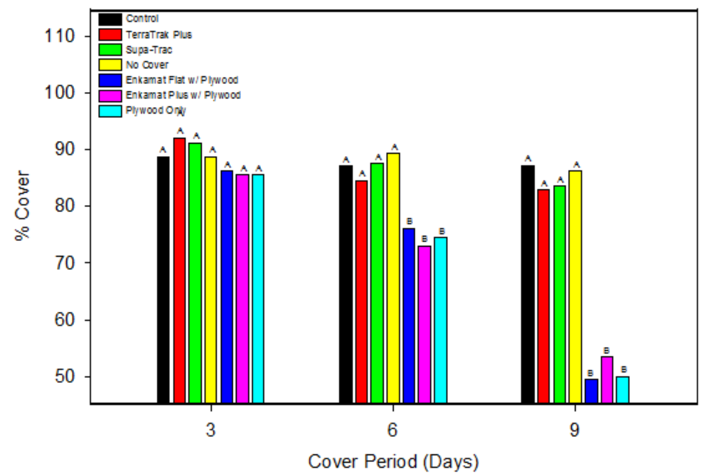

Fig. 4. The effect of cover type and cover duration on percent cover, June 2010.

DISPLACEMENT

No Cover w/traffic had the greatest displacement following traffic. Plywood only, Enkamat Plus w/plywood, and Enkamat Flat w/plywood had the least amount of displacement. Terratrak Plus had less displacement than Supa-Trac (Fig. 5).

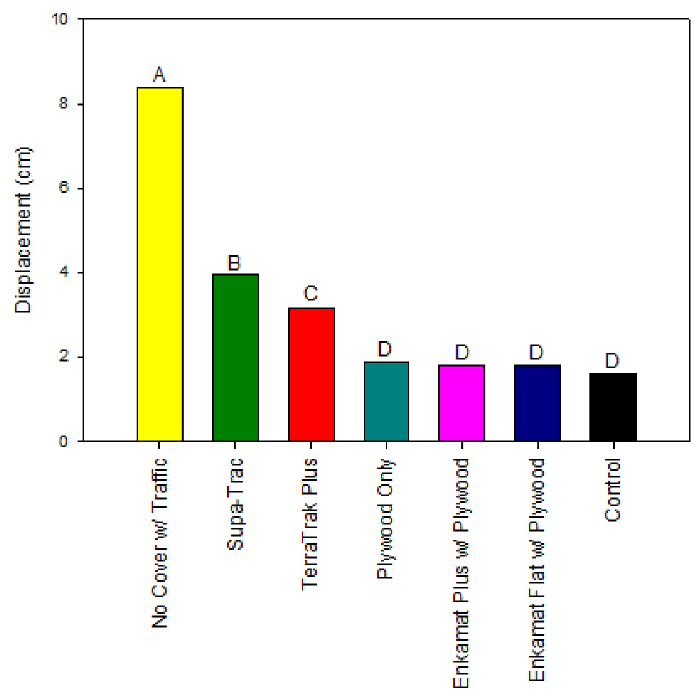

Fig. 5. The effect of cover type on surface displacement after 10 passes with a loaded dump truck (GVWR = 20,000lbs).

SUMMARY TO DATE

Preserving the aesthetics of the turfgrass and protecting the consistency of the playing surface are paramount when utilizing these portable roadway systems. There were no differences between cover types for percent cover when the covers were utilized for a three day period. However, Terratrak Plus had darker green turfgrass color than Enkamat Flat w/plywood and Enkamat Plus w/ plywood, following the three day cover period. As the cover duration increased, Terratrak Plus and Supa-Trac retained better color and cover than all the plywood treatments. Terratrak Plus retained the best turfgrass color following the nine day cover period. The plywood treatments provided the best protection against displacement given the load range tested, while Terratrak Plus had less displacement than Supa-Trac.

LITERATURE CITED

1. Canaway, P.M., and M.J. Bell. 1986. Technical note: An apparatus for measuring traction and friction on natural and artificial playing surfaces. J. Sports Turf Res. Inst. 62:211-214.

2. Karcher, D.E., and M.D. Richardson. 2003. Quantifying turfgrass color using digital image analysis. Crop Sci. 43:943-951.

THE EFFECT OF SAND TYPE AND APPLICATION RATE ON TURFGRASS QUALITY, DISEASE SEVERITY, EARTHWORM CASTINGS AND SOIL PHYSICAL PROPERTIES ON GOLF COURSE FAIRWAYS

MAY 2006 – DECEMBER 2010

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INTRODUCTION

Fairway topdressing is a cultural practice that requires a significant budget, considerable time, and commitment to implement properly. Sands that meet the United States Golf Association (USGA) specifications for putting green construction are typically recommended for topdressing fairways. However, due to the strict specifications, these sands are prohibitively expensive when considered for use on larger fairway acreage. Research evaluating the effects of different sand types applied at multiple rates as topdressing on soil physical properties and turfgrass performance when managed as a golf course fairway is lacking. The objectives were to: 1) determine whether particle size distribution and/or application rate will affect turfgrass color, quality, cover, disease incidence, and earthworm activity and 2) quantify the effects of particle size distribution and topdressing layer depth on moisture retention, soil temperature, and resistance to surface displacement.

MATERIALS & METHODS

This experiment was a 3 x 3 (sand type x application rate) factorial arranged in a random complete block design with three replications. The first factor, sand type, had three levels: Fine, USGA, and Coarse (Table 1). The second factor, application rate, had three levels: 0.001 m^3 m^{-2} (4ft^3 1000ft^{-2}), 0.002 m^3 m^{-2} (8ft^3 1000ft^{-2}), and 0.003 m^3 m^{-2} (12ft^3 1000ft^{-2}). A control was also included that received no topdressing applications. The study was initiated on an L-93 creeping bentgrass (*Agrostis stolonifera*) stand managed as a golf course fairway at the University of Connecticut Plant Science Research and Education Facility, originally seeded in September 2006. The research area was located on a sandy loam soil with a pH of 6.4. Treatments were mowed three times a week at a height of 0.5 inches. Plot sizes were 10 ft wide by 20 ft long. Topdressing applications were initiated on 3 July 2007 and were applied once per month ending in November. In subsequent years, topdressing applications started in May and ended in November. This design allows the comparisons of each sand type applied at each of the three rates. The three different rates will also enable the development of three different depths of topdressing over time.

Fertilizer applications began in May of each year and were repeated on 21 day intervals with the last treatment being applied in mid-October. Nitrogen application rates varied between 0.5 and 0.75 lbs N 1000ft^{-2}. The total nitrogen applications averaged 5.5 lbs. nitrogen 1000 ft^{-2} per growing season. Phosphorus and potassium were applied according to soil test results. Fungicides were applied predominately on a curative basis to determine the effect of treatments on disease incidence.

Data collected in this study included ratings of turfgrass color and quality. This was done by visual rating using a scale of 1 to 9, where 1 = brown/dead turf; 6 = minimum acceptable color/quality; and 9 = optimum quality or dark green color. Digital image analysis was utilized in assessing turfgrass 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=40-125 and saturation=10-100. Color, quality, and cover data were collected biweekly. Volumetric soil moisture was measured using a Trime-FM TDR probe, 5 cm (MESA Systems Co., Medfield, MA). Resistance to surface displacement was measured using a proving ring soil penetrometer (ELE International, Ames, IA). Soil temperature was measured using a digital thermometer (Fisher Scientific, Waltham, MA) at a 5 cm depth. Measurements were taken biweekly. On each sampling date, five readings were taken per plot and then averaged. Earthworm castings and dollar spot count data were obtained as incidence occurred. Earthworm castings and dollar spots were quantified using 25 ft^2 grid placed in the center of each plot.

RESULTS AND DISCUSSION

This study was initiated in September 2006 with the establishment of the creeping bentgrass fairway. Topdressing treatments began in July 2007 with monthly applications occurring through November 2007. Comprehensive data collection ensued in April 2008. Parameters that were measured in the laboratory and in the field during 2007 and 2010 are discussed in the following sections.

Particle Size Distribution

The particle size distributions of the three sands are detailed in Table 1. The USGA particle size recommendations for putting green construction are included in the table for comparison purposes. The fine sand does not meet the USGA specifications for putting green construction due to the high fine sand content and high very fine sand content. The USGA sand is very close to meeting the specifications, but falls just short with a slightly high fine sand content. The coarse sand does not meet the specifications due to high very coarse sand content.

Table 1. Particle size analyses of sand types. USGA recommendations for putting green construction are included for reference only.

	Soil Separate %				% Retained					
Treatment	**Sand**	**Silt**	**Clay**	**No. 10 Gravel 2 mm**	**No. 18 VCS 1 mm**	**No. 35 CS 0.5 mm**	**No. 60 MS 0.25 mm**	**No. 100 FS 0.15 mm**	**No. 140 VFS 0.10 mm**	**No. 270 VFS 0.05 mm**
Fine Sand (Desiato Mason)	97.3	1.3	0.6	0.8	4.4	11.0	31.6	31.1	12.1	7.1
USGA Sand (Holliston #40)	99.3	0.1	0.5	0.1	2.6	20.2	52.3	20.6	2.7	0.9
Coarse Sand (AA Will Mat. 2mm)	99.5	0.0	0.4	0.1	11.0	31.5	42.0	13.0	1.6	0.4
USGA Rec. for Putting Grn Const.		**≤ 5%**	**≤ 3%**	**≤ 3% Gravel ≤ 10% Combined**		**≥ 60%**		**≤ 20%**	**≤ 5%**	

Turfgrass Color

Topdressing applications resulted in a positive turfgrass color response (Figure 1, 2 and 3). This would appear one to two weeks following topdressing applications as an overall rate effect. However, the greening response was most apparent in the spring with plots receiving higher application rates of topdressing greening up faster.

Figure 1. Plots that received higher topdressing rates showed a faster greening response. This has been consistent through the duration of the study.

Figure 2. The increase in turfgrass color related top dressing rate was observed throughout the growing season.

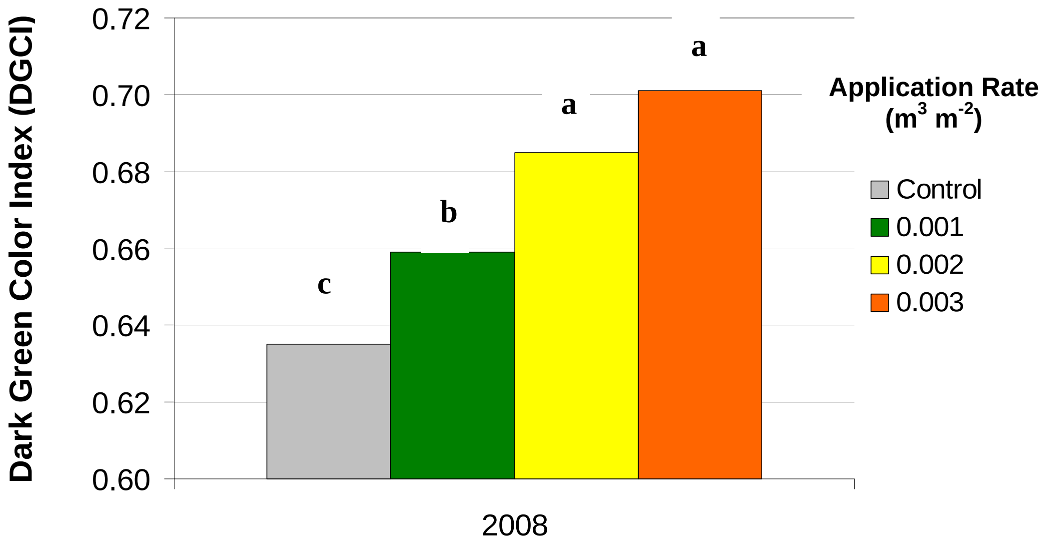

Figure 3. Application rate main effects on turfgrass color, April 2008. Turfgrass color was quantified using digital image analysis

Soil Penetration Resistance

Soil penetration resistance was primarily observed as both an overall rate effect and an overall sand type effect (Figures 4 and 5). The higher rates of application and finer sands (Fine and USGA) had the greatest resistance to penetration. These effects have become less apparent as the topdressing layers developed.

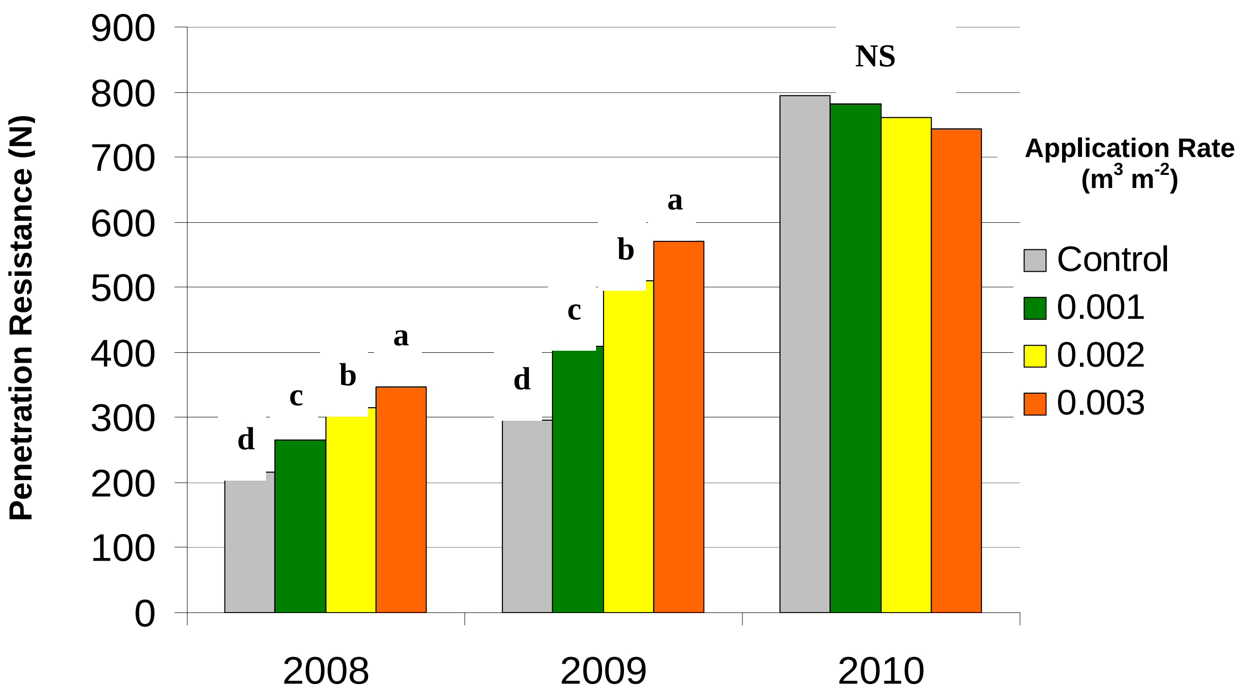

Figure 4. Application rate main effects on penetration resistance, April 2008, April 2009, and May 2010.

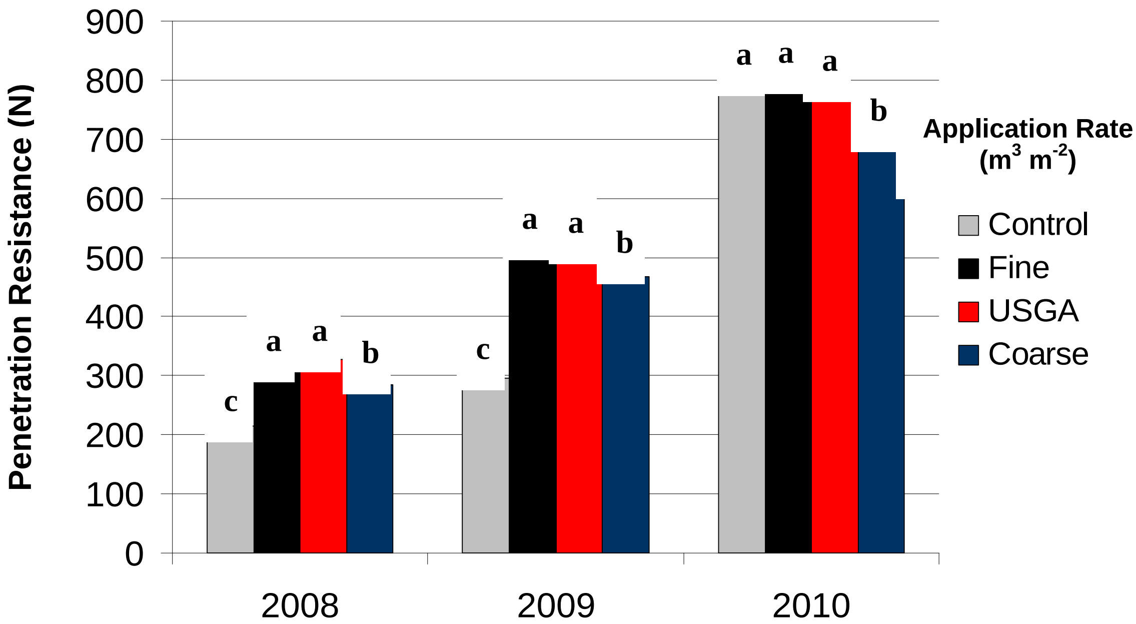

Figure 5. Sand type main effects on penetration resistance, April 2008, April 2009, and May 2010

Earthworm Activity

The effect of sand type and application rate on earthworm activity was observed as an overall rate effect with higher rates of application showing less earthworm activity (Figure 6).

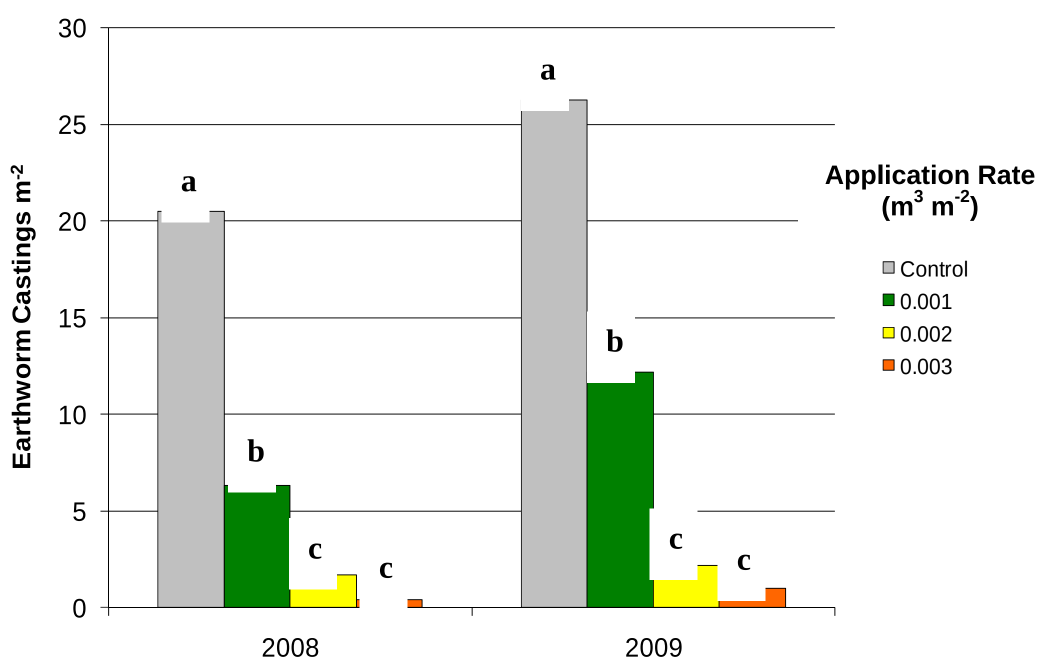

Figure 6. The overall effect of sand topdressing rate on the number of earthworm castings m^{-2}, November 2008, and December 2009. Earthworm pressure was not intense enough for data collection in 2010.

Dollar Spot Incidence

The effect of sand topdressing on dollar spot incidence was observed as an overall rate effect in 2007, 2008, 2009, and 2010. In 2007, 2008, and 2010 dollar spots were counted per m^{-2} (Figure 7). However, in 2009 disease pressure was too intense for counting and dollar spot incidence was rated on a severity scale of 1 to 9 where 1=little or no disease and 9=severe disease (Figure 8). These data indicate that the highest rate of application was required in 2007 and 2008 to get a significant reduction in dollar spot incidence. However, in 2009 a reduction in dollar spot incidence was observed at the medium rate and in 2010 dollar spot incidence was reduced at all application rates. This trend shows that as the topdressing layer accumulates, less sand needs to be applied to continue to see a reduction in dollar spot incidence.

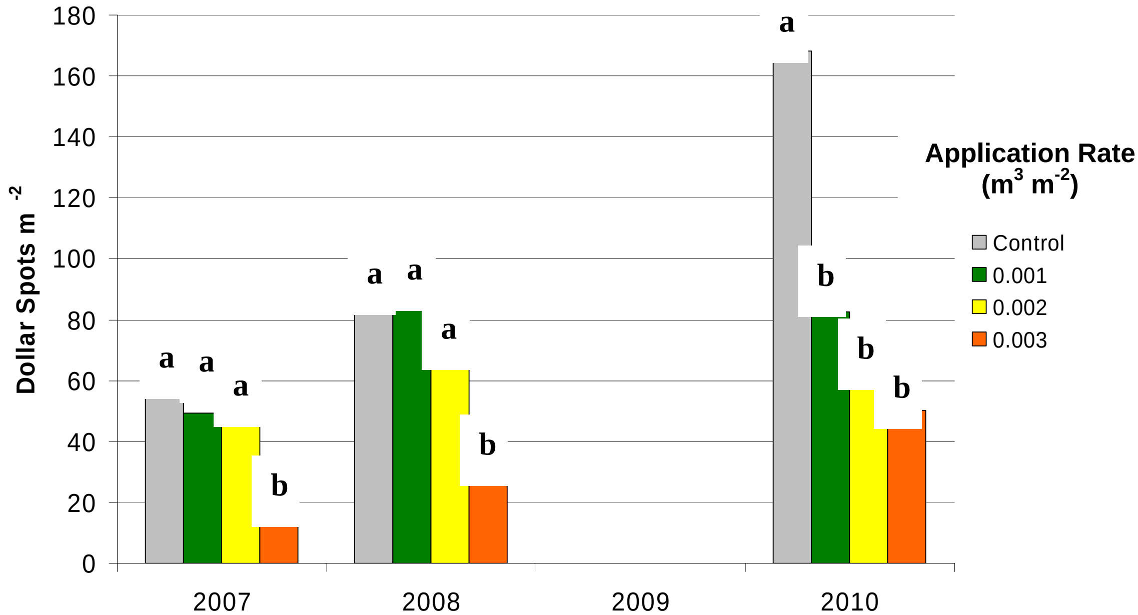

Figure 7.The overall effect of sand topdressing rate on the number of dollar spots m^{-2}, October 2007, June 2008, and August 2010

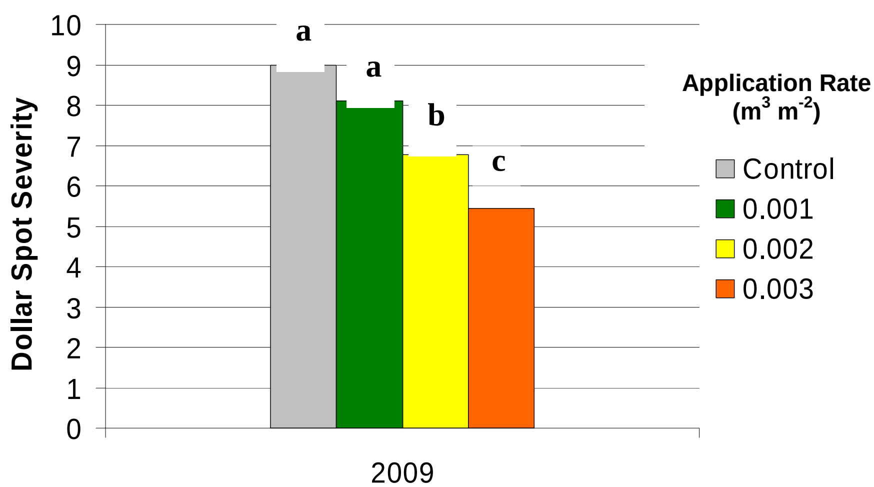

Figure 8.The overall effect of sand topdressing rate on dollar spots severity, September 2009 (1=little or no disease, 9=severe disease).

Conclusions to date

The results of this study are preliminary and are not conclusive due to the relatively short duration of this research. Given the data collected to date, it is apparent that there are many positive effects associated with the practice of fairway topdressing. However, this practice remains expensive, labor intensive, extremely time consuming and rough on equipment. The good news is that the majority of the responses appear to be related to application rate rather than sand type, which could result in a significant cost savings associated with sand purchases. This study will be continued as long as funding can be obtained to support further investigations. The turfgrass management implications as the topdressing layer continues to form will hopefully offer more information into this cultural practice. Please continue to work closely with your accredited laboratory to conduct all the appropriate testing procedures to select all your topdressing materials. Results to date are summarized as follows:

- Topdressed treatments showed a faster greening response than control plots. Plots that received higher rates of application exhibited a greater greening response than plots receiving lower rates.
- Topdressed treatments had higher resistance to penetration than control plots. The fine and USGA sands had the greatest resistance to penetration, followed by the coarse sand. Higher rates had greater resistance to penetration.
- As topdressing rate increased, earthworm castings decreased
- As topdressing rate increased, dollar spot incidence decreased
- Infiltration rates were not significantly different (Figure 9) (data not shown).

Figure 9. Infiltration rates were quantified in 2009 using a rain simulator developed by Ogden et al. 1997.

LITERATURE CITED

Ogden, C.B., H.M. van Es, and R.R. Schindelbeck. 1997. Miniature rain simulator for field measurement of soil infiltration. Soil Sci. Soc. Am. J. 61:1041-1043.

FIELD EVALUATION OF TURF TYPE TALL FESCUE FOR USE AS A HOME LAWN TURF IN SOUTHERN NEW ENGLAND 2010

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INTRODUCTION

Turf-type tall fescue has gained consumer interest over the last ten years. It maintains a dense, dark green color. The water and fertilizer requirements are less than those of the conventional Kentucky bluegrass/ryegrass home lawns. When trying to reduce inputs such as fertilizer and water, Turf-type tall fescue can be a good alternative. In the spring of 2007, a Turf-type tall fescue demonstration/cultivar evaluation site was established in Storrs, CT; 2010 marked the fourth and final season that turfgrass color and quality ratings were measured (refer to the 2007, 2008, and 2009 UCONN Turfgrass Research reports for seasons one through three data).

MATERIALS AND METHODS

Eighteen tall fescue cultivars were established using a completely randomized block design with three replicates of each. Plot size was 5'x 5'. Cultivars and respective suppliers are listed in Table 1.

Establishment and Management Practices

Season one 2007 - All cultivars and plots received the same management practices throughout the study. Plots were planted on May 16, 2007. During season one (establishment) plots received a total of 3 pounds of nitrogen per 1000 ft^2. Plots were maintained at a 2" height of cut and mowed weekly. Irrigation was applied as needed.

Management practices followed 2008 -2010 – Plots were mowed once per week at a height of cut of 2.5 inches. Clippings were returned. Irrigation was rarely applied but available as needed to keep from dormancy. All plots received one pound of nitrogen per 1,000 ft^2 in the spring (50% urea and 50% sulfur coated urea). A pre-emergent (*dithiopyr)* was applied for crabgrass control and Imidicloprid was applied as a grub control preventative on the following dates.

Date	*Product*
4/24/08	Dithiopyer
6/12/08	Imidicloprid
4/29/09	Dithiopyer
6/23/09	Imidicloprid
4/22/10	Dithiopyer
6/28/10	Imidicloprid

Table. 1 Turf-type Tall Fescue Cultivars

Cultivar	*Supplier*
Kentucky 31*	NTEP-
Silverado*	Turf-Seed, Inc
Falcon IV*	Pro Seeds Marketing, Inc
Rebel IV*	Budd Seed, Inc.
Justice*	Pennington Seed, Inc
03-5TF	PICKSEED
Dynasty	PICKSEED
04-3 FA	PICKSEED
M4	PICKSEED
#M30-6-CF2-257	PICKSEED
Barvado	BARENBRUG USA
BAR FA 6253	BARENBRUG USA
BAR FA 6363	BARENBRUG USA
TurfSAVOR with RTF	BARENBRUG USA
Firebird	BURLINGHAM SEEDS
Turbo	BURLINGHAM SEEDS
Tempest	BURLINGHAM SEEDS
Daytona	BURLINGHAM SEEDS

*Cultivars submitted to NTEP for consumer trial evaluations

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Figure 1. Tall Fescue Evaluation Plots – University of Connecticut

Quality and Color ratings

Two different rating systems were used on a monthly basis to rate 1) overall turf quality and 2) turfgrass color. Quality and color ratings were taken on the same day and at the same time of day. Overall turfgrass quality (Table 2) was evaluated using a visual rating system where a score of 1 illustrated the poorest quality turf and 9 the highest quality. Color readings (Table 3) were made using the Spectrum CM 1000 Chlorophyll Meter (Spectrum Technologies Inc., Plainfield, IL) The higher Spectrum CM 1000 readings indicate greener turf.

RESULTS & DISCUSSION

Results for overall turfgrass quality and color are provided in Tables 2 and 3. For the visual rating system, all cultivars with a rating of five or greater were considered acceptable. In examining seasonal data utilizing the visual rating system there were no significant differences in the top 7 cultivars: M4, Rebel IV, 04-3FA, BAR FA 6253, BAR 6353, 03-5TF, and Justice (Table 2). In ratings utilizing the Spectrum CM 1000 there was no significant difference between the top five cultivars: M4, Barvado, BAR FA 6253, Rebel IV, and 04-3FA, (Table 3). Four of the top rated cultivars from the Spectrum CM 1000 ratings were cultivars that were also in the top seven cultivars of visual quality ratings. In 2010 there was less variability among species evaluations when compared to the previous three seasons, particularly with the visual rating system (refer to the 2007, 2008, and 2009 UCONN Turfgrass Research reports for season 1, 2 and 3). All plots maintained color and density throughout the four growing seasons. When taking visual ratings in 2009 and 2010 leaf texture (fineness) was consistent among all cultivars. This was not the case in 2007 and 2008 where a higher degree of variability in leaf texture was noted. The lack of variation in texture and consistent green color is a plausible explanation for four of the five top rated cultivars being the same when comparing the two ratings systems, visual quality and the Spectrum CM 1000.

Table 2 Visual Quality Ratings for Eighteen Turf-type Tall Fescue Cultivars
Storrs, Connecticut 2010

Cultivar		*11 May*	*11 June*	*13 July*	*27 Aug*	*Mean*
M4		8.7 a	8.0 a	6.7 abc	9 a	8.1 a
Rebel IV		8.3ab	7.3 abc	7.0 abc	8.3 ab	7.8 ab
04-3 FA		8.0 abc	7.6 ab	7.3 ab	8.0 abc	7.8 ab
BAR FA 6253		8.7 a	7.3 abc	7.0 abc	8.0 abc	7.8 ab
BAR FA 6363		8.3 ab	7.3 abc	7.0 abc	8.3 ab	7.8 ab
03-5TF		8.0 abc	7.3 abc	7.7 a	7.7 bcd	7.7 ab
Justice		8.7 a	6.3 cde	6.7 abc	9.0 a	7.7 ab
Barvado		7.3 bcd	7.3 abc	7.7 a	7.3 bcd	7.4 bc
Falcon IV		8.3 ab	6.7 bcde	6.7 abc	8.0 abc	7.4 bc
TurfSAVOR		8.0 abc	6.7 bcde	7.3 ab	7.0 cde	7.3 bcd
Turbo		7.7 a	7.0 abcd	6.3 abc	7.0 cde	7.3 bcd
Daytona		7.3 bcd	7.0 abcd	6.3 abc	8.0 abc	7.2 bcd
Firebird		8.0 abc	6.7 bcde	6.3 abc	7.7 bcd	7.2 bcd
Dynasty		8.3 ab	7.0 abcd	6.7 abc	6.0 e	7.0 cde
Tempest		7.0 cd	7.3 abc	6.7 abc	6.0 e	6.8 def
Silverado		7.0 cd	5.7 e	6.0 bc	7.0 cde	6.4 ef
M30-30-6-CF2-257		6.3 d	5.7 e	6.3 abc	6.7 de	6.3 fg
Kentucky 31		5.0 e	6.0 de	5.6 c	6.0 e	5.7 g

† Cultivar visual ratings with the same letter within a column are not significantly different according to Fisher's Protected Least Significant Difference at p=0.05.

Table 3 Spectrum CM 1000 Color Meter Readings for Eighteen Turf-type Tall Fescue Cultivars
Storrs, Connecticut 2010

Cultivar		*11 May*	*13 July*	*27 Aug*	*Mean*
M4		441ab	396 ab	352 a	396 a
Barvado		420 abcd	411 a	342 abc	391 a
BAR FA 6253		451 a	365 abcd	334 abcde	383 ab
Rebel IV		393 cdefgh	377 abc	342 abcd	371 abc
04-3 FA		424 abcd	341 cdef	347 ab	370 abc
Firebird		424 abc	325 def	328 abcde	359 bcd
03-5TF		406 bcde	351 bcdef	314 defg	357 bcd
Falcon IV		397 cdefg	355 bcde	314 cdefg	356 cd
Turbo		403cdef	347 bcdef	314 defg	355 cd
BAR FA 6363		405 bcdef	324 def	333 abcde	354 cd
Justice		390 cdefgh	345 bcdef	321 bcdef	352 cd
Dynasty		395 cdefg	358 bcde	296 fgh	350 cde
TurfSAVOR		386 defgh	344 cdef	318 cdef	349 cde
Tempest		362 gh	333 cdef	311 efg	335 def
Daytona		369 efgh	300 f	307 efgh	325 ef
M30-30-6-CF2-257		368 fgh	309 ef	280 h	319 fg
Silverado		356 h	308 ef	288 gh	318 fg
Kentucky 31		298 i	309 ef	287 gh	298 g

† Cultivar meter readings within a column with the same letter are not significantly different according to Fisher's Protected Least Significant Difference at p=0.05.

Acknowledgements: In addition to the cultivars supplied by NTEP, the following companies supplied turf type tall fescue cultivars for this consumer trial evaluation: Barenbrug USA, Burlingham Seed, Pickseed West.

TRAFFIC RESPONSE OF KENTUCKY BLUEGRASS USED FOR ATHLETIC FIELDS 2010

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INTRODUCTION

It is common for natural athletic fields in Connecticut to receive heavy play beginning in late August into December. Kentucky bluegrass is the primary turfgrass used on athletic fields in our region because of its general tolerance to traffic and good recuperative capacity. Selection of Kentucky bluegrass types with superior traffic tolerance will contribute to higher carrying-capacity sports fields and greater play on those fields. The objective of this study was to determine the responses of various Kentucky bluegrass cultivars and experimental lines to traffic.

MATERIALS & METHODS

The field was seeded in the spring of 2008 and the experiment was set out as a split-plot design with 3 replicates. Main plots were either traffic or no traffic, and subplots were 35 Kentucky bluegrass entries. Subplot size was 5 by 5 ft.. Traffic was imposed on the plots beginning in early September into early December of 2008 by using a Cady Traffic Simulator. Traffic was applied in two perpendicular directions across the plots. The study was repeated on the established plots in 2009 and 2010. Traffic was imposed on the following dates in 2010, which would be consistent with fall sporting events in southern New England:

September: 5, 17, 20, 22, 23, 24, 29
October: 4, 8, 11, 13, 14, 18, 20, 22, 25, 28, 29
November: 3, 10, 11, 12, 15, 17, 18, 22, 24, 29
Excessive wet weather in early December prevented traffic.

The plots were mowed to 1½ inches as needed. No supplemental irrigation was applied in 2010. Additional cultural practices are provided in the following table.

Table 1. Fertilizer and pest control practices for the 2010 growing season.

Date	Activity
April 21	Pre-emergent weed control; Dimension Ultra WSP at 10 oz/acre.
May 10	Andersons Contec DG 18-9-18 fertilizer to provide. 1.0 lb N/1000ft^2
June 7	Broadleaf weed control, Trimec Classic at 65 oz./acre
June 10	LESCO 21-2-20 fertilizer (16.75% slow release) to provide. 0.75 lbs N/1000ft^2
June 28	Grub control, Merit 2F .at 261 oz./acre
September 13	Andersons Contec DG 18-9-18 fertilizer to provide. 1.0 lb N/1000ft^2
October 11	Andersons Contec DG 18-9-18 fertilizer to provide. 1.0 lb N/1000ft^2

Measurements for cover (%), color (hue angle), and dark green color index (DGCI, derived from hue, saturation, and brightness coordinates) were made by using digital image analysis. Observations were taken in the spring of 2010 to access recovery from traffic in 2009, and again in early September 2010 prior to traffic imposition. After traffic was initiated, measurements were taken on approximately monthly intervals through early December. Data were analyzed with analysis of variance to determine differences, and Fisher's Protected Least Significant Difference ($\alpha = 0.05$) was used to separate means when differences were found.

RESULTS

Singificant ($p < 0.05$) differences were observed for entries with all variables measured. The means values for trafficked and non-trafficked plots are given in the tables on the following pages of this report.

We appreciate the support for the UConn Turfgrass Science Program from Barenbrug USA.

Table 2. Cover (%) of non-trafficked plots during the growing season of 2010.

Entry	05/10/10	09/15/10	10/18/10	11/18/10	12/10/10
BAR VV 0709	74.9	78.3	81.6	78.4	68.7
BAR VV 9630	83.0	79.3	85.2	80.7	69.1
Barderby	73.8	77.1	76.3	66.4	59.7
Barduke	83.2	74.2	83.3	72.8	60.6
Barimpala	81.2	81.5	88.7	85.4	73.1
Bariris	90.4	78.1	81.6	75.8	65.2
Baron	82.8	82.1	82.8	67.9	52.0
Baroness	84.6	82.2	82.9	72.8	64.7
Barrister	84.8	81.9	84.0	71.9	54.7
Clone 234	69.8	85.1	87.9	79.5	71.6
Clone 235	62.1	85.5	88.8	78.6	68.3
Clone 5	67.8	83.3	83.9	74.1	65.9
Clone 69	68.7	82.2	83.4	74.9	64.2
Kenblue	72.2	77.3	82.4	68.5	60.4
Monnlight	87.4	83.8	86.1	80.6	70.7
VK-0701	78.7	80.8	87.5	82.2	73.2
VK7501A	83.3	69.9	82.6	73.6	61.7
VV 02-142	68.5	78.8	83.3	73.8	68.1
VV 02-152	65.0	82.3	81.8	71.0	62.2
VV 02-153A	65.2	78.9	81.6	69.2	64.5
VV 02-58	81.2	82.9	86.3	81.0	69.8
VV 02-72	73.9	85.1	85.7	73.3	64.0
VV 02-77	76.2	84.9	86.2	82.0	69.7
VV-0724	79.7	74.0	67.4	58.0	37.7
VV2916	78.6	78.1	82.2	79.3	71.3
VV2923	80.2	75.5	83.3	75.5	62.8
VV2924	75.7	62.2	79.1	74.5	68.7
VV2942	85.5	74.4	79.6	73.9	60.4
VV2950	84.0	79.3	84.1	74.0	64.4
VV2951	81.6	83.5	84.1	71.8	58.6
VV8320	77.3	76.5	79.7	74.2	62.5
VV-8357	79.3	80.9	87.4	72.0	60.5
VV-8365	72.2	79.6	79.0	71.3	61.8
VV8532	84.7	78.8	82.3	78.6	69.1
VV-9634	87.7	80.8	89.0	84.4	73.3
LSD	5.12	7.22	4.85	5.47	8.68
CV%	4.0	5.6	3.6	4.5	8.3

Table 3. Cover (%) of trafficked plots during 2010. The May date indicates residual effects due to the previous year's fall trafficking. The September date indicates conditions prior to traffic imposition in the fall of 2010.

Entry	05/10/10	09/15/10	10/18/10	11/18/10	12/10/10
BAR VV 0709	77.1	80.4	87.8	65.7	40.1
BAR VV 9630	82.9	83.6	87.6	62.1	37.1
Barderby	75.2	79.1	74.5	53.1	25.5
Barduke	82.6	83.0	86.2	59.6	28.7
Barimpala	85.5	82.1	88.3	61.5	32.2
Bariris	90.2	74.0	80.6	60.5	34.9
Baron	79.9	82.7	86.9	55.2	29.4
Baroness	84.2	83.6	86.9	59.5	35.2
Barrister	82.7	84.1	82.9	50.7	19.2
Clone 234	72.2	85.7	89.7	60.3	36.5
Clone 235	75.1	88.5	92.4	66.0	43.2
Clone 5	74.5	81.6	87.7	62.2	36.9
Clone 69	68.7	82.9	81.7	51.7	25.1
Kenblue	68.9	78.3	76.9	44.4	21.5
Monnlight	85.3	85.3	81.8	56.1	27.2
VK-0701	80.4	83.9	83.6	57.6	27.4
VK7501A	89.0	81.7	88.3	62.1	36.0
VV 02-142	70.1	81.6	82.6	49.0	24.2
VV 02-152	62.8	79.9	80.4	46.9	26.1
VV 02-153A	65.1	77.2	73.9	51.9	26.4
VV 02-58	78.0	83.3	82.5	53.1	24.6
VV 02-72	81.6	87.4	86.6	60.9	30.7
VV 02-77	82.0	83.8	85.4	62.8	29.7
VV-0724	73.5	68.9	54.2	34.0	14.2
VV2916	82.0	89.3	81.5	52.3	23.5
VV2923	83.7	78.1	84.3	58.0	31.1
VV2924	74.2	68.9	65.2	47.7	23.9
VV2942	81.7	76.2	75.8	47.6	24.4
VV2950	82.5	81.1	84.8	57.1	29.5
VV2951	82.8	84.2	79.9	51.3	25.7
VV8320	79.4	79.4	77.8	53.7	25.1
VV-8357	82.8	84.0	85.3	48.0	25.2
VV-8365	79.5	81.6	87.3	57.0	29.3
VV8532	87.9	82.5	89.4	67.2	39.4
VV-9634	86.1	83.3	88.8	67.4	43.1
LSD	7.84	6.57	8.19	12.25	12.89
CV%	6.1	5.0	6.1	13.5	26.8

Table 4. Color (hue angle) of non-trafficked plots during the growing season of 2010. A higher value indicates greener turf.

Entry	05/10/10	09/15/10	10/18/10	11/18/10	12/10/10
BAR VV 0709	104.5	110.7	114.0	111.8	106.8
BAR VV 9630	114.7	119.3	127.3	119.0	113.0
Barderby	105.3	112.9	110.4	105.4	105.9
Barduke	124.0	117.6	127.9	120.3	112.7
Barimpala	107.5	120.6	122.3	116.9	115.7
Bariris	118.6	116.7	122.6	117.6	111.8
Baron	123.6	119.5	124.5	114.6	107.6
Baroness	125.9	120.7	121.2	114.3	109.0
Barrister	127.3	127.3	131.7	121.4	113.6
Clone 234	105.8	125.2	121.5	114.1	113.9
Clone 235	103.5	116.3	121.2	112.0	110.2
Clone 5	104.1	116.3	120.2	110.6	108.3
Clone 69	104.1	117.7	118.8	113.6	109.8
Kenblue	108.6	112.4	116.5	108.8	107.9
Monnlight	132.8	127.1	134.8	132.0	119.9
VK-0701	109.2	118.3	124.3	117.3	115.3
VK7501A	112.7	110.6	118.2	110.4	105.8
VV 02-142	106.5	118.7	122.6	115.5	113.8
VV 02-152	107.9	118.8	119.9	110.9	108.3
VV 02-153A	107.8	118.2	119.3	110.9	111.0
VV 02-58	109.9	120.3	126.4	123.5	117.0
VV 02-72	110.1	122.8	124.7	114.9	110.1
VV 02-77	109.0	129.4	129.7	126.4	117.9
VV-0724	106.9	105.8	105.0	106.9	101.5
VV2916	105.1	111.8	111.8	111.3	109.7
VV2923	114.9	115.7	121.7	115.7	112.0
VV2924	110.3	109.1	120.0	114.1	108.6
VV2942	122.6	112.8	118.5	112.7	107.5
VV2950	126.3	118.5	126.8	121.6	113.7
VV2951	115.8	119.9	121.9	114.2	110.7
VV8320	109.9	115.3	118.3	114.3	110.6
VV-8357	109.2	115.4	116.7	108.2	105.5
VV-8365	108.6	113.1	114.8	110.4	109.6
VV8532	116.2	121.2	124.5	117.8	112.2
VV-9634	114.8	119.2	125.9	118.7	115.7
LSD	3.14	8.46	4.05	4.37	5.25
CV%	1.7	4.4	2.0	2.3	2.9

Table 5. Color (hue angle) of trafficked plots during 2010. The May date indicates residual effects due to the previous year's fall trafficking. The September date indicates conditions prior to traffic imposition in the fall of 2010. A higher value indicates greener turf.

Entry	05/10/10	09/15/10	10/18/10	11/18/10	12/10/10
BAR VV 0709	111.1	108.8	111.4	108.1	107.8
BAR VV 9630	117.1	119.7	118.2	107.0	106.4
Barderby	112.8	114.4	108.5	105.5	102.2
Barduke	127.8	118.1	118.7	108.6	107.6
Barimpala	115.1	119.6	116.5	107.8	108.1
Bariris	124.4	114.7	117.5	107.5	106.7
Baron	126.2	116.3	117.6	106.1	105.5
Baroness	127.1	116.7	117.4	107.4	103.6
Barrister	128.4	124.9	124.0	108.8	103.8
Clone 234	114.6	118.2	117.8	106.7	107.2
Clone 235	112.7	118.8	116.5	107.6	109.5
Clone 5	113.1	116.9	118.5	107.4	107.7
Clone 69	109.6	113.1	112.7	104.7	103.9
Kenblue	116.2	113.1	109.9	103.5	99.3
Monnlight	131.9	129.4	129.2	112.7	107.0
VK-0701	116.0	118.9	116.2	106.5	107.1
VK7501A	121.9	112.2	116.2	107.3	105.1
VV 02-142	114.6	114.8	113.9	104.9	105.4
VV 02-152	113.1	114.4	110.9	101.7	100.3
VV 02-153A	113.5	115.4	110.8	106.2	105.4
VV 02-58	118.7	122.9	118.1	108.0	105.7
VV 02-72	124.0	126.3	123.6	113.5	107.0
VV 02-77	120.3	127.7	122.3	110.7	107.1
VV-0724	111.5	105.0	101.1	103.2	98.2
VV2916	112.8	118.9	107.4	101.0	98.3
VV2923	122.7	115.3	115.5	106.1	104.4
VV2924	115.3	110.0	108.5	106.1	105.6
VV2942	123.8	114.8	108.5	101.9	100.9
VV2950	124.6	119.1	118.4	108.5	107.0
VV2951	120.9	116.9	115.4	106.5	107.5
VV8320	117.5	117.0	112.0	106.4	104.2
VV-8357	114.6	110.2	108.7	100.5	100.7
VV-8365	117.9	115.9	115.6	106.4	105.5
VV8532	118.2	119.0	120.0	109.0	108.1
VV-9634	117.6	122.1	120.2	109.6	107.3
LSD	4.07	4.33	3.77	4.91	6.08
CV%	2.1	2.3	2.0	2.8	3.6

Table 6. Dark green color index (DGCI) of non-trafficked plots during the growing season of 2010. A higher value indicates darker green turf.

Entry	05/10/10	09/15/10	10/18/10	11/18/10	12/10/10
BAR VV 0709	0.681	0.694	0.696	0.679	0.752
BAR VV 9630	0.750	0.740	0.760	0.709	0.777
Barderby	0.694	0.708	0.672	0.636	0.750
Barduke	0.807	0.731	0.766	0.729	0.786
Barimpala	0.698	0.753	0.736	0.698	0.803
Bariris	0.781	0.734	0.743	0.712	0.779
Baron	0.812	0.748	0.750	0.691	0.754
Baroness	0.822	0.755	0.736	0.695	0.760
Barrister	0.846	0.795	0.794	0.739	0.800
Clone 234	0.679	0.778	0.725	0.677	0.780
Clone 235	0.664	0.714	0.722	0.663	0.755
Clone 5	0.668	0.717	0.722	0.652	0.741
Clone 69	0.671	0.731	0.712	0.679	0.762
Kenblue	0.736	0.700	0.703	0.655	0.760
Monnlight	0.872	0.786	0.815	0.798	0.832
VK-0701	0.720	0.734	0.747	0.705	0.803
VK7501A	0.743	0.686	0.717	0.660	0.736
VV 02-142	0.695	0.735	0.737	0.695	0.785
VV 02-152	0.706	0.727	0.715	0.655	0.746
VV 02-153A	0.704	0.739	0.718	0.662	0.762
VV 02-58	0.714	0.752	0.766	0.750	0.811
VV 02-72	0.746	0.783	0.769	0.710	0.776
VV 02-77	0.716	0.805	0.782	0.765	0.819
VV-0724	0.689	0.639	0.616	0.634	0.717
VV2916	0.692	0.701	0.671	0.669	0.769
VV2923	0.767	0.726	0.739	0.703	0.790
VV2924	0.735	0.675	0.721	0.683	0.747
VV2942	0.804	0.697	0.713	0.674	0.752
VV2950	0.829	0.734	0.765	0.734	0.794
VV2951	0.762	0.739	0.729	0.684	0.768
VV8320	0.723	0.721	0.716	0.685	0.767
VV-8357	0.720	0.710	0.701	0.647	0.733
VV-8365	0.715	0.708	0.694	0.657	0.756
VV8532	0.766	0.750	0.750	0.708	0.775
VV-9634	0.744	0.739	0.750	0.707	0.797
LSD	0.0245	0.0531	0.0270	0.0299	0.0370
CV%	2.0	4.5	2.3	2.7	2.9

Table 7. Dark green color index (DGCI) of trafficked plots during 2010. The May date indicates residual effects due to the previous year's fall trafficking. The September date indicates conditions prior to traffic imposition in the fall of 2010. A higher value indicates darker green turf.

Entry	05/10/10	09/15/10	10/18/10	11/18/10	12/10/10
BAR VV 0709	0.733	0.677	0.657	0.650	0.757
BAR VV 9630	0.770	0.741	0.703	0.630	0.738
Barderby	0.740	0.720	0.643	0.634	0.725
Barduke	0.821	0.736	0.711	0.642	0.751
Barimpala	0.740	0.753	0.689	0.633	0.750
Bariris	0.815	0.724	0.712	0.650	0.742
Baron	0.825	0.726	0.700	0.629	0.736
Baroness	0.830	0.726	0.702	0.642	0.725
Barrister	0.845	0.788	0.751	0.663	0.732
Clone 234	0.745	0.731	0.695	0.623	0.736
Clone 235	0.732	0.729	0.680	0.629	0.749
Clone 5	0.732	0.726	0.704	0.631	0.738
Clone 69	0.717	0.695	0.663	0.620	0.731
Kenblue	0.768	0.698	0.647	0.615	0.704
Monnlight	0.860	0.805	0.779	0.685	0.752
VK-0701	0.756	0.739	0.697	0.630	0.750
VK7501A	0.804	0.696	0.694	0.640	0.736
VV 02-142	0.752	0.708	0.675	0.621	0.738
VV 02-152	0.732	0.699	0.645	0.592	0.696
VV 02-153A	0.746	0.720	0.653	0.630	0.738
VV 02-58	0.780	0.768	0.715	0.652	0.747
VV 02-72	0.818	0.801	0.753	0.691	0.760
VV 02-77	0.792	0.793	0.740	0.674	0.756
VV-0724	0.714	0.628	0.582	0.616	0.699
VV2916	0.753	0.741	0.632	0.594	0.700
VV2923	0.810	0.723	0.694	0.630	0.734
VV2924	0.757	0.681	0.634	0.626	0.740
VV2942	0.795	0.716	0.636	0.595	0.705
VV2950	0.803	0.741	0.708	0.646	0.750
VV2951	0.786	0.721	0.687	0.635	0.753
VV8320	0.779	0.731	0.665	0.633	0.732
VV-8357	0.753	0.669	0.632	0.590	0.707
VV-8365	0.768	0.727	0.689	0.630	0.735
VV8532	0.769	0.738	0.716	0.645	0.748
VV-9634	0.759	0.754	0.718	0.660	0.743
LSD	0.0336	0.0302	0.0234	0.0367	0.0391
CV%	2.7	2.5	2.1	3.6	3.3

Table 8. Cover (%) comparison at each date between non-trafficked (No) and trafficked (Yes) plots. Significant differences (α = 0.05) for a specific entry at a particular date indicated by yellow box. The May date indicates residual effects due to the previous year's fall trafficking. The September date indicates conditions prior to traffic imposition in the fall of 2010.

	05/10/10		09/15/10		10/18/10		11/18/10		12/10/10	
Entry	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
BAR VV 0709	74.9	77.1	78.3	80.4	81.6	87.8	78.4	65.7	68.7	40.1
BAR VV 9630	83.0	82.9	79.3	83.6	85.2	87.6	80.7	62.1	69.1	37.1
Barderby	73.8	75.2	77.1	79.1	76.3	74.5	66.4	53.1	59.7	25.5
Barduke	83.2	82.6	74.2	83.0	83.3	86.2	72.8	59.6	60.6	28.7
Barimpala	81.2	85.5	81.5	82.1	88.7	88.3	85.4	61.5	73.1	32.2
Bariris	90.4	90.2	78.1	74.0	81.6	80.6	75.8	60.5	65.2	34.9
Baron	82.8	79.9	82.1	82.7	82.8	86.9	67.9	55.2	52.0	29.4
Baroness	84.6	84.2	82.2	83.6	82.9	86.9	72.8	59.5	64.7	35.2
Barrister	84.8	82.7	81.9	84.1	84.0	82.9	71.9	50.7	54.7	19.2
Clone 234	69.8	72.2	85.1	85.7	87.9	89.7	79.5	60.3	71.6	36.5
Clone 235	62.1	75.1	85.5	88.5	88.8	92.4	78.6	66.0	68.3	43.2
Clone 5	67.8	74.5	83.3	81.6	83.9	87.7	74.1	62.2	65.9	36.9
Clone 69	68.7	68.7	82.2	82.9	83.4	81.7	74.9	51.7	64.2	25.1
Kenblue	72.2	68.9	77.3	78.3	82.4	76.9	68.5	44.4	60.4	21.5
Monnlight	87.4	85.3	83.8	85.3	86.1	81.8	80.6	56.1	70.7	27.2
VK-0701	78.7	80.4	80.8	83.9	87.5	83.6	82.2	57.6	73.2	27.4
VK7501A	83.3	89.0	69.9	81.7	82.6	88.3	73.6	62.1	61.7	36.0
VV 02-142	68.5	70.1	78.8	81.6	83.3	82.6	73.8	49.0	68.1	24.2
VV 02-152	65.0	62.8	82.3	79.9	81.8	80.4	71.0	46.9	62.2	26.1
VV 02-153A	65.2	65.1	78.9	77.2	81.6	73.9	69.2	51.9	64.5	26.4
VV 02-58	81.2	78.0	82.9	83.3	86.3	82.5	81.0	53.1	69.8	24.6
VV 02-72	73.9	81.6	85.1	87.4	85.7	86.6	73.3	60.9	64.0	30.7
VV 02-77	76.2	82.0	84.9	83.8	86.2	85.4	82.0	62.8	69.7	29.7
VV-0724	79.7	73.5	74.0	68.9	67.4	54.2	58.0	34.0	37.7	14.2
VV2916	78.6	82.0	78.1	89.3	82.2	81.5	79.3	52.3	71.3	23.5
VV2923	80.2	83.7	75.5	78.1	83.3	84.3	75.5	58.0	62.8	31.1
VV2924	75.7	74.2	62.2	68.9	79.1	65.2	74.5	47.7	68.7	23.9
VV2942	85.5	81.7	74.4	76.2	79.6	75.8	73.9	47.6	60.4	24.4
VV2950	84.0	82.5	79.3	81.1	84.1	84.8	74.0	57.1	64.4	29.5
VV2951	81.6	82.8	83.5	84.2	84.1	79.9	71.8	51.3	58.6	25.7
VV8320	77.3	79.4	76.5	79.4	79.7	77.8	74.2	53.7	62.5	25.1
VV-8357	79.3	82.8	80.9	84.0	87.4	85.3	72.0	48.0	60.5	25.2
VV-8365	72.2	79.5	79.6	81.6	79.0	87.3	71.3	57.0	61.8	29.3
VV8532	84.7	87.9	78.8	82.5	82.3	89.4	78.6	67.2	69.1	39.4
VV-9634	87.7	86.1	80.8	83.3	89.0	88.8	84.4	67.4	73.3	43.1

Table 9. Color (hue angle) comparison at each date between non-trafficked (No) and trafficked (Yes) plots. Significant differences (α = 0.05) for a specific entry at a particular date indicated by yellow box. The May date indicates residual effects due to the previous year's fall trafficking. The September date indicates conditions prior to traffic imposition in the fall of 2010.

	05/10/10		09/15/10		10/18/10		11/18/10		12/10/10	
Entry	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
BAR VV 0709	104.5	111.1	110.7	108.8	114.0	111.4	111.8	108.1	106.8	107.8
BAR VV 9630	114.7	117.1	119.3	119.7	127.3	118.2	119.0	107.0	113.0	106.4
Barderby	105.3	112.8	112.9	114.4	110.4	108.5	105.4	105.5	105.9	102.2
Barduke	124.0	127.8	117.6	118.1	127.9	118.7	120.3	108.6	112.7	107.6
Barimpala	107.5	115.1	120.6	119.6	122.3	116.5	116.9	107.8	115.7	108.1
Bariris	118.6	124.4	116.7	114.7	122.6	117.5	117.6	107.5	111.8	106.7
Baron	123.6	126.2	119.5	116.3	124.5	117.6	114.6	106.1	107.6	105.5
Baroness	125.9	127.1	120.7	116.7	121.2	117.4	114.3	107.4	109.0	103.6
Barrister	127.3	128.4	127.3	124.9	131.7	124.0	121.4	108.8	113.6	103.8
Clone 234	105.8	114.6	125.2	118.2	121.5	117.8	114.1	106.7	113.9	107.2
Clone 235	103.5	112.7	116.3	118.8	121.2	116.5	112.0	107.6	110.2	109.5
Clone 5	104.1	113.1	116.3	116.9	120.2	118.5	110.6	107.4	108.3	107.7
Clone 69	104.1	109.6	117.7	113.1	118.8	112.7	113.6	104.7	109.8	103.9
Kenblue	108.6	116.2	112.4	113.1	116.5	109.9	108.8	103.5	107.9	99.3
Monnlight	132.8	131.9	127.1	129.4	134.8	129.2	132.0	112.7	119.9	107.0
VK-0701	109.2	116.0	118.3	118.9	124.3	116.2	117.3	106.5	115.3	107.1
VK7501A	112.7	121.9	110.6	112.2	118.2	116.2	110.4	107.3	105.8	105.1
VV 02-142	106.5	114.6	118.7	114.8	122.6	113.9	115.5	104.9	113.8	105.4
VV 02-152	107.9	113.1	118.8	114.4	119.9	110.9	110.9	101.7	108.3	100.3
VV 02-153A	107.8	113.5	118.2	115.4	119.3	110.8	110.9	106.2	111.0	105.4
VV 02-58	109.9	118.7	120.3	122.9	126.4	118.1	123.5	108.0	117.0	105.7
VV 02-72	110.1	124.0	122.8	126.3	124.7	123.6	114.9	113.5	110.1	107.0
VV 02-77	109.0	120.3	129.4	127.7	129.7	122.3	126.4	110.7	117.9	107.1
VV-0724	106.9	111.5	105.8	105.0	105.0	101.1	106.9	103.2	101.5	98.2
VV2916	105.1	112.8	111.8	118.9	111.8	107.4	111.3	101.0	109.7	98.3
VV2923	114.9	122.7	115.7	115.3	121.7	115.5	115.7	106.1	112.0	104.4
VV2924	110.3	115.3	109.1	110.0	120.0	108.5	114.1	106.1	108.6	105.6
VV2942	122.6	123.8	112.8	114.8	118.5	108.5	112.7	101.9	107.5	100.9
VV2950	126.3	124.6	118.5	119.1	126.8	118.4	121.6	108.5	113.7	107.0
VV2951	115.8	120.9	119.9	116.9	121.9	115.4	114.2	106.5	110.7	107.5
VV8320	109.9	117.5	115.3	117.0	118.3	112.0	114.3	106.4	110.6	104.2
VV-8357	109.2	114.6	115.4	110.2	116.7	108.7	108.2	100.5	105.5	100.7
VV-8365	108.6	117.9	113.1	115.9	114.8	115.6	110.4	106.4	109.6	105.5
VV8532	116.2	118.2	121.2	119.0	124.5	120.0	117.8	109.0	112.2	108.1
VV-9634	114.8	117.6	119.2	122.1	125.9	120.2	118.7	109.6	115.7	107.3

Table 10. Dark green color index (DGCI) comparison at each date between non-trafficked (No) and trafficked (Yes) plots. Significant differences (α = 0.05) for a specific entry at a particular date indicated by yellow box. The May date indicates residual effects due to the previous year's fall trafficking. The September date indicates conditions prior to traffic imposition in the fall of 2010.

	05/10/10		09/15/10		10/18/10		11/18/10		12/10/10	
Entry	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
BAR VV 0709	0.681	0.733	0.694	0.677	0.696	0.657	0.679	0.650	0.752	0.757
BAR VV 9630	0.750	0.770	0.740	0.741	0.760	0.703	0.709	0.630	0.777	0.738
Barderby	0.694	0.740	0.708	0.720	0.672	0.643	0.636	0.634	0.750	0.725
Barduke	0.807	0.821	0.731	0.736	0.766	0.711	0.729	0.642	0.786	0.751
Barimpala	0.698	0.740	0.753	0.753	0.736	0.689	0.698	0.633	0.803	0.750
Bariris	0.781	0.815	0.734	0.724	0.743	0.712	0.712	0.650	0.779	0.742
Baron	0.812	0.825	0.748	0.726	0.750	0.700	0.691	0.629	0.754	0.736
Baroness	0.822	0.830	0.755	0.726	0.736	0.702	0.695	0.642	0.760	0.725
Barrister	0.846	0.845	0.795	0.788	0.794	0.751	0.739	0.663	0.800	0.732
Clone 234	0.679	0.745	0.778	0.731	0.725	0.695	0.677	0.623	0.780	0.736
Clone 235	0.664	0.732	0.714	0.729	0.722	0.680	0.663	0.629	0.755	0.749
Clone 5	0.668	0.732	0.717	0.726	0.722	0.704	0.652	0.631	0.741	0.738
Clone 69	0.671	0.717	0.731	0.695	0.712	0.663	0.679	0.620	0.762	0.731
Kenblue	0.736	0.768	0.700	0.698	0.703	0.647	0.655	0.615	0.760	0.704
Monnlight	0.872	0.860	0.786	0.805	0.815	0.779	0.798	0.685	0.832	0.752
VK-0701	0.720	0.756	0.734	0.739	0.747	0.697	0.705	0.630	0.803	0.750
VK7501A	0.743	0.804	0.686	0.696	0.717	0.694	0.660	0.640	0.736	0.736
VV 02-142	0.695	0.752	0.735	0.708	0.737	0.675	0.695	0.621	0.785	0.738
VV 02-152	0.706	0.732	0.727	0.699	0.715	0.645	0.655	0.592	0.746	0.696
VV 02-153A	0.704	0.746	0.739	0.720	0.718	0.653	0.662	0.630	0.762	0.738
VV 02-58	0.714	0.780	0.752	0.768	0.766	0.715	0.750	0.652	0.811	0.747
VV 02-72	0.746	0.818	0.783	0.801	0.769	0.753	0.710	0.691	0.776	0.760
VV 02-77	0.716	0.792	0.805	0.793	0.782	0.740	0.765	0.674	0.819	0.756
VV-0724	0.689	0.714	0.639	0.628	0.616	0.582	0.634	0.616	0.717	0.699
VV2916	0.692	0.753	0.701	0.741	0.671	0.632	0.669	0.594	0.769	0.700
VV2923	0.767	0.810	0.726	0.723	0.739	0.694	0.703	0.630	0.790	0.734
VV2924	0.735	0.757	0.675	0.681	0.721	0.634	0.683	0.626	0.747	0.740
VV2942	0.804	0.795	0.697	0.716	0.713	0.636	0.674	0.595	0.752	0.705
VV2950	0.829	0.803	0.734	0.741	0.765	0.708	0.734	0.646	0.794	0.750
VV2951	0.762	0.786	0.739	0.721	0.729	0.687	0.684	0.635	0.768	0.753
VV8320	0.723	0.779	0.721	0.731	0.716	0.665	0.685	0.633	0.767	0.732
VV-8357	0.720	0.753	0.710	0.669	0.701	0.632	0.647	0.590	0.733	0.707
VV-8365	0.715	0.768	0.708	0.727	0.694	0.689	0.657	0.630	0.756	0.735
VV8532	0.766	0.769	0.750	0.738	0.750	0.716	0.708	0.645	0.775	0.748
VV-9634	0.744	0.759	0.739	0.754	0.750	0.718	0.707	0.660	0.797	0.743

QUALITY RESPONSE OF LOW-CUT, LOW-INPUT FINE FESCUES 2010

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INTRODUCTION

There is increasing interest in reducing inputs on turf areas to save money on resource and labor costs. Fine fescue species are well-known for their ability to persist under less than ideal conditions. New introductions of fine fescue species have potential to improve upon those characteristics that are valued with these species. This study was set out to evaluate the quality response of fine fescues under low-cut and low-input conditions.

MATERIALS & METHODS

This study was initiated August 2007. A seedbed was prepared on a Paxton fine sandy loam soil, and 3 x 3 foot plots were seeded with fine fescue entries on August 17, 2007. During the grow-in period, 1 lb of N, P, and K per 1000ft^2 were applied to the plots on October 17, 2007 and again on November 29, 2007 using a 15-15-15 all soluble fertilizer. In the spring 2008, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. No irrigation or pest control was applied. On May 14, 2009, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. No irrigation or pest control was applied in 2008 or 2009.

On May 10, 2010, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. No irrigation was applied. Bensumec 4LF was applied for pre-emergent weed control on April 22, 2010 at 318 oz./acre. Merit 2F was applied on June 28, 2010 for grub control at 261 oz/acre. These were the only pesticide applications made in the 3-year study. No irrigation was applied in 2010. Plots were visually rated for density (1 to 9 scale for one date; 9 = best) and quality (1 to 9 scale; 9 = best). Color was measured by using a Spectrum CM1000 chlorophyll meter.

Data were analyzed with analysis of variance to determine differences, and Fisher's Protected Least Significant Difference (α = 0.05) was used to separate means when differences were found.

RESULTS

Singificant ($p < 0.05$) differences were observed for entries with all variables measured. The means values for the different entries are given in the tables on the following pages of this report.

CONCLUSIONS

New introductions of fine fesuces show promise for maintaining density and quality under a 2-inch height of cut when managed with low inputs. This would be especially beneficial for golf courses and other high-value turf areas where lower heights of cuts are required with lower overall inputs.

We appreciate the support for the UConn Turfgrass Science Program from Barenbrug USA.

Table 1. Visual density rating (1 to 9) of fine fescue entries under 2-inch mowing height and low input in 2010.

	Rating			
Entry	05/10/10	07/15/10	10/27/10	mean
05-FF-Vp-15 (VA)	4.0	7.3	7.0	6.1
05-FF-Vp-17 (VA)	3.7	6.3	7.0	5.7
05-FF-Vp-3 (VA)	4.0	7.0	7.0	6.0
05-FFV-2 (VA)	4.0	5.0	5.3	4.8
4FR 920	2.7	4.3	5.7	4.2
4FR 930	4.3	7.0	6.7	6.0
6FR 035	4.7	5.7	6.7	5.6
6FR 124	4.7	6.3	5.7	5.5
6FR 126	5.0	6.7	6.0	5.9
6FR 130	4.7	6.0	6.0	5.6
6FR 132	3.3	5.3	5.0	4.5
6RT JASA	2.3	5.3	6.0	4.5
BAR FR 4001	2.3	4.7	5.7	4.2
BARBIRDIE	4.0	5.3	5.7	5.0
BARCROWN	3.3	4.7	6.0	4.7
BARCROWN II	3.3	5.0	5.0	4.4
BARDIVA	3.3	5.3	5.0	4.6
BARDUR	4.0	5.0	5.3	4.8
BARGENA III	2.5	4.5	4.8	4.0
BARGREEN	4.0	6.3	6.0	5.4
BARMALIA	4.0	5.3	6.0	5.1
BARNOVA	2.7	5.0	4.7	4.1
BAROK	2.7	3.0	3.0	2.9
BAROYAL	3.3	6.3	5.7	5.1
BARPEARL	3.3	5.0	5.3	4.5
BARSWING	4.3	5.7	6.0	5.3
BARTHEMA	3.0	5.7	6.0	4.9
BARUSTIC	2.3	5.0	4.0	3.8
BOREAL	2.7	4.3	5.0	4.0
BRIDGEPORT II	2.7	5.7	5.0	4.5
FLORENTINE	3.0	5.3	5.3	4.5
FR-1R05 (Romania)	2.7	4.0	5.0	3.9
FR-2R05 (Romania)	3.0	5.3	5.0	4.5
FR-3R05 (Romania)	3.0	4.7	4.7	4.1
HARDTOP	3.7	6.0	6.0	5.2
QUATRO	2.7	3.3	4.0	3.3
SOBERANA	3.7	5.3	5.7	4.9
TEDI	4.0	6.0	5.3	5.1
CV%	32.6	29.0	27.1	26.4
LSD	1.80	2.50	2.40	2.03

Table 2. Visual overall quality rating (1 to 9) of fine fescue entries under 2-inch mowing height and low input in 2010.

	Rating					
Entry	05/10/10	06/10/10	07/15/10	08/27/10	10/27/10	mean
05-FF-Vp-15 (VA)	4.0	5.3	5.7	5.7	5.7	5.3
05-FF-Vp-17 (VA)	4.0	4.7	4.7	5.7	5.7	4.9
05-FF-Vp-3 (VA)	4.0	4.3	5.0	5.7	5.7	4.9
05-FFV-2 (VA)	3.3	4.3	4.7	4.7	5.0	4.4
4FR 920	2.7	2.7	3.3	2.3	4.7	3.1
4FR 930	4.3	5.3	5.0	5.3	5.3	5.1
6FR 035	4.3	4.7	5.0	3.7	5.7	4.7
6FR 124	4.0	4.7	4.7	4.0	4.7	4.4
6FR 126	4.0	6.3	4.7	3.7	5.3	4.8
6FR 130	4.3	5.3	5.0	3.7	6.3	4.9
6FR 132	3.7	4.0	4.3	2.7	4.7	3.9
6RT JASA	2.3	3.7	4.3	4.7	5.3	4.1
BAR FR 4001	3.0	3.7	3.7	3.0	4.3	3.5
BARBIRDIE	4.0	5.3	3.7	3.7	5.0	4.3
BARCROWN	3.3	3.7	4.0	3.0	5.3	3.9
BARCROWN II	3.0	4.0	4.0	3.7	4.7	3.9
BARDIVA	3.0	3.7	3.7	2.7	4.3	3.5
BARDUR	3.3	4.7	4.3	4.3	5.0	4.3
BARGENA III	2.7	3.8	4.0	3.3	4.5	3.7
BARGREEN	4.3	3.7	5.3	4.7	6.0	4.8
BARMALIA	3.3	4.3	4.3	3.0	5.7	4.1
BARNOVA	4.0	4.7	3.7	3.0	4.7	4.0
BAROK	2.7	3.0	2.0	1.7	2.7	2.4
BAROYAL	3.3	3.7	5.0	4.0	5.7	4.3
BARPEARL	3.0	3.0	3.0	2.7	4.7	3.3
BARSWING	4.0	4.0	4.7	4.7	5.7	4.6
BARTHEMA	3.3	4.3	4.3	3.7	4.3	4.0
BARUSTIC	2.3	3.0	3.0	2.3	3.7	2.9
BOREAL	2.3	4.3	3.3	4.0	4.3	3.7
BRIDGEPORT II	2.3	3.7	4.3	4.0	5.0	3.9
FLORENTINE	3.0	3.3	3.3	4.0	4.7	3.7
FR-1R05 (Romania)	3.3	4.0	2.7	3.3	4.0	3.5
FR-2R05 (Romania)	3.0	3.7	3.0	3.3	4.0	3.4
FR-3R05 (Romania)	3.0	4.3	3.0	4.0	4.7	3.8
HARDTOP	4.3	4.7	4.3	4.0	5.7	4.6
QUATRO	3.0	3.0	2.7	2.7	4.0	3.1
SOBERANA	4.0	4.3	4.3	3.7	5.3	4.3
TEDI	3.7	5.3	4.3	4.3	5.7	4.7
CV%	21.3	31.3	38.2	37.8	25.2	25.8
LSD	1.17	2.10	2.50	2.28	2.00	1.69

Table 3. Turf color quality, as measured by Spectrum CM1000 Chlorophyll meter, of fine fescue entries under 2-inch mowing height and low input in 2010. Higher values indicate more green.

	Reading					
Entry	05/10/10	06/09/10	07/15/10	08/26/10	11/09/10	mean
05-FF-Vp-15 (VA)	126	333	234	236	168	220
05-FF-Vp-17 (VA)	122	326	236	254	189	225
05-FF-Vp-3 (VA)	134	345	231	253	173	227
05-FFV-2 (VA)	139	305	238	250	192	225
4FR 920	128	300	219	249	188	217
4FR 930	142	361	228	235	170	227
6FR 035	138	318	214	246	187	221
6FR 124	133	347	208	227	172	217
6FR 126	131	362	212	230	182	223
6FR 130	126	338	224	256	195	228
6FR 132	128	298	207	261	181	215
6RT JASA	131	335	201	224	186	215
BAR FR 4001	126	312	229	249	176	218
BARBIRDIE	127	303	195	249	191	213
BARCROWN	131	333	210	260	202	227
BARCROWN II	131	315	219	259	206	226
BARDIVA	133	303	200	242	173	210
BARDUR	131	310	217	257	160	215
BARGENA III	143	324	228	246	176	223
BARGREEN	130	309	243	243	175	220
BARMALIA	142	319	221	239	196	224
BARNOVA	125	307	230	256	183	220
BAROK	124	286	221	217	137	197
BAROYAL	142	345	237	254	188	233
BARPEARL	123	282	205	245	180	207
BARSWING	145	380	236	249	173	237
BARTHEMA	138	320	211	245	178	218
BARUSTIC	129	303	200	217	162	202
BOREAL	142	300	205	254	177	216
BRIDGEPORT II	130	335	241	243	166	223
FLORENTINE	125	353	215	256	198	229
FR-1R05 (Romania)	122	296	207	215	159	200
FR-2R05 (Romania)	117	282	195	215	155	193
FR-3R05 (Romania)	122	288	190	223	167	198
HARDTOP	132	329	245	257	181	229
QUATRO	129	279	252	251	156	213
SOBERANA	137	317	218	237	181	218
TEDI	127	301	194	230	174	205
CV%	9.5	8.6	7.4	9.2	13.5	5.7
LSD	20.1	44.4	26.1	36.3	38.6	19.9

QUALITY RESPONSE OF LOW-CUT, LOW-INPUT TURF SPECIES AND MIXTURES 2010

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INTRODUCTION

There is increasing interest in reducing inputs on turf areas to save money on resource and labor costs. Several species are well-known for their ability to persist under less than ideal conditions. New introductions of these species have potential to improve upon those characteristics that are valued with these species. This study was set out to evaluate the quality response of various cool-season turfgrass species and their mixtures under low-cut and low-input conditions.

MATERIALS & METHODS

This study was initiated August 2007 to determine the quality responses of various species and mixtures under low input. A seedbed was prepared on a Paxton fine sandy loam soil, and 3 x 5 foot plots were seeded with various entries on August 20, 2007. During the grow-in period, 1 lb of N, P, and K per 1000ft^2 were applied to the plots on Octover 17, 2007 and again on November 29, 2007 using a 15-15-15 all soluble fertilizer. In the spring 2008, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. On May 14, 2009, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. No irrigation or pest control was applied in 2007 or 2008.

On May 10, 2010, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. No irrigation was applied. Bensumec 4LF was applied for pre-emergent weed control on April22, 2010 at 318 oz./acre. Merit 2F was applied on June 28, 2010 for grub control at 261 oz/acre. These were the only pesticide applications made in the 3-year study. No irrigation was applied in 2010. Plots were visually rated for density (1 to 9 scale for one date; 9 = best) and quality (1 to 9 scale; 9 = best). Color was measured by using a Spectrum CM1000 chlorophyll meter.

Data were analyzed with analysis of variance to determine differences, and Fisher's Protected Least Significant Difference (α = 0.05) was used to separate means when differences were found.

RESULTS

Singificant (p < 0.05) differences were observed for entries with all variables measured. The means values for the different entries are given in the tables on the following pages of this report.

CONCLUSIONS

New introductions of various cool-season turfgrass species show promise for maintaining density and quality under a 2-inch height of cut when managed with low inputs. This would be especially beneficial for golf courses and other high-value turf areas where lower heights of cuts are required with lower overall inputs.

We appreciate the support for the UConn Turfgrass Science Program from Barenbrug USA.

The following is the key for table entries:

Code	Species or Mix	Cultivar or Percentage of Mix
Fod	Hard Fescue	Hardtop
Frc	Chewings Fescue	Bridgeport II
Frl	Slender Creeping Red Fescue	Barcrown II
Frr	Strong Creeping Red Fescue	Bargena III
Ff	Sheep Fescue	Barok
Km	Crested Hairgrass	Barleria
Km	Crested Hairgrass	Barkoel
Fa	Tall Fescue blend	TurfSaver w/RTF blend
Pp	Kentucky bluegrass blend	Turfblue blend
Lp	Perennial Ryegrass blend	TurfStar blend
Dc	Tufted Hairgrass	Barcampsia
Pc	Canadian bluegrass	Barpressa
Pn	Wood bluegrass	Barchopin
Ac	Colonial bentgrass	Heriot
Mix	Fod:Frc:Frl:Km	25:25:25:25
Mix	Fa:Pp	30:70
Mix	Fa:Pp	70:30
Mix	Fa:Fod:Pp	45:45:10
Mix	Fa:Km	70:30
Mix	Fa:Km:Pp	60:30:10
Mix	Fa:Fod:Pc:Km	25:25:25:25
Mix	Fod:Pc:Km	33:33:33
Mix	Fod:Frc:Frl:Ac	30:30:30:10
Mix	Pc:Km	60:40
Mix	Fa:Pc	70:30
Mix	Frc:Pc	70:30
Mix	Pp:Pc	50:50
Mix	Wear & Tear mix (35% Common KBG, 35% common CRF, 20% Fiesta 4 PRG 10% Express PRG)	
Mix	Team Jr. tall fescue mix (35% Crossfire II, 35% Shortstop II, 30% Dynasty)	
Mix	Coastal mix (30% Spartan hard fescue, 30% Jasper II CRF, 30% Victory II Chewings fescue, 10% Transit Intermediate ryegrass)	

Table 1. Visual density rating (1 to 9) of various species and mixtures entries under 2-inch mowing height and low input in 2010.

	Rating			
Entry	05/10/10	07/15/10	10/27/10	mean
Barcampsia tufted hairgrass	5.0	3.3	4.5	4.2
Barchopin wood bluegrass	2.0	2.0	2.8	2.3
Barcrown II Slender CRF	4.8	5.0	5.5	5.1
Bargena III Strong CRF	3.3	3.5	5.3	4.0
Barkoel crested hairgrass	4.3	5.3	6.5	5.3
Barleria crested hairgrass	4.8	5.0	6.8	5.5
Barok sheep fescue	2.5	2.8	3.0	2.8
Barpressa Canada bluegrass	2.0	1.3	1.5	1.6
Bridgeport II Chewings fescue	4.3	5.5	5.5	5.1
Coastal mix	4.5	5.8	7.0	5.8
Fa:Fod:Pc:Km 25:25:25:25	5.3	6.0	6.5	5.9
Fa:Fod:Pp 45:45:10	6.8	5.8	7.8	6.8
Fa:Km 70:30	6.5	6.0	7.5	6.7
Fa:Km:Pp 60:30:10	5.3	6.3	7.5	6.3
Fa:Pc 70:30	6.8	3.8	7.5	6.0
Fa:Pp 30:70	5.3	5.8	7.5	6.2
Fa:Pp 70:30	6.3	6.0	7.3	6.5
Fod:Frc:Frl:Ac 30:30:30:10	5.0	6.8	7.0	6.3
Fod:Frc:Frl:Km 25:25:25:25	4.3	5.8	6.5	5.5
Fod:Pc:Km 33:33:33	6.5	5.8	7.5	6.6
Frc:Pc 70:30	5.0	6.3	6.5	5.9
Hardtop hard fescue	5.0	5.3	6.8	5.7
Heriot Colonial bentgrass	3.8	4.3	7.0	5.0
Pc:Km 60:40	2.8	1.8	4.5	3.0
Pp:Pc 50:50	3.3	3.5	5.5	4.1
Team Jr.	6.0	5.8	7.3	6.4
TurfSaver w/RTF	6.5	4.5	6.0	5.7
Turfblue blend KBG	4.5	3.3	6.8	4.9
Turfstar blend PRG	4.5	3.0	5.8	4.4
Wear & Tear	3.8	4.0	6.0	4.6
CV%	24.3	26.2	18.4	13.7
LSD	1.59	1.70	1.57	0.98

Table 2. Visual overall quality rating (1 to 9) of various species and mixtures entries under 2-inch mowing height and low input in 2010.

	Rating					
Entry	05/10/10	06/10/10	07/15/10	08/27/10	10/27/10	mean
Barcampsia tufted hairgrass	4.0	3.5	3.0	2.8	4.0	3.5
Barchopin wood bluegrass	2.0	2.0	1.8	2.0	2.8	2.1
Barcrown II Slender CRF	3.8	4.0	4.0	4.3	4.5	4.1
Bargena III Strong CRF	3.0	3.8	3.3	4.3	4.0	3.7
Barkoel crested hairgrass	3.5	5.3	4.3	6.0	5.0	4.8
Barleria crested hairgrass	3.3	3.8	4.3	5.0	5.5	4.4
Barok sheep fescue	2.8	4.0	3.3	3.3	3.3	3.3
Barpressa Canada bluegrass	2.3	1.5	1.0	1.3	1.0	1.4
Bridgeport II Chewings fescue	3.3	3.5	5.0	3.5	5.0	4.1
Coastal mix	3.8	4.8	4.8	4.3	5.8	4.7
Fa:Fod:Pc:Km 25:25:25:25	4.5	4.8	5.0	5.8	5.8	5.2
Fa:Fod:Pp 45:45:10	5.0	5.3	5.8	6.0	6.5	5.7
Fa:Km 70:30	5.5	5.0	5.5	6.3	6.8	5.8
Fa:Km:Pp 60:30:10	4.8	4.5	5.3	5.8	6.3	5.3
Fa:Pc 70:30	5.0	4.5	4.0	4.5	5.8	4.8
Fa:Pp 30:70	4.5	4.8	5.3	5.8	6.0	5.3
Fa:Pp 70:30	5.3	5.0	5.5	5.8	6.0	5.5
Fod:Frc:Frl:Ac 30:30:30:10	4.5	5.0	6.3	4.8	5.0	5.1
Fod:Frc:Frl:Km 25:25:25:25	3.5	3.8	4.8	3.8	4.5	4.1
Fod:Pc:Km 33:33:33	4.8	5.8	5.3	4.5	6.3	5.3
Frc:Pc 70:30	4.0	3.8	4.5	3.5	5.0	4.2
Hardtop hard fescue	4.0	4.0	5.0	4.8	5.8	4.7
Heriot Colonial bentgrass	3.5	3.3	3.3	3.3	4.0	3.5
Pc:Km 60:40	2.0	2.0	2.3	3.0	3.5	2.6
Pp:Pc 50:50	3.0	3.5	2.0	4.8	4.5	3.6
Team Jr.	5.3	5.3	4.5	5.5	6.0	5.3
TurfSaver w/RTF	5.0	5.0	4.8	5.3	5.3	5.1
Turfblue blend KBG	4.3	4.8	3.3	5.8	5.3	4.7
Turfstar blend PRG	2.5	3.8	2.8	3.3	4.3	3.3
Wear & Tear	3.0	4.0	4.5	4.8	4.8	4.2
CV%	20.5	21.9	22.1	22.2	17.7	13.2
LSD	1.10	1.27	1.28	1.38	1.23	0.80

Table 3. Turf color quality, as measured with a Spectrum CM1000 Chlorophyll meter, of various species and mixtures entries under 2-inch mowing height and low input in 2010. Higher values indicate more green.

	Reading					
Entry	05/10/10	06/09/10	07/15/10	08/26/10	12/11/10	mean
Barcampsia tufted hairgrass	147	253	201	217	125	189
Barchopin wood bluegrass	133	235	198	221	125	182
Barcrown II Slender CRF	147	296	216	230	157	209
Bargena III Strong CRF	133	279	200	235	148	199
Barkoel crested hairgrass	169	279	223	247	143	212
Barleria crested hairgrass	153	294	218	249	143	211
Barok sheep fescue	155	277	224	244	141	208
Barpressa Canada bluegrass	127	226	170	198	123	169
Bridgeport II Chewings fescue	121	284	213	224	136	195
Coastal mix	123	282	200	209	140	191
Fa:Fod:Pc:Km 25:25:25:25	140	285	218	250	146	208
Fa:Fod:Pp 45:45:10	167	299	239	250	147	220
Fa:Km 70:30	141	294	241	296	142	223
Fa:Km:Pp 60:30:10	151	298	219	249	132	210
Fa:Pc 70:30	157	281	217	250	137	208
Fa:Pp 30:70	149	306	226	250	126	211
Fa:Pp 70:30	157	308	235	271	128	220
Fod:Frc:Frl:Ac 30:30:30:10	143	279	219	206	129	195
Fod:Frc:Frl:Km 25:25:25:25	129	283	215	227	140	199
Fod:Pc:Km 33:33:33	138	275	205	218	145	196
Frc:Pc 70:30	125	276	200	221	132	191
Hardtop hard fescue	132	300	235	251	155	215
Heriot Colonial bentgrass	124	254	202	225	124	186
Pc:Km 60:40	133	266	193	223	134	190
Pp:Pc 50:50	134	281	215	229	126	197
Team Jr.	142	297	226	261	124	210
TurfSaver w/RTF	161	307	241	293	132	227
Turfblue blend KBG	133	329	232	241	132	213
Turfstar blend PRG	143	293	249	268	142	219
Wear & Tear	121	266	203	232	126	189
CV%	13.9	7.2	10.1	9.0	6.8	6.8
LSD	27.6	28.5	30.6	30.3	13.1	19.3

QUALITY RESPONSE OF HIGH-CUT, LOW-INPUT TURF SPECIES AND MIXTURES 2010

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INTRODUCTION

There is increasing interest in reducing inputs on turf areas to save money on resource and labor costs. Several species are well-known for their ability to persist under less than ideal conditions. New introductions of these species have potential to improve upon those characteristics that are valued with these species. This study was set out to evaluate the quality response of various cool-season turfgrass species and their mixtures under low-cut and low-input conditions.

MATERIALS & METHODS

This study was initiated August 2007 to determine the quality responses of various species and mixtures under low input. A seedbed was prepared on a Paxton fine sandy loam soil, and 3 x 5 foot plots were seeded with various entries on August 20, 2007. During the grow-in period, 1 lb of N, P, and K per 1000ft^2 were applied to the plots on Octover 17, 2007 and again on November 29, 2007 using a 15-15-15 all soluble fertilizer. In the spring 2008, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 3 inches as needed. On May 14, 2009, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. No irrigation or pest control was applied in 2007 or 2008.

On May 10, 2010, 1 lb of N per 1000ft^2 was applied to the plots using a LESCO 45% slow-release, poly-plus coated 18-2-18 fertilizer. The plots were mowed to 2 inches as needed. No irrigation was applied. Bensumec 4LF was applied for pre-emergent weed control on April22, 2010 at 318 oz./acre. Merit 2F was applied on June 28, 2010 for grub control at 261 oz/acre. These were the only pesticide applications made in the 3-year study. No irrigation was applied in 2010. Plots were visually rated for density (1 to 9 scale for one date; 9 = best) and quality (1 to 9 scale; 9 = best). Color was measured by using a Spectrum CM1000 chlorophyll meter.

Data were analyzed with analysis of variance to determine differences, and Fisher's Protected Least Significant Difference (α = 0.05) was used to separate means when differences were found.

RESULTS

Singificant ($p < 0.05$) differences were observed for entries with all variables measured. The means values for the different entries are given in the tables on the following pages of this report.

CONCLUSIONS

New introductions of various cool-season turfgrass species show promise for maintaining density and quality under a 3-inch height of cut when managed with low inputs. This would be especially beneficial for lawns, parks, and other turf areas where lower inputs are required because of budgetaryor environmental restrictions.

We appreciate the support for the UConn Turfgrass Science Program from Barenbrug USA.

The following is the key for table entries:

Code	Species or Mix	Cultivar or Percentage of Mix
Fod	Hard Fescue	Hardtop
Frc	Chewings Fescue	Bridgeport II
Frl	Slender Creeping Red Fescue	Barcrown II
Frr	Strong Creeping Red Fescue	Bargena III
Ff	Sheep Fescue	Barok
Km	Crested Hairgrass	Barleria
Km	Crested Hairgrass	Barkoel
Fa	Tall Fescue blend	TurfSaver w/RTF blend
Pp	Kentucky bluegrass blend	Turfblue blend
Lp	Perennial Ryegrass blend	TurfStar blend
Dc	Tufted Hairgrass	Barcampsia
Pc	Canadian bluegrass	Barpressa
Pn	Wood bluegrass	Barchopin
Ac	Colonial bentgrass	Heriot
Mix	Fod:Frc:Frl:Km	25:25:25:25
Mix	Fa:Pp	30:70
Mix	Fa:Pp	70:30
Mix	Fa:Fod:Pp	45:45:10
Mix	Fa:Km	70:30
Mix	Fa:Km:Pp	60:30:10
Mix	Fa:Fod:Pc:Km	25:25:25:25
Mix	Fod:Pc:Km	33:33:33
Mix	Fod:Frc:Frl:Ac	30:30:30:10
Mix	Pc:Km	60:40
Mix	Fa:Pc	70:30
Mix	Frc:Pc	70:30
Mix	Pp:Pc	50:50
Mix	Wear & Tear mix (35% Common KBG, 35% common CRF, 20% Fiesta 4 PRG 10% Express PRG)	
Mix	Team Jr. tall fescue mix (35% Crossfire II, 35% Shortstop II, 30% Dynasty)	
Mix	Coastal mix (30% Spartan hard fescue, 30% Jasper II CRF, 30% Victory II Chewings fescue, 10% Transit Intermediate ryegrass)	

Table 1. Visual density rating (1 to 9) of various species and mixtures entries under 3-inch mowing height and low input in 2010.

	Rating			
Entry	05/10/10	07/15/10	10/27/10	mean
Barcampsia tufted hairgrass	5.0	3.8	3.3	4.0
Barchopin wood bluegrass	2.5	1.8	4.0	2.8
Barcrown II Slender CRF	3.3	6.0	5.3	4.8
Bargena III Strong CRF	2.5	3.8	4.8	3.7
Barkoel crested hairgrass	3.3	5.5	5.8	4.9
Barleria crested hairgrass	3.5	5.5	6.0	5.0
Barok sheep fescue	3.3	2.8	2.5	2.8
Barpressa Canada bluegrass	3.0	1.0	1.5	1.9
Bridgeport II Chewings fescue	3.5	6.0	6.3	5.3
Coastal mix	4.3	6.8	7.3	6.1
Fa:Fod:Pc:Km 25:25:25:25	5.0	6.8	6.5	6.1
Fa:Fod:Pp 45:45:10	5.0	7.5	7.3	6.6
Fa:Km 70:30	5.3	7.0	6.5	6.3
Fa:Km:Pp 60:30:10	5.3	6.0	6.5	5.9
Fa:Pc 70:30	5.0	5.5	5.5	5.3
Fa:Pp 30:70	4.0	6.8	5.5	5.4
Fa:Pp 70:30	5.3	6.8	7.0	6.4
Fod:Frc:Frl:Ac 30:30:30:10	4.5	7.8	7.5	6.6
Fod:Frc:Frl:Km 25:25:25:25	3.8	6.3	6.5	5.5
Fod:Pc:Km 33:33:33	5.0	7.3	7.3	6.5
Frc:Pc 70:30	3.8	6.0	7.0	5.6
Hardtop hard fescue	4.0	6.8	6.3	5.7
Heriot Colonial bentgrass	3.3	6.5	5.8	5.2
Pc:Km 60:40	3.0	2.8	4.3	3.4
Pp:Pc 50:50	2.5	4.8	4.3	3.8
Team Jr.	5.0	7.3	7.3	6.5
TurfSaver w/RTF	5.0	6.8	5.8	5.8
Turfblue blend KBG	3.3	6.8	4.5	4.8
Turfstar blend PRG	3.3	3.8	3.3	3.4
Wear & Tear	3.3	3.8	6.0	4.3
CV%	21.4	21.8	19.8	14.3
LSD	1.19	1.69	1.55	1.01

Table 2. Visual overall quality rating (1 to 9) of various species and mixtures entries under 3-inch mowing height and low input in 2010.

	Rating					
Entry	05/10/10	06/10/10	07/15/10	08/27/10	10/27/10	mean
Barcampsia tufted hairgrass	3.8	3.8	3.3	2.8	3.0	3.3
Barchopin wood bluegrass	3.0	3.0	2.0	1.5	2.8	2.5
Barcrown II Slender CRF	3.5	3.5	4.8	2.8	4.5	3.8
Bargena III Strong CRF	3.0	3.0	3.5	3.0	3.3	3.2
Barkoel crested hairgrass	3.3	4.8	4.5	4.8	4.5	4.4
Barleria crested hairgrass	2.8	4.3	4.3	4.8	5.8	4.4
Barok sheep fescue	2.8	2.8	3.8	3.3	2.3	3.0
Barpressa Canada bluegrass	2.8	1.5	1.3	1.3	1.3	1.6
Bridgeport II Chewings fescue	3.3	5.0	4.5	3.0	4.8	4.1
Coastal mix	3.8	4.8	4.5	4.8	5.3	4.6
Fa:Fod:Pc:Km 25:25:25:25	4.5	4.8	5.0	5.0	4.5	4.8
Fa:Fod:Pp 45:45:10	4.8	5.0	6.0	5.5	6.0	5.5
Fa:Km 70:30	5.3	5.0	5.0	5.8	5.5	5.3
Fa:Km:Pp 60:30:10	4.3	5.5	5.0	5.5	5.5	5.2
Fa:Pc 70:30	4.5	4.8	4.3	3.0	4.3	4.2
Fa:Pp 30:70	3.8	4.3	5.3	4.8	5.0	4.6
Fa:Pp 70:30	3.8	4.5	5.3	5.8	5.0	4.9
Fod:Frc:Frl:Ac 30:30:30:10	4.3	5.3	5.0	4.8	5.0	4.9
Fod:Frc:Frl:Km 25:25:25:25	3.5	4.3	4.0	3.8	5.0	4.1
Fod:Pc:Km 33:33:33	5.0	5.0	5.5	4.0	6.0	5.1
Frc:Pc 70:30	3.5	5.0	4.8	4.3	5.5	4.6
Hardtop hard fescue	4.5	3.8	6.0	4.3	4.8	4.7
Heriot Colonial bentgrass	3.5	3.8	3.0	2.5	4.3	3.4
Pc:Km 60:40	3.3	3.0	2.3	2.8	3.5	3.0
Pp:Pc 50:50	2.8	3.0	3.3	2.8	3.3	3.0
Team Jr.	4.8	5.5	5.8	5.3	5.3	5.3
TurfSaver w/RTF	4.8	4.5	5.0	4.5	4.5	4.7
Turfblue blend KBG	3.3	3.3	5.0	3.5	3.3	3.7
Turfstar blend PRG	3.3	4.5	3.3	2.5	3.8	3.5
Wear & Tear	3.3	4.3	3.8	4.0	4.5	4.0
CV%	21.8	19.8	22.2	25.3	21.8	12.7
LSD	1.14	1.16	1.34	1.37	1.34	0.73

Table 3. Turf color quality, as measured with a Spectrum CM1000 Chlorophyll meter, of various species and mixtures entries under 3-inch mowing height and low input in 2010. Higher values indicate more green.

	Reading					
Entry	05/10/10	06/10/10	07/16/10	08/26/10	12/11/10	mean
Barcampsia tufted hairgrass	156	253	196	217	122	189
Barchopin wood bluegrass	139	270	196	228	116	190
Barcrown II Slender CRF	151	297	209	219	141	203
Bargena III Strong CRF	140	291	217	242	136	205
Barkoel crested hairgrass	182	296	233	276	139	225
Barleria crested hairgrass	183	297	212	264	140	219
Barok sheep fescue	161	275	231	261	143	214
Barpressa Canada bluegrass	133	219	188	190	117	169
Bridgeport II Chewings fescue	130	307	207	220	131	199
Coastal mix	140	284	202	223	128	195
Fa:Fod:Pc:Km 25:25:25:25	153	274	192	236	134	198
Fa:Fod:Pp 45:45:10	159	290	220	253	140	212
Fa:Km 70:30	169	319	229	308	134	232
Fa:Km:Pp 60:30:10	142	304	222	273	125	213
Fa:Pc 70:30	152	264	204	228	117	193
Fa:Pp 30:70	143	297	216	238	116	202
Fa:Pp 70:30	161	327	234	277	128	225
Fod:Frc:Frl:Ac 30:30:30:10	129	277	206	233	126	194
Fod:Frc:Frl:Km 25:25:25:25	159	296	227	241	141	213
Fod:Pc:Km 33:33:33	141	263	197	215	139	191
Frc:Pc 70:30	154	275	196	228	130	196
Hardtop hard fescue	148	283	223	257	150	212
Heriot Colonial bentgrass	113	258	199	211	111	178
Pc:Km 60:40	149	247	191	235	121	189
Pp:Pc 50:50	141	254	189	251	119	191
Team Jr.	149	287	211	277	120	209
TurfSaver w/RTF	151	289	220	284	124	214
Turfblue blend KBG	123	291	203	231	116	193
Turfstar blend PRG	143	277	209	244	136	202
Wear & Tear	123	265	183	230	118	184
%CV	18.4	7.0	12.4	13.2	9.4	9.6
LSD	38.0	27.7	36.2	45.0	17.0	27.3

AMINO-SUGAR SOIL N TEST (ASNT) AND ACTIVE SOIL C TEST (ASCT) AS PREDICTORS OF LAWN TURF RESPONSE 2010

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INTRODUCTION

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

MATERIALS & METHODS

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

In the spring of 2010, soil samples were collected from each plot to a depth of 10 cm below the thatch layer, and analyzed for concentrations of soil amino-sugar N and active soil C. During the 2010 growing season, plots were mowed to a height of 7.5 cm twice a week, or as needed depending on growth. No supplemental irrigation was applied. At approximately two-week intervals after soil sampling, and continuing until November, turf canopy reflectance was measured using Spectrum CM1000 and TCM500 NDVI reflectance meters (Spectrum Technologies, Inc., Planfield, IL). Meter values for each sampling date were converted to a relative scale by dividing each value by the plateau value for each respective sampling date. When a plateau was not present, values were divided by the mean of the six highest meter readings for that respective sampling date. Relative values were pooled across the sampling dates and correlated with soil amino-sugar and active C concentrations.

Linear response-plateau (LRP) and quadratic response-plateau (QRP) models were applied to the data to determine a critical level for soil amino-sugar and active C concentrations relative to turf color. The critical soil amino-sugar and active C value marks the concentration where no further change in response is observed with increasing concentration of soil values. The response value at this point and beyond the critical value is referred to as the plateau, which indicates the maximum response that will be observed in the relationship. No plateau response was observed for soil amino-sugar or for active C concentrations with either meter or turf species. Therefore, the data were tested to determine simple linear responses.

RESULTS

Readings from reflectance meters were significant, but weakly correlated to soil amino-sugar concentration (Figs. 1 and 2), or soil active C (Figs. 5 and 6). The lack of a plateau response may be due to insufficient N being mineralized from the organic fertilizer during the first three years of application. The range of values for amino-sugar N and active C were relatively narrow, and this narrow range restricted the application of the plateau models.

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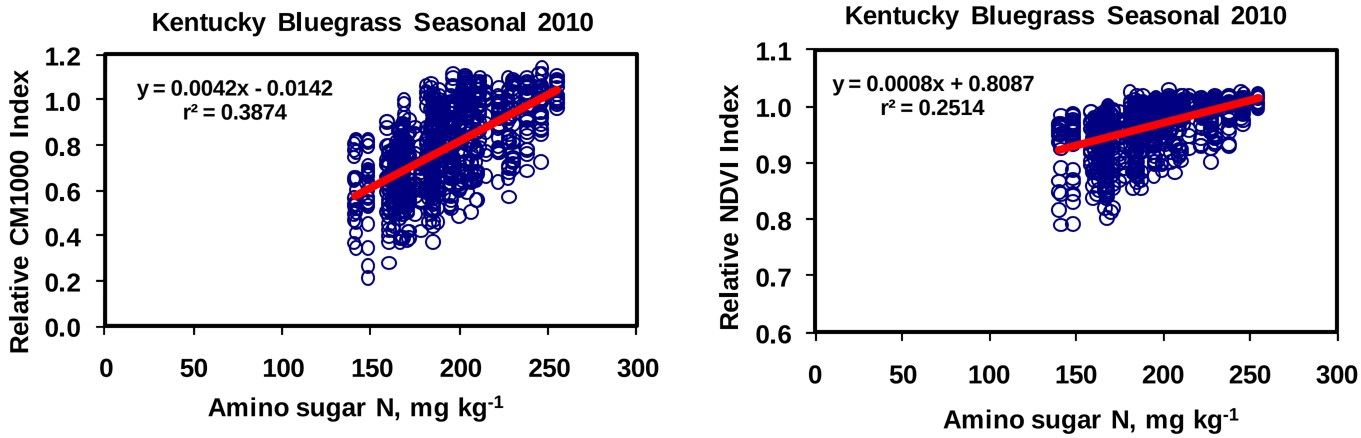

Fig. 1. **Relationship between relative CM1000 (left panel) and TCM500 NDVI (right panel) meter readings with soil amino-sugar N for Kentucky bluegrass lawn turf across 12 sampling dates during the 2010 growing season.**

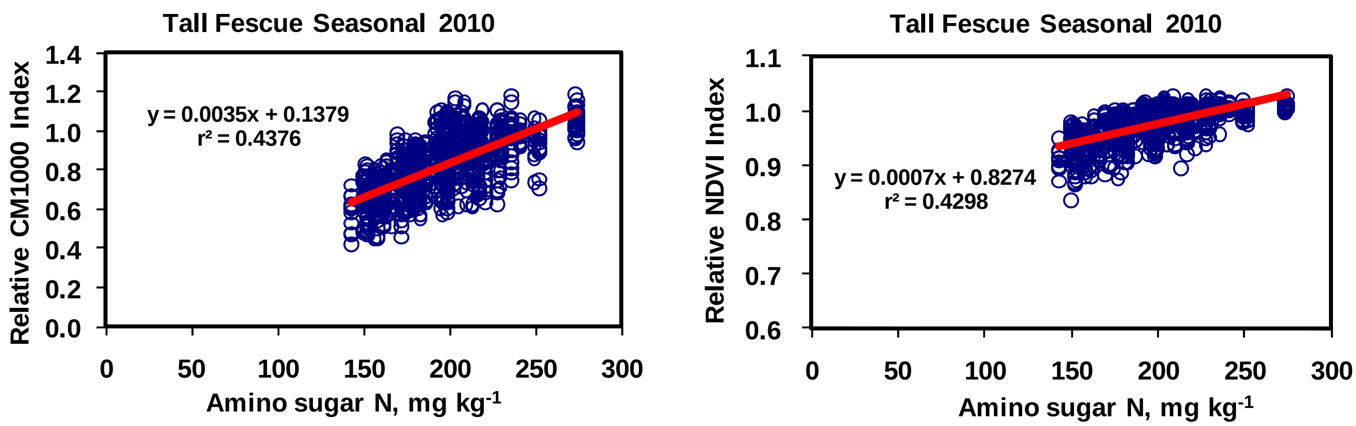

Fig. 2. **Relationship between relative CM1000 (left panel) and TCM500 NDVI (right panel) meter readings with soil amino-sugar N for tall fescue lawn turf across 12 sampling dates during the 2010 growing season.**

Fig. 3. Kentucky bluegrass response to varying rates of compost.

Fig. 4. Tall fescue response to varying rates of compost.

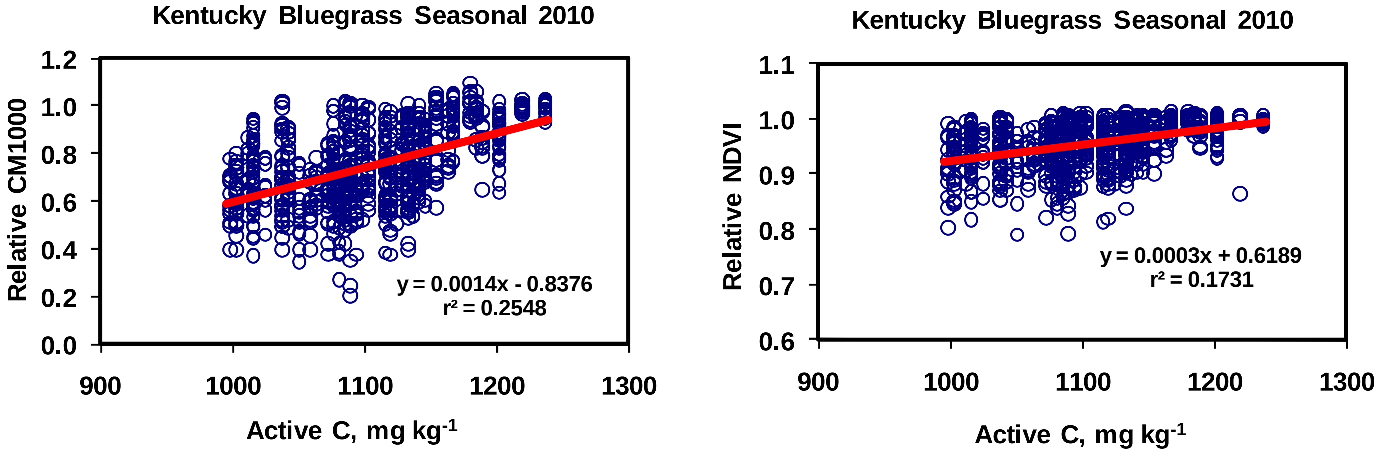

Fig. 5. Relationship between relative CM1000 (left panel) and TCM500 NDVI (right panel) meter readings with soil active C for Kentucky bluegrass lawn turf across 12 sampling dates during the 2010 growing season.

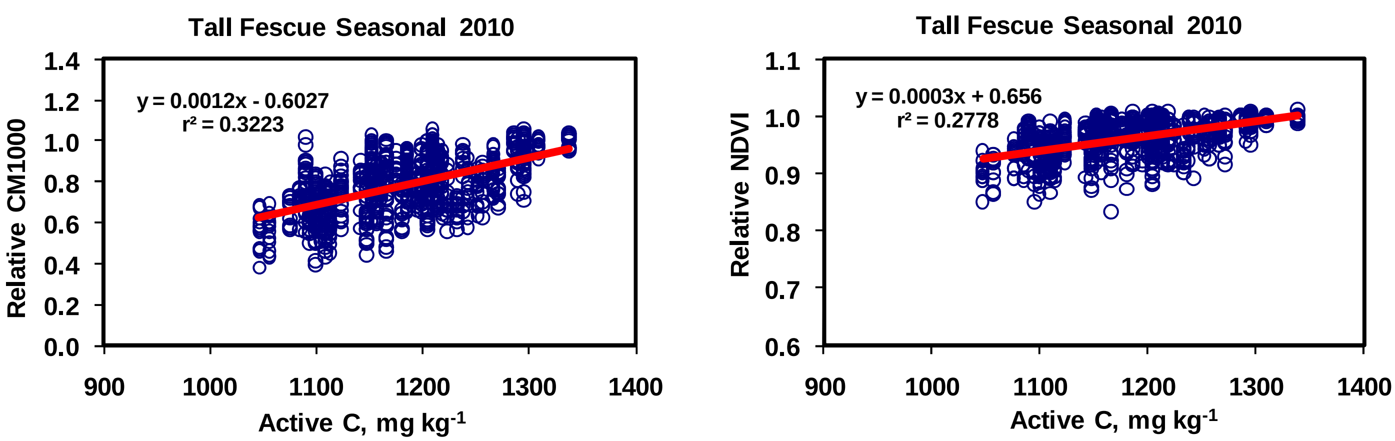

Fig. 6. Relationship between relative CM1000 (left panel) and TCM500 NDVI (right panel) meter readings with soil active C for tall fescue lawn turf across 12 sampling dates during the 2010 growing season.

DISCUSSION

The third year's results of this study show positive, but weak relationships for Kentucky bluegrass and tall fescue color response to soil amino-sugar and active C. More time may be needed for mineralization of the composted organic fertilizer to release sufficient N for optimum turf quality response. A fourth application of compost was made to the plots in the fall of 2010 and monitoring will continue through 2011. It is hoped that a wider range of soil amino-sugar and active C can be produced in the plots by these additional applications so that plateau responses can be established.

VERDURE SAP NITRATE-N CONCENTRATIONS AS A PREDICTOR OF TURF COLOR RESPONSE FALL 2010 – SPRING 2011

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INTRODUCTION

Annual grasses tend to store N as nitrate in the bases of stems and shoots. Measurement of this nitrate pool can be used as an indicator of soil N availability for these grasses. For example, the end-of-season cornstalk nitrate test has been shown to correlate well with corn yield. This test gives corn producers a diagnostic assessment of their N management for the past growing season after corn has been harvested. Nitrate concentrations in the cornstalks at harvest are compared with an established critical value. If the values are far below the critical value, then the corn plant received insufficient N; if they are far above the critical value, then excess N was supplied. Concentrations nearer the critical value suggest that optimum N was available to the plant. A review of the past year's N management can then be useful in planning the following year's N management strategies.

Perennial turfgrasses also store N as nitrate, but storage of nitrate is typically minimal during the active growing season because of frequent mowing. This leads to the rapid assimilation of nitrate into leaf proteins as new leaf blades are formed. In northern climates, however, autumn marks the period when new leaf blade formation in perennial turfgrasses declines as the onset of winter dormancy begins. It is during this time that we believe N storage as nitrate in the shoot bases of perennial turfgrasses increases since the amount of N assimilated into leaf proteins is reduced because overall leaf formation declines. The storage of nitrate may mark the stage of the fall N assimilation period when chlorophyll levels in the plant are maximized. At this point, any further uptake of nitrate goes primarily into storage. A measure of this nitrate pool could be useful in the fall N fertilizer management of turfgrasses.

Typical measurements of plant tissues for nitrate-N concentrations are conducted on a dry weight basis. This entails the drying and grinding of samples prior to extraction and analysis. The availability of field-use nitrate meters has provided an alternative to drying and grinding of samples, which is a time-consuming process and delays results. In other horticultrually important crops such as potatoes, cotton, and numerous vegetables, sap is squeezed from fresh plant parts and analyzed directly for nitrate. This then serves as a guide for N fertilization based on previous calibration studies with those crops. The objective of this study was to determine if any relationship exists between fall sap nitrate-N concentrations in the verdure (all aboveground portions of the turf plant remaining after clippings removed by mowing) from a cool-season lawn grass mixture and fall turf color.

MATERIALS & METHODS

This study was conducted in the autumn of 2010 on a two-year old stand consisting of a mixture of 35% Kentucky bluegrass (*Poa pratensis*), 30% perennial ryegrass (*Lolium perenne*), and 35% creeing red fescue (*Festuca rubra*). The experiment was set out as two randomized complete block designs with three replicates. One experiment was fertilized in September and the other experiment was fertilized in October. Plot size was 5 × 5 feet. Treatments in each experiment were 13 N application rates (0, 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.5, 3.0, 3.5, and 4.0 lbs N/1000ft^2) applied as urea on September 15 for the first experiment and on October 18 for the second experiment. For the September-fertilized plots, turf color was measured with a Spectrum TCM500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Planfield, IL) on October 3, 9, 16, 23, and 30 before plots were mowed to a height of 2¼ inches using a rotary hand mower with a bagger to collect the clippings (Fig. 1). For the October-fertilized plots, turf color was measured with the NDVI meter on November 12, 19, 24, and December 4. After mowing, verdure samples were removed from a small section (approximately 4 × 4-inch square) of each plot down to the soil surface using hand shears (Fig. 2). Fresh verdure samples were placed in a Spectrum hydraulic plant sap press and squeezed to expel the sap. The sap was placed into the sample well of a Cardy Nitrate Meter (Horiba B-343 Twin Nitrate Meter, Spectrum Technologies, Inc., Planfield, IL; Fig. 9), and measurements were made for concentrations of nitrate-N. Measurements for all dates were taken between 1200 and 1500 hr. The sensor membrane in the sap nitrate meter was cleaned after each use with a mild dish-washing detergent to prevent the buildup of residue from the sap from interfering with the meter performance.

NDVI values for each sampling date were converted to a relative scale by dividing each value by the plateau value for each respective sampling date. Relative NDVI values were pooled across the sampling dates and correlated with fall verdure sap nitrate-N concentrations. Linear response-plateau (LRP) and quadratic response-plateau (QRP) models were applied to the data to determine a critical level for sap nitrate-N concentrations relative to turf color as indicated by NDVI. The critical fall sap nitrate-N value marks the concentration where no further change in NDVI response is observed with increasing concentration of verdure sap nitrate-N. The response value at this point and beyond the critical value is referred to as the plateau, which indicates the maximum response that will be observed in the relationship.

Fig. 1. Removing clippings after NDVI meter readings and prior to verdure sap nitrate measurements.

Fig. 2. Collection of verdure samples down to the ground surface after clippings are removed.

Fig. 3. Fall color response of September fertilized plots on December 11, 2010.

Fig. 4. Fall color response of October fertilized plots on December 11, 2010.

Fig. 5. Spring color response of September 2010 fertilized plots on April 26, 2011.

Fig. 6. Spring color response of October 2010 fertilized plots on April 26, 2011.

RESULTS & DISCUSSION

2010 Fall Turf Color

Fall turf color response is presented in Figs. 3 and 4, and was highly correlated to fall verdure sap nitrate-N concentrations from Oct. 3 to Dec. 4. The relationship between fall verdure nitrate-N concentrations and fall NDVI readings are shown in Fig. 7. At all dates, NDVI readings were relatively well correlated to sap nitrate-N concentrations. Similar critical level values were observed with sampling dates from October 3 to November 19 (individual date response not shown).

However, markedly higher critical levels were observed for the November 24 and December 4 sampling dates compared with the earlier dates. Much colder weather was associated with the later sampling dates. This suggests that the turf plants were storing more nitrate in the verdure as top growth slowed with dormancy. It is probable that less leaf proteins were being assimilated at the later dates, resulting in more verdure nitrate.

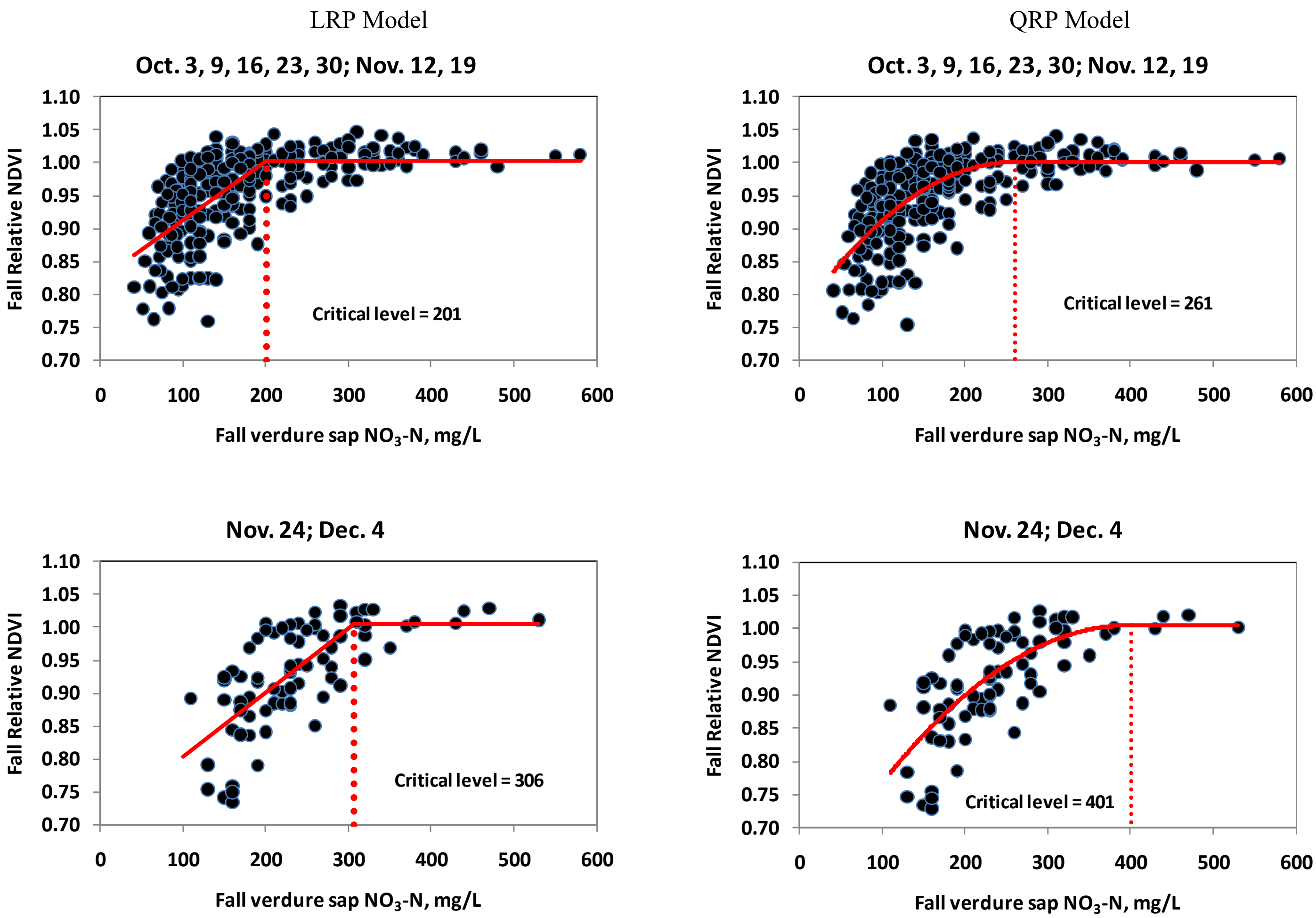

Figure 7. Linear Response and Plateau (LRP) and Quadratic Response and Plateau (QRP) modeling of fall turf color, as indicated by relative NDVI, in response to fall verdure sap nitrate-N concentrations, 2010.

2011 Spring Turf Color

Fall turf color response is presented in Figs. 5 and 6, and was highly corrected to the previous fall verdure sap nitrate-N concentrations from Oct. 3 to Dec. 4. The relationship between fall verdure nitrate-N concentrations and spring NDVI readings are shown in Fig. 8. Like the fall color response, similar critical level values were observed with sampling dates from October 3 to November 19 (individual date response not shown), and higher critical levels were observed for the November 24 and December 4 sampling dates compared with the earlier dates. Almost identical critical values for sap nitrate-N were observed for 2011 spring NDVI and 2010 fall NDVI for the October 3 through November 19 verdure samplings (198 to 261 vs. 201 to 261, respectively). Whereas, slightly lower sap nitrate-N critical values were found to optimize 2011 spring NDVI compared with 2010 fall NDVI for the November through December 4 verdure samplings (255 to 344 vs. 306 to 401)

LRP Model QRP Model

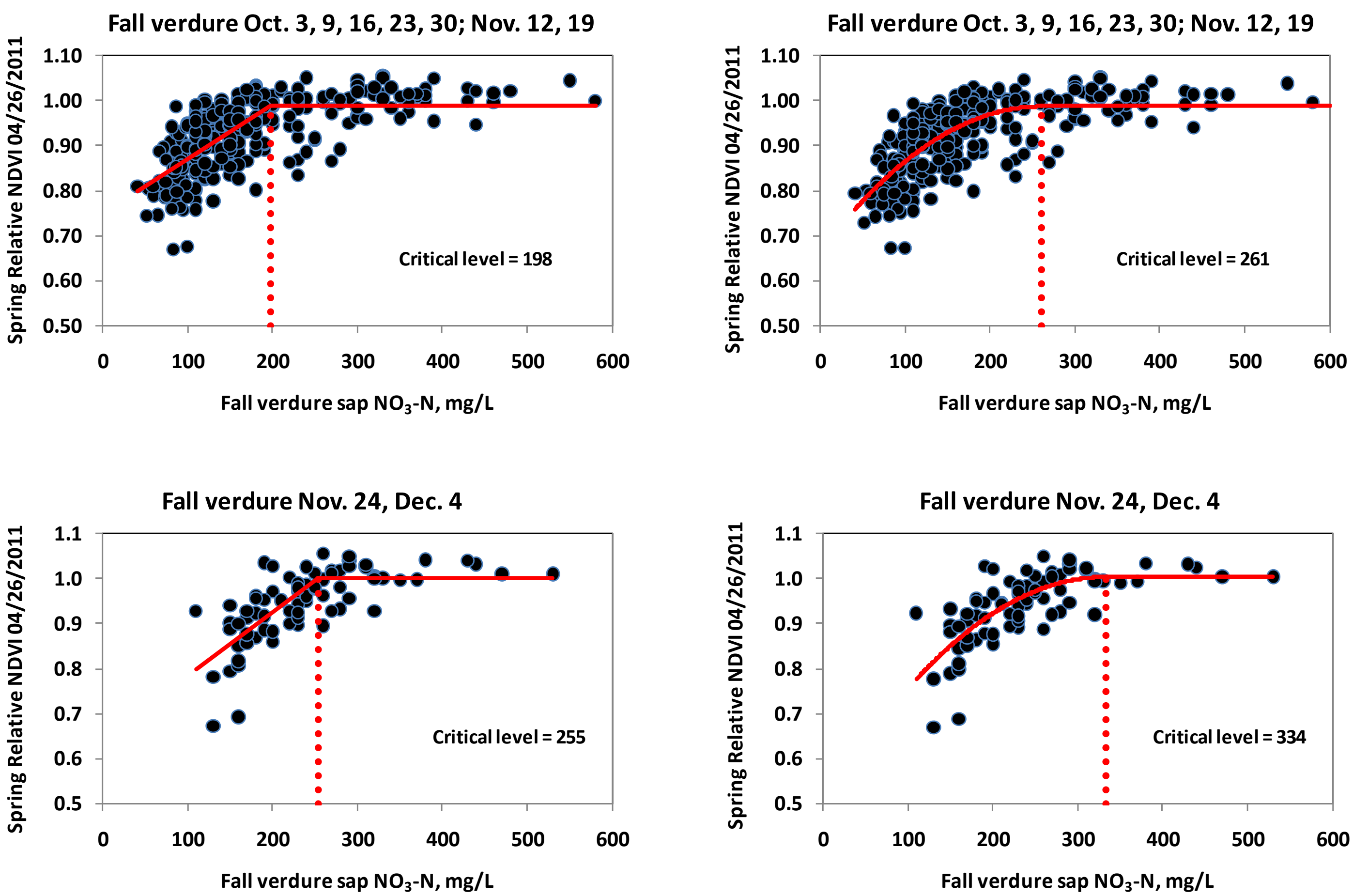

Figure 8. Linear Response and Plateau (LRP) and Quadratic Response and Plateau (QRP) modeling of 2011 spring turf color, as indicated by relative NDVI, in response to 2010 fall verdure sap nitrate-N concentrations.

These results suggest that sap nitrate concentrations from the verdure of fresh-cut turf can be used to predict turf color response in the fall and following spring. This further suggests that a sap nitrate test may have promise as an objective test to guide fall N fertilization of lawn and/or other types of turf.

However, a continuing issue we encountered with the meter concerned calibration drift. When testing a large number of samples, we suggest a regular checking of the standards and re-calibration if necessary. For research purposes, going from known lower nitrate concentrations to higher nitrate concentrations (i.e., lower to higher N rate treatments) resulted in better nitrate meter performance. However, in practice it may not be known which samples have higher nitrate-N concentrations. Additionally, we found that saturating the membrane (with the low nitrate standard solution) for a few hours prior to use increased the stability of meter readings. Because of the low moisture concentration in the verdure, especially for turf fertilized at low N rates, it was necessary to use a hydraulic press to expel the sap from the verdure tissue. A common kitchen garlic press was not able to exert sufficient pressure to produce consistent volumes of sap across samples.

The ability to conduct a nitrate analysis in the field, without the need for drying, grinding, and extracting plant tissue samples, significantly reduces the time needed for the return of results and actions based on those results. This could dramatically change the way in which turf N recommendations are made for fall-fertilized turf.

Fig. 9. Cardy nitrate sap meter. Left-side of meter shows collection well, where sap is placed on membrane for direct nitrate analysis. Digitial reading is shown in the display on the right.

BENEFICIAL SOIL BACTERIAL AMENDMENT EFFECTS ON PERENNIAL RYEGRASS GROWTH AND QUALITY, AND SOIL PHOSPHORUS DURING THE ESTABLISHMENT SEASON, 2010

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INTRODUCTION

There is growing interest in producing acceptable quality turf with reduced inputs from fertilizers in a more environmentally and sustainable manner. One approach to this challenge is the use of beneficial soil bacteria and other microbes that are purported to enhance soil phosphorus (P) and nitrogen (N) availability through natural biological processes in the turf rootzone. If true, this should reduce the reliance on supplemental fertilizers to produce desired turf growth and quality goals. However, there are few studies that report on the use of beneficial soil bacteria as a means to reduce P and N fertilizer inputs for turf.

The objectives of this study were to determine if the application of beneficial soil bacteria affected turf growth and quality when fertilized with various rates of P and N, and to determine if soil extractable P concentrations were increased by the application of beneficial soil bacteria. Our expectation was that if these microbes enhanced soil P and N availability, then turf growth and quality under the lower rates of P and N should match that of higher P and N rates without the addition of the beneficial bacterial.

MATERIALS & METHODS

This field study was established in the 2010 growing season into a newly prepared seedbed on a fine-sandy loam soil. The field was seeded to 'Express II' perennial ryegrass (*Lolium perenne*), at 294 kg/ha on May 10, 2010. Experimental plots were arranged in a 2 × 4 × 4 factorial set out as a split-block design with three replicates. Plot size was 0.9 by 1.8 m. The factors were 2 beneficial soil bacterial treatments (with and without) which constituted the vertical factor of the design, and 4 rates of P (0, 10, 20, and 30 kg/ha/month) in combination with 4 rates of N (0, 10, 20, and 30 kg/ha/month). The various combinations of P and N rates constituted the horizontal factor of the design. Nitrogen and P fertilizers were applied monthly in May, June, July, August, September, and October as urea and triple superphosphate. The beneficial soil bacteria were obtained from the commercial product BioPak (Plant Health Care, Inc., Pittsburgh, PA). This product contained 7.5 billion CFU/lb each of *Bacillus licheniformis, B. megaterium, B. polymyxa, B. subtilis, B. thuringiensis*, and *Paenibacillus azotofixans*. Additional ingredients included 31% humic acids derived from Leonardite, 13.5% maltodextrin, 24% seaweed extract derived from *Ascophyllum nodosum*, 5.5% yeast extract, 14% Leonardite extract other than humic acids, 11% precipitated silica, and 1% polyethylene glycol. BioPak was applied at a rate of 98 kg/ha in 153 L/ha of water every 2 weeks beginning in May through October, then watered-in with overhead irrigation. The material was applied with a CO_2 backpack sprayer using AI9508EVS nozzles at a pressure of 40 PSI. Plots were mowed to a height of 31.75 mm (1.25 inches) using a Toro rotary hand mower.

Tenacity, Drive 75DF, and Acclaim Extra were applied to control crabgrass (*Digitaria* spp.) and common ragweed (*Ambrosia artemisiifolia*). Leaf spot diseases were controlled using ProStar 70WDG and Compass fungicides. Turf color was measured with a Spectrum TCM500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Planfield, IL) on four dates (18 Sept.; 2, 14, and 26 Oct.) before mowing. Visual quality of turfgrass was determined based on turfgrass uniformity, frequency, and weed presence. The quality ratings were classified by using a scale of 1 to 9, with 9 being the best. Green cover percentage, hue, color saturation, and color brightness of the turf were determined using digital image analysis. Digital images were taken of each plot then scanned using SigmaScan software (Systat Software, Inc., Chicago, IL) using the following threshold values: hue = 55 to 125 and saturation = 10 to 100. The Dark Green Color Index (DGCI) was calculated based on hue, saturation, and brightness values obtained from the image. Clipping yield was determined September 18; October 2, 14, 26 by hand cutting the central 0.25 × 0.25 m of each plot and recording the weights after drying the clipping in a paper bag at 70 °C for 48 hours. Clipping weights from each plot were summed to produce a total weight of clippings.

Soil samples were taken randomly from each plot at 4 to 5 different locations to a 10-cm depth on August 10, and November 10. Samples were air dried, then sieved to pass a 2-mm screen. Soil bacterial analysis was made on all samples to determine the bacterial density in the rooting zone and expressed as Colony Forming Units (CFU)/g soil. Soil extractable P was determined for all soil samples by an ascorbic-acid colorimetric method after extraction with the modified-Morgan extractant.

Data were analyzed using SAS/STAT software, version 9.2 (SAS, Cary, NC).

RESULTS & DISCUSSION

NDVI

For each sampling date, N had the greatest effect on NDVI values (Table 1). Increasing the rate of N, regardless of BioPak addition resulted in higher NDVI values, indicating more green turf. Overall effects of BioPak were not significant, but there was a significant BioPak × N interaction for the last sampling date. However, further analysis (not shown) indicated no difference between NDVI values with or without BioPak addition at each individual N rate.

Table 1. Source effects for NDVI analysis of variance.

	Date (mm/dd/yy)			
Source	09/18/10	10/02/10	10/14/10	10/26/10
BioPak	ns	ns	ns	ns
N	**	**	**	**
P	ns	ns	ns	ns
BioPak*N	ns	ns	ns	*
BioPak*P	ns	ns	ns	ns
N*P	ns	ns	ns	ns
BioPak*N*P	ns	ns	ns	ns

*,** significant at $p \leq 0.05$, and 0.01, respectively.

Visual Quality

For each sampling date, N also had the greatest effect on overall turf visual quality (Table 2). Increasing the rate of N, regardless of BioPak addition or not resulted in higher overall visual quality values. Overall effects of BioPak were not significant, and there were no interactions of N and or P with Biopak.

Table 2. Source effects for Quality analysis of variance.

	Date (mm/dd/yy)			
Source	09/18/10	10/02/10	10/14/10	10/26/10
BioPak	ns	ns	ns	ns
N	**	**	**	**
P	ns	ns	ns	ns
BioPak*N	ns	ns	ns	ns
BioPak*P	ns	ns	ns	ns
N*P	ns	ns	ns	ns
BioPak*N*P	ns	ns	ns	ns

*,** significant at $p \leq 0.05$, and 0.01, respectively.

Soil Bacterial Colony Forming Units (CFU)

Addition of BioPak had the greatest effect on soil microbial counts on both sampling dates (Table 3). The number of soil bacteria CFUs increased in the rooting zone when BioPak was applied compared to not being applied from 67×10^8 CFUs to 90×10^8 CFUs on the August sampling date, and from 93×10^8 CFUs to 204×10^8 CFUs on the November sampling date. On the November sampling date, increasing the P rate overall, decreased the number of soil bacteria CFUs in a linear response from 177×10^8 CFUs to 141×10^8 CFUs. At the last sampling date in November, there was also a significant BioPak × N × P interaction, but no clear trends were discernable (Fig. 1).

Table 3. Source effects for soil bacterial Colony Forming Units (CFUs) analysis of variance.

	Date (mm/dd/yy)	
Source	08/10/10	11/10/10
BioPak	*	**
N	ns	ns
P	ns	*
BioPak*N	ns	ns
BioPak*P	ns	ns
N*P	ns	ns
BioPak*N*P	ns	*

*,** significant at $p \leq 0.05$, and 0.01, respectively.

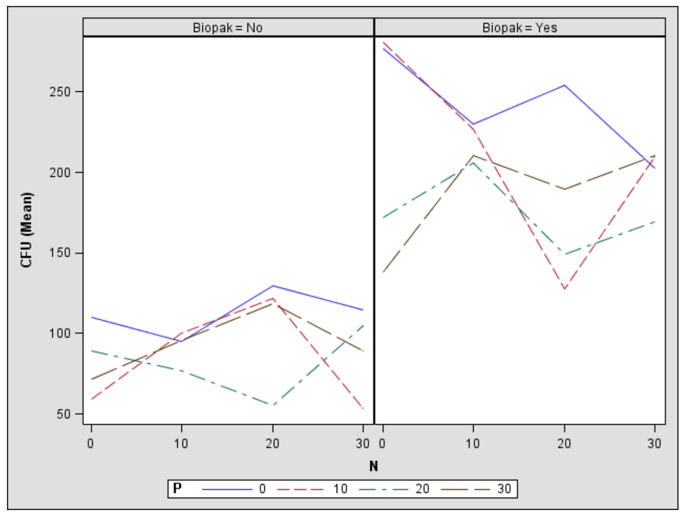

Fig. 1. Mean soil bacterial Colony Forming Unit (CFU) response ($\times 10^8$) for the BioPak × N × P interaction at the November sampling date. Left panel shows the N × P response without BioPak, and the right panel shows the N × P response with BioPak.

Digital Image Analysis (DIA)

Significant effects for DIA were attributable to N for all variables, in addition to BioPak treatments for Dark Green Color Index (DGCI) (Table 4). Across BioPak and P treatments, increasing the rate of N from 0 to 30 kg/ha/month resulted in increasing green cover percentage (from 47 to 77%), hue angle (from 100 to 119), saturation of color (from 0.326 to 0.335), and DGCI (from 0.634 to 0.767). However, increasing N rates from 0 to 30 kg/ha/month resulted in decreasing brightness of the turf color (from 0.435 to 0.348). Across N and P treatments, mean DGCI was 0.706 without BioPak, but was significantly reduced to 0.698 with BioPak.

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Table. 4. Source effects for green cover percentage, hue angle, saturation of color, brightness of color, and Dark Green Color Index (DGCI) analysis of variance

	Variable				
Source	Cover	Hue	Saturation	Brightness	DGCI
BioPak	ns	ns	ns	ns	*
N	**	**	**	**	**
P	ns	ns	ns	ns	ns
BioPak*N	ns	ns	ns	ns	ns
BioPak*P	ns	ns	ns	ns	ns
N*P	ns	ns	ns	ns	ns
BioPak*N*P	ns	ns	ns	ns	ns

*,** significant at $p \leq 0.05$, and 0.01, respectively.

Extractable Soil P

Phosphorus fertilizer treatments had the greatest effect on extractable soil P concentrations at both the August and November soil sampling dates (Table 5). As expected, increasing the rate of P from 0 to 30 kg/ha/month resulted in increasing extractable soil P concentrations at both dates. At the August sampling date, however, there was a significant BioPak treatment effect, and a significant BioPak × P interaction. Addition of BioPak significantly increased soil extractable P concentrations at the 0 and 30 kg P/ha/month treatments compared to no BioPak treatment, but there were no significant differences with and without BioPak at the 10 and 20 kg P/ha/month treatments (Fig. 2).

Table 5. Source effects for extractable soil P analysis of variance

	Date (mm/dd/yy)	
Source	08/10/10	11/10/10
BioPak	*	ns
N	ns	ns
P	**	**
BioPak*N	ns	ns
BioPak*P	**	ns
N*P	ns	ns
BioPak*N*P	ns	ns

*,** significant at $p \leq 0.05$, and 0.01, respectively.

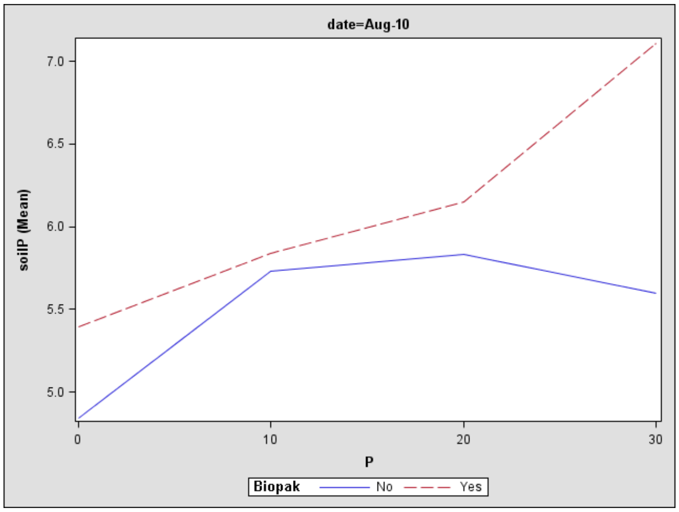

Fig. 2. Mean soil extractable soil P concentrations (lbs/ac; lbs/ac ÷ 2 = ppm) with and without BioPak additions across P rates from 10 to 30 kg/ha/month. Means at the 0 and 30 kg P/ha/month treatments are significantly different from one another.

Clipping Yields

Significant effects on total clipping yields were attributable to N and P fertilization (Table 6). Across all clipping dates, N showed the most consistent effect. As N rates increased from 0 to 30 kg/ha/month, clipping yields increased linearly from 368 to 3600 kg/ha. As P rates increased from 0 to 30 kg/ha/month, clipping yields showed a quadratic response with peak yields at the 10 and 20 kg/ha treatments (2128 kg/ha), then yields slightly decreased at the highest rate (1850 kg/ha).

Table 6. Source effects for clipping yield analysis of variance.

	Date (mm/dd/yy)				
Source	09/18/10	10/02/10	10/14/10	10/26/10	Total
BioPak	ns	ns	ns	ns	ns
N	**	**	**	**	**
P	**	ns	ns	ns	*
BioPak*N	ns	ns	*	ns	ns
BioPak*P	ns	ns	ns	ns	ns
N*P	ns	ns	ns	ns	ns
BioPak*N*P	ns	ns	ns	*	ns

Conclusions

During the establishment year of a perennial ryegrass turf, BioPak significantly increased the bacterial populations in the rooting zone. However, this increase did not translate into meaningful effects on turf growth or quality during the first year. The study will be repeated in 2011 on the same plots to determine any effects of BioPak on the growth and quality of established plots receiving varying rates of N and P.

DO TIPHIID WASPS USE HERBIVORE-INDUCED PLANT VOLATILES FOR FINDING WHITE GRUBS?

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INTRODUCTION

Two important white grub species, the Japanese beetle (*Popillia japonica*) and Oriental beetle (*Anomala orientalis*) have been reported as key pests of urban landscapes in the Northeast (Koppenhofer and Fuzy 2007). *Tiphia vernalis* Rohwer and *Tiphia popilliavora*, were introduced as biocontrol agents against these beetles (Legrand 2009). These parasitic wasps burrow into the soil and search for grubs. When a host is found, the wasp paralyzes it momentarily and attaches an egg in a location that is specific for that species (Clausen et al. 1927). Successful above-ground host location is considered as one of the critical steps in host selection behaviors of parasitoids (Barbosa et al. 1982). Little is known about the role of herbivore-induced plant volatiles in host habitat location of Tiphiid wasps. It is still unclear 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. The main goal of this study is to increase our understanding of *Tiphia* wasp host location in turfgrass systems. Achieving this goal entails two specific objectives; 1) Determine whether females of adult *T. vernalis* and *T. popilliavora* are attracted to plant volatiles from grub-infested plants and 2) Determine whether *T. vernalis* and *T. popilliavora* are attracted to plant volatiles from any given healthy-turfgrass species

MATERIALS & METHODS

The project was conducted in Spring and Summer 2010. *T. vernalis* were collected during early May to mid June while *T. popilliavora* were collected during August to early September. Plants for tests included Kentucky bluegrass (KBG), *Poa pratensis* L., tall fescue (TF), *Festuca arundinacea* Schreb., and perennial ryegrass (PR), *Lolium perenne* L. These plants were grown in separate pots and reared in a plant growth chamber (25^{o}C, 70% r.h., L16:D18) for 6 weeks. Third, instar grubs of *P. japonica and A. orientalis* were introduced to plants. The grubs were then allowed to feed on the roots for a week.

Behavioral Assays: Test plants were placed in Pyrex glass volatile collection chambers and sealed with water. Two-choice bioassays were conducted in a Y-tube olfactometer. Air was filtered through activated charcoal, humidified, and split into two air streams that were fed through the glass containers to the olfactometer at a flow of 1 l min^{-1} in each arm. Experiments were performed between 0900 and 1700 hours at 20–25°C and 50–60% r.h., and using a light bulb (50W) positioned above the olfactometer. The pots were sealed using Teflon bags in order to prevent contamination due to larval products and any other byproduct of larvae in the soil. Wasps were individually released at the down-wind end of the Y-tube and observed for a maximum period of 5 min. A total of 405 female Tiphiid wasps were tested. These include 165 of *T. vernalis and 240 of T. popilliavora.* Data were analyzed using a Chi-square goodness-of-fit test using SAS 9.2.

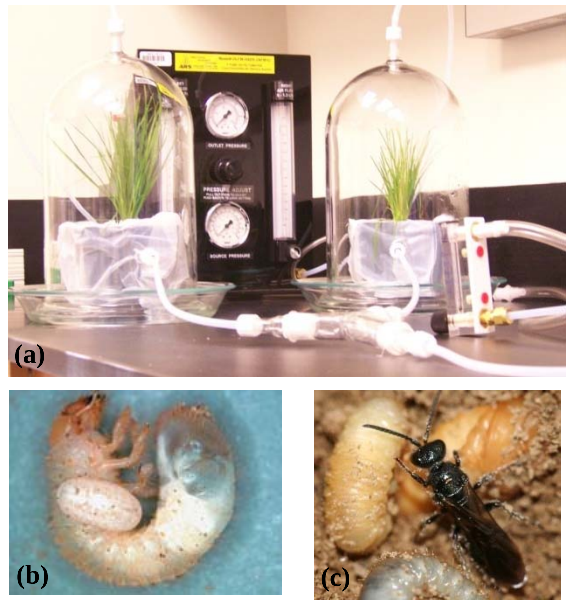

Figure 1: (a) Olfactometer setup, (b) A *Tiphia vernalis* larva on a white grub, and (c) A Tiphiid wasp approaching a white grub (*photo courtesy: Omar Fahmy)*

RESULTS & DISCUSSION

Our study demonstrated that *T. vernalis* and *T. popilliavora* females are significantly attracted to volatiles emanating from grub infested KBG and TF over uninfested grasses (Table 1). This significant preference for grub infested plants has been observed in other parasitoid species (Neveu et al. 2001). This may be due to relatively higher levels of certain green leaf volatiles emanating from grub-infested plants acting as a reliable signal to inform the parasitoid about the host presence. This study shows that volatiles attracting *T. vernalis and T. popillavora* females are emitted systemically from plants infested by root-feeding white grubs. The Tiphiid wasps examined did not exhibit a significant preference for grub-infested PR as compared to the control plants. It is possible that PR does not produce any plant volatiles that can attract the *Tiphia* wasps. Future work will examine the volatile profiles of all the turfgrasses used in this study to better explain the wasp responses.

REFERENCES

Barbosa, P., J.A. Saunders, and M. Waldvogel. 1982. Plant-mediated variation in herbivore suitability and parasitoid fitness. Proc. 5th Int. Symp. Insect–Plant Relationships. pp. 63–71. Pudoc, Wageningen.

Clausen, C. P., and J. L. King, 1927. The parasites of *Popillia japonica* in Japan and Chosen (Korea), and their introduction into the United States. U.S. Department of Agriculture (technical bulletin 1429). Washington, D.C.

Legrand, A. 2009. Tiphia parasitic wasps take on Japanese and Oriental Beetle grubs. Turfgrass trends: 49.

Koppenhofer, A. M., and E. M. Fuzy. 2007. Nematodes for white grub control. Rutgers University, New Brunswick.

Neveu, N., J. Grandgirard, J. P. Nenon, and A. M. Cortesero. 2002. Systemic release of herbivore-induced plant volatiles by turnips infested by concealed root-feeding larvae *Delia radicum* L. Journal of Chemical Ecology 28: 1717-1732.

Table 1. Response of *T. vernalis* and *T. popilliavora* to test plants (pots with *P. Japonica* and *A. orientalis* grubs) versus control plants (pots without grubs).

Turfgrass[1]	Parasitoid species	Trail selected		χ^2
		Test plants	Control plants	
KBG	*T. vernalis*	27	8	10.31*
	T. popilliavora	33	17	5.12*
TF	*T. vernalis*	24	11	4.83*
	T. popilliavora	34	16	6.48*
PR	*T. vernalis*	19	16	0.26
	T. popilliavora	27	23	0.32

KBG – Kentucky bluegrass, TF- Tall fescue, PR – Perennial ryegrass. * P <0.05

Table 2. Response of Tiphiid wasps for healthy-turfgrass volatiles

Parasitoid species	Selected Turfgrass[1]		χ^2
	KBG	PR	
T. vernalis	14	6	1.6
T. popilliavora	21	9	4.8*
	KBG	TF	
T. vernalis	14	6	1.6
T. popilliavora	19	11	2.13
	PR	TF	
T. vernalis	8	12	0.8
T. popilliovora	19	11	2.13

KBG – Kentucky bluegrass, TF- Tall fescue, PR – Perennial ryegrass. * P <0.05

EVALUATION OF LANDSCAPE ORNAMENTAL AND HERB PLANTS AS NECTAR SOURCES FOR *TIPHIA* PARASITOID WASPS

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INTRODUCTION

During 1920's and early 1930's USDA entomologists imported *Tiphia vernalis* Rohwer from Korea and *Tiphia popilliavora* Rohwer. (Hymenoptera: Tiphiidae) from Japan for Japanese beetle control. Several wasp releases were made throughout the northeastern United States. Releases of *T. vernalis* were made between 1936 and 1949 in six of Connecticut's eight counties and *T. popilliavora* was released in 5 counties between 1921-1940 (King et al. 1951). The primary target of these releases was the Japanese beetle. However, *T. vernalis* and *T. popilliavora* are parasitoids of the Oriental beetle as well. These parasitoids feed on the larvae with *T. vernalis* attacking the 3rd instars during spring and *T. popilliavora* attacking 2nd or 3rd instars during late summer. A survey by Ramoutar and Legrand (2007) indicated that *T. vernalis* wasps are widely distributed in the state with a peak occurrence around the last week of May. Moreover, a second survey indicated that *T. popilliavora* wasps are found in the state and are active from August to early September (Legrand 2008).

Many parasitoid wasp species visit flowers to obtain nectar and/or pollen that provide essential nutrients. This in turn improves fecundity, longevity and increases rates of parasitism (Landis et al. 2000, Rogers and Potter 2004, Rebek et al. 2005, Ellis et al. 2005). Thus, one approach in conservation biological control is to provide food resources to natural enemies either through food sprays or by including flowering plants that could provide food resources over a period of time. The *Tiphia* species described here use nectar resources to supplement their diet. *T. vernalis* adults emerge in the spring and they have been observed feeding on honeydew deposits from soft scales or aphids and on nectar (Balock 1934, King and Parker 1950). Research by Rogers and Potter (2004) in Kentucky examined the potential to recruit
T. vernalis and *T. pygidialis* by using sugar water sprays and flowering plants. Out of the fifteen plants species examined in their study only peonies attracted *T. vernalis.* In addition, there is very little information on the type of plants that could be used to attract *Tiphia* wasps that are present during summer. Thus, the objectives of this study were: 1) to identify ornamental plant species and cultivars that can serve as a source of nectar for the Spring *Tiphia* in Connecticut; and 2) to determine if members of the Apiaceae (Umbelliferae), other than wild carrot, could attract Tiphia wasps during summer.

MATERIALS & METHODS

Evaluation of Ornamental Plants as Sources of Nectar for the Spring *Tiphia*

Ornamental plants were selected for this evaluation based on their production of extrafloral nectar. It was hypothesized that this characteristic will be the best suited to the nectar feeding habits of this wasp given the timing of its occurrence and the lack of preference for many other flowering plants. For the first evaluation, plants selected included peonies *Paeonia lactiflora*, arrowwood viburnum *Viburnum dentatum* 'Blue Muffin' and elderberry *Sambucus canadensis* 'York'. Peony cultivars used in this study were 'Big Ben', 'Sarah Bernhardt' and 'Festiva'. These three peonies were selected to identify locally available cultivars that could attract *Tiphia* wasps. Peonies secrete extrafloral nectar through the calyx of unopened flower buds, in the selectected viburnum the extrafloral nectaries are located on the leaf margin close to the petiole and in *S. canadensis* the extrafloral nectaries are found on the stems or as modified leaflets along the rachis. For all evaluations, single potted plants were arranged in a completely randomized block design with five replications for each plant type and wasp observations were conducted during May 2010. The cumulative number of wasps feeding on nectar or being on the flower bud was recorded during hourly observation periods. A square root transformation was done on the data before conducting an analysis of variance using the SAS Mixed procedure (SAS Institute Inc., Cary NC). Tukey's mean comparison procedure was used when required.

Evaluation of Flowering Plants as Sources of Nectar for Summer *Tiphia* wasps

Apiaceae (Umbelliferae) species were selected for this evaluation because in a previous study only the wild carrot *Daucus carota* attracted *Tiphia* wasps during late summer (Legrand 2009a). Other plants such as yarrows of various flower colors and ornamental goldenrod did not attract them. In 2010, the evaluation included wild carrot, dill *Anethum graveolens*, fennel *Foeniculum vulgare*, and cilantro *Coriandrum sativum*. Yarrow *Achillea* spp. belongs to the asteraceae but it was included as a replicate of the 2009 study. Wild carrot was originally selected in 2009 because of previous accounts noting that the Summer *Tiphia* feeds on nectar from these flowers. For all evaluations, single potted plants were arranged in a completely randomized block design with three replications for each plant type and wasp observations were conducted during the first two weeks of September. Wild carrot plants were set out as bouquets of cut flowers. Plants were set out at two distant locations, W11 and G2 fields, within the UConn Plant Science Research Facility.

The number of *Tiphia* spp. wasps observed nectaring on flowers was recorded during each daily plant census. *Tiphia* wasps were collected for identification. Data was also collected on the number of other insects (by species and family level) visiting the flowers and were collectively summarized by insect order for each location.

RESULTS & DISCUSSION

Evaluation of Ornamental Plants as Sources of Nectar for the Spring *Tiphia*

All of the plants selected attracted the spring *Tiphia* (Fig. 1). However, there were significant differences observed in the mean cumulative number of wasps counted during hourly observations on the peonies, *V. dentatum* 'Blue Muffin' and on *S. canadensis* 'York' ($F = 12.39$, $df = 4$, $P < 0.001$). All of the three peony cultivars tested attracted the most wasps as compared to the other plants. These results are similar to those obtained in 2009 for this evaluation (Legrand 2009b). Peonies consistently have attracted the Spring *Tiphia* and are the best choice of plants for this purpose. The three peony cultivars tested perfomed similarly in their attraction of *Tiphia* wasps in spite of their flower color. Peony 'Festiva' has white flowers, 'Sarah Bernhardt' has pink flowers and 'Big Ben' has burgundy red flowers. The viburnum and elderberry do not attract as many wasps and Japanese beetles feed on these plants to greater extent than on peonies (Legrand 2009b). Based on previous studies and on this report, one can conclude that the spring *Tiphia* will utilize extrafloral nectaries as a source of nectar and it is not likely to feed directly from flowers as other beneficial wasps do. Thus, peonies will be a good choice for persons wishing to provide nectar sources for the Spring *Tiphia* and aid in their conservation.

Evaluation of Flowering Plants as Sources of Nectar for Summer *Tiphia* wasps

Of the plants selected only the wild carrot attracted any *Tiphia* spp. individuals at either location (Figs. 2 & 3). The yarrow and the apiaceae species selected did not attract any *Tiphia* wasps. In spite of not attracting *Tiphia* spp., these plants did attract a low number of other insects including syrphid flies and vespid wasps. The orders most often represented in the data collected were the hymenoptera and diptera. It is possible that very low numbers of hymenoptera, including *Tiphia*, and of diptera were observed because data was collected towards the end of summer. These results follow the same pattern observed in 2009 when only the wild carrot attracted the most *Tiphia* over any of the other ornamental plants tested. Wild carrot is considered a weed so its usefulness for conservation biocontrol in settings like golf courses or public landscapes might be limited. However, it is an aesthetically pleasing plant (its popular name is Queen Anne's Lace) that some homeowners or other private entities might find useful for conserving *Tiphia* wasps present in summertime.

REFERENCES

Ellis, J.A., A.D. Walter, J.F. Tooker, M.D. Ginzel, P.F. Reagel, E.S. Lacey, A.B. Bennett, E.M.Grossman and L.M. Hanks. 2005. Conservation biological control in urban landscapes: manipulating parasitoids of bagworm (Lepidoptera:Psychidae) with flowering forbs. Biological Control 34:99-107.

King, J., L. Parker and H. Willard. 1951. Status of imported parasites of the Japanese beetle in 1950. USDA Agricultural Research Administration, Bureau of Entomology and Plant Quarantine. Insect Pest Survey. Special Supplement June 5, 1951, No.5.

Landis, D.A., S.D. Wratten, and G. M. Gurr. 2000. Habitat management to conserve natural enemies of arthropod pests in agriculture. Annu. Rev. Entomol. 45:175-201.

Legrand, 2009a. Evaluation of ornamental plants as nectar sources for summer *Tiphia.* p. 77-79. *In* K. Guillard (ed), 2009 Annual Turfgrass Research Report, College of Agriculture and Natural Resources, University of Connecticut.

Legrand, 2009b. Evaluation of landscape ornamental plants as nectar plants for *Tiphia vernalis* and as host plants for pest scarab beetles. p. 73-76. *In* K. Guillard (ed.), 2009 Annual Turfgrass Research Report, College of Agriculture and Natural Resources, University of Connecticut.

Ramoutar, D. and A. Legrand. 2007. Survey of *Tiphia vernalis* (Hymenoptera:Tiphiidae) a parasitoid wasp of *Popillia japonica* (Coleoptera: Scarabaeidae) in Connecticut. Florida Entomologist 90(4): 780-2.
PDF link: http://www.fcla.edu/FlaEnt/fe90p780.pdf

Rebek, E.J., C.S. Sadof, and L.M. Hanks. 2005. Manipulating the abundance of natural enemies in ornamental landscapes with floral resource plants. Biological Control 33:203-216.

Rogers, M.E. and D. A. Potter. 2004. Potential for sugar sprays and flowering plants to increase parasitism of white grubs (Coleoptera:Scarabaeidae) by Tiphiid wasps (Hymenoptera:Tiphiidae). Environ. Entomol. 33:619-626.

ACKNOWLEDGEMENTS

I would like to thank UConn undergraduates Spandana Sudapalli and Lionel Meda and graduate student Laura Eckman for their assistance. Funding for this study was provided by the Northeastern IPM Center.

Figure 1. Attraction of *Tiphia vernalis* by ornamental plants with extrafloral nectaries. Plants located at UConn Plant Science Research Facility.

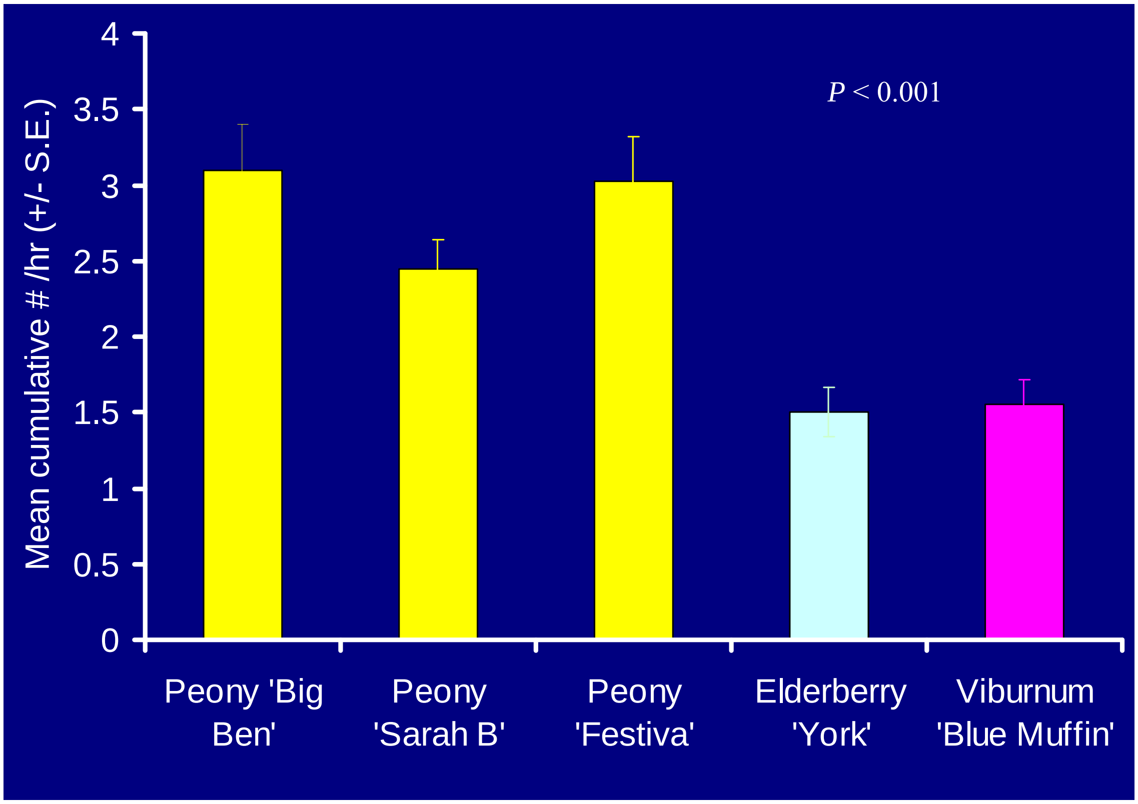

Figure 2. Attraction of *Tiphia spp.* by selected herbs, yarrow and wild carrot during late summer. Plants located at UConn Plant Science Research Facility W11 field.

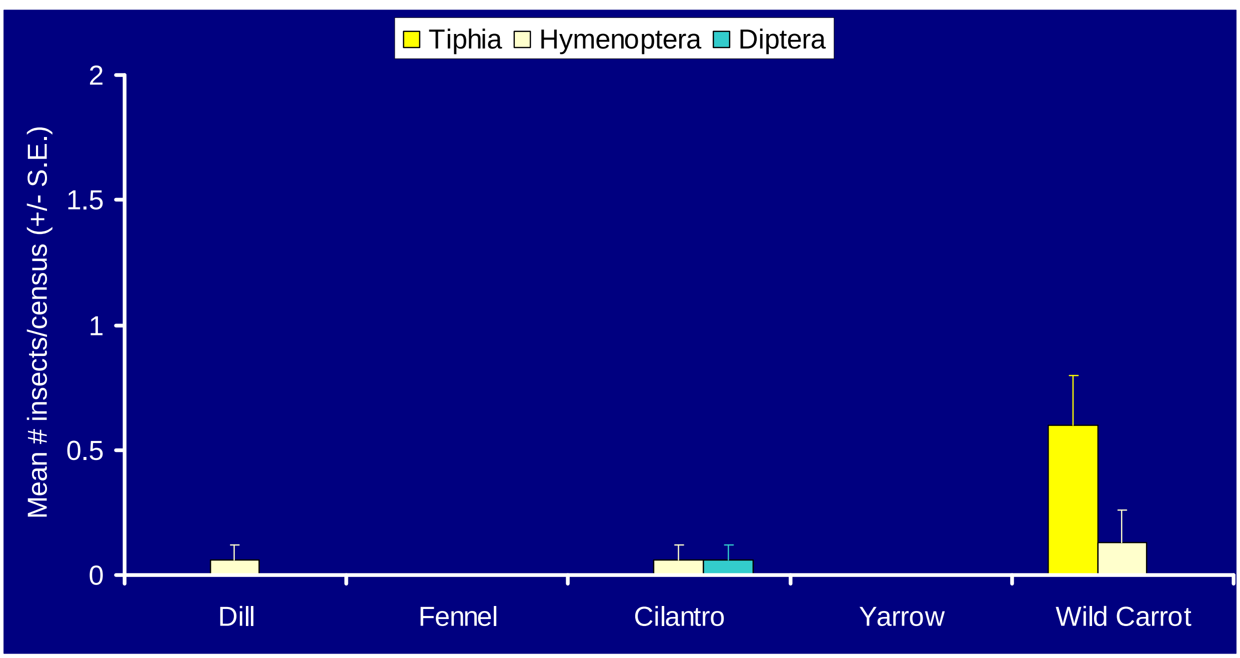

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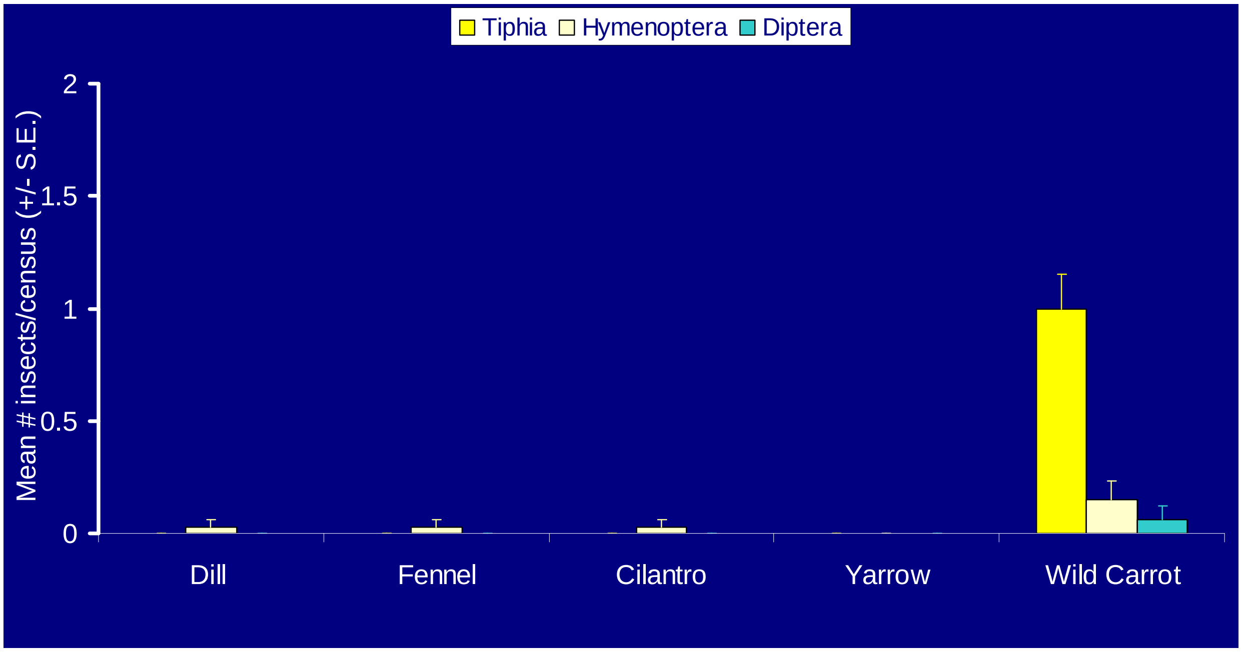
Figure 3. Attraction of *Tiphia spp.* by selected herbs, yarrow and wild carrot during late summer. Plants located at UConn Plant Science Research Facility G2 field.



COLOR PREFERENCE OF THE JAPANESE BEETLE PARASITOID *TIPHIA VERNALIS*

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INTRODUCTION

The Spring Tiphia *Tiphia vernalis* Rohwer (Hymenoptera: Tiphiidae) was imported from Korea for Japanese beetle control. *T. vernalis* is also a parasitoid of the Oriental beetle and it attacks the 3rd instars of both pest species during spring. A survey by Ramoutar and Legrand (2007) indicated that *T. vernalis* wasps are widely distributed in the state with a peak occurrence around the last week of May. These wasps can be monitored by spraying a 10% sugar water solution on turfgrass areas or on low-lying branches of shrubs and trees. These wasps are well adapted to search for insect honeydew so sugar water is very attractive to them. Information on the color preferences exhibited by this wasp, if any, would be useful for the development of monitoring tools and to better understand the wasp's behavior. Thus, an experiment was conducted to determine what colors would attract Spring *Tiphia* wasps.

MATERIALS & METHODS

The experiment was conducted in May 2009 at the UConn Plant Science Research Facility. Six sets of color cards were placed in a turfgrass field and cards were made of blue (Navy blue), red, yellow and white poster board. The rectangular cards were 7.5 cm by 9.5 cm in size and were attached to green bamboo canes used as holders. Cards were placed at 70cm above the ground and were covered by plastic so that they could be sprayed with 10% sugar water at the beginning of each observation period. Cards of each color were randomly placed in a row for each set and sets were separated by 9.1 m. The cumulative number of wasps found on each of the cards for each set was recorded during hourly observation periods. Three observation periods were done as 'morning' observations between 10am and 12pm and three observation periods were done as 'afternoon' observations between 1 and 5pm. Data from all sets of cards were pooled to give a total of wasps observed for each color and time period. A square root transformation was done on the data before conducting an analysis of variance using the SAS software (SAS Institute Inc., Cary NC). Tukey's mean comparison procedure was used when required.

RESULTS & DISCUSSION

The wasps were attracted to all the color cards sprayed with sugar water and they were observed feeding on the liquid. However, card color produced a significant difference in the number of wasps recorded (F= 4.69, df = 3, P = 0.01). Yellow cards attracted the highest number of wasps followed by white, blue and red cards (Table 1). The time period when observations were taken did not have a significant effect on the number of wasps observed (F= 0.81, df = 1, P = 0.38). The mean for the total wasp count recorded in the morning was 2.5 ± 0.4 and 2.9 ± 0.3 for those recorded in the afternoon. The color by time interaction was also not significant (F= 0.18, df = 3, P = 0.9). Since the interaction was not significant only the color and time means are reported.

Yellow cards placed in the field could be used as a monitoring tool since the wasps are highly attracted to this color and a person could spray sugar water on the cards instead of on the turfgrass or on plants. The 70 cm height for the card placement is important because a preliminary experiment had showed that wasps were not attracted to cards placed at ground level. Using yellow color and sugar water as baits in any monitoring device will aid in the detection of these wasps in an area or for collection of live specimens.

Table 1. Spring *Tiphia* color preferences. Means followed by the same letter are not significantly different at $P \leq 0.05$ level according to Tukey's mean comparison procedure.

COLOR	MEAN (± 1 S.E.) TOTAL WASP COUNT [x]
Blue	2.03 ± 0.2^{a}
Red	1.9 ± 0.4^{a}
White	2.6 ± 0.4^{ab}
Yellow	4.2 ± 0.7^{b}

[x]Means are of square root transformed data.

REFERENCES

Ramoutar, D. and A. Legrand. 2007. Survey of *Tiphia vernalis* (Hymenoptera:Tiphiidae) a parasitoid wasp of *Popillia japonica* (Coleoptera: Scarabaeidae) in Connecticut. Florida Entomologist 90(4): 780-2.
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I would like to thank UConn undergraduates Katie Rausher and Tintu Thottungal for their assistance. Funding for this study was provided by the Northeastern IPM Center.

RESPONSE OF *AGROSTIS STOLONIFERA* (CREEPING BENTGRASS) AND *AGROSTIS GIGANTEA* (REDTOP) TO CHANGES IN PLANT COMPETITION DUE TO GLYPHOSATE APPLICATION

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INTRODUCTION

The bentgrasses (*Agrostis*) comprise a widely distributed and adaptable group of turfgrasses, weeds, and native perennial grasses. Creeping bentgrass (*Agrostis stolonifera*, CB) is commonly used on golf courses, and a genetically-engineered (GE) herbicide-resistant line has been developed to help golf course managers control weeds. The potential release of this GE creeping bentgrass has raised questions about its escape from cultivation, increased vegetative growth, pollen-mediated gene flow, and changes in reproductive potential in habitats outside of golf courses. The primary goals of this study were to determine if CB and redtop plants would experience advantages with regard to growth and reproduction if they had less competition from neighboring vegetation due to annual glyphosate applications. This study was conducted in five plots that represented agricultural hayfields and natural meadow plant communities. The herbicide resistance trait was mimicked by protecting the bentgrass plants from herbicide sprays. Our hypothesis was that CB and redtop would have *increased reproductive potential and vegetative spread* when surrounding vegetation was removed with glyphosate.

MATERIALS & METHODS

Locations in Mansfield, Connecticut (Lower New England Ecoregion, subecoregion Southern New England Coastal Hills and Plains) were chosen for five field plots (12 m × 15 m). Two plots were placed on the upper and lower edges of a hayfield that was mowed once per year (designated Hayfield 1, Hayfield 2). Two plots were established in a natural meadow near the Fenton River (Fenton Meadow 1, Fenton Meadow 2). The fifth plot was established in an agricultural wasteland adjacent to a cow pasture (Wasteland).

The 2 × 2 factorial experiment was set up using a random complete block design with two treatments (annual glyphosate spray or non-sprayed control) and two bentgrass species (CB or redtop). Each treatment group in the factorial design was replicated five times creating 20 randomized subplots (3 m × 3 m) within each of the five separate plots. To supply acclimated CB and redtop plugs for the field plots, non-genetically engineered bentgrasses were grown in 2007. In May, 2008, small bentgrass plugs (3 cm × 3 cm) were transplanted into field subplots. Glyphosate was sprayed in the appropriate treatment subplots once during each year of the study. Bentgrass plants in those plots were covered with plastic to mimic herbicide resistance. Measurements of the bentgrass plants were taken every four weeks between May and October for three years. Measurements included: surface area covered, maximum height, number of tillers (including stolons), number of panicles, number of flowers, dried biomass, and bentgrass survival.

For the field data, analysis of variance (ANOVA using SAS ver. 9) was performed within bentgrass species and/or between treatment groups for the dependant variables. The data from all subplots were combined and analyzed for treatment, year, and species interaction effects. End of study survivability was studied using a probit model to determine the significance that glyphosate application on bentgrass survivorship.

RESULTS

Plots

Soil samples taken before and after the study revealed that nitrogen was significantly higher in all subplots receiving glyphosate. In the plot with the highest initial plant species richness (Hayfield 1), glyphosate treatments reduced species richness. This effect was also observed in the Fenton Meadow 2 plot. The other three plots had lower plant species richness scores before the experiment, and did not show a significant change due to glyphosate applications.

Bentgrass Growth

CB and redtop plant survivorship over the three years differed based on glyphosate application (Table 1). The probit model revealed that glyphosate application had a significant effect on the survival of the bentgrass plants regardless of species ($\alpha<0.001$). Only 4% (1 subplot plant) of the bentgrass plants receiving competition from surrounding vegetation survived. In contrast, 56% of bentgrass plants with glyphosate application and little competition from neighboring plants survived (Table 1).

No panicles or flowers were produced in either species in the first year (2008). In the second year, redtop plants with glyphosate application had 86-fold higher number of flowers compared to redtop plants in control (unsprayed) plots (Fig 1). It is remarkable that 13 redtop plants were able to produce a total of 238,896 flowers compared with only 640 flowers from 3 redtop plants in control subplots (Fig 1). In 2010, there were fewer redtop flowers in sprayed subplots (119,381) from a slightly higher number of total plants (15 subplots), but there was only one living redtop plant in control plots. CB plants showed the same trend as redtop, although they had lower overall reproductive potential (flower number).

Comparing plot sites, there were differences between species with regards to biomass, but no difference between plots. The number of tillers per plant showed differences within species and between plots. Redtop in sprayed subplots produced a higher number of tillers than control subplots. This was also true for CB except the Wasteland plot.

DISCUSSION

According to government data from 2007, glyphosate is the most frequently used herbicide in agricultural systems, and the second most frequently used herbicide in non-agricultural systems. It is used to control weeds and invasive plants in diverse landscapes including hayfields, pasture, herbicide-resistant agronomic crops (soybeans, corn), lawns, home landscapes, forest plantings, greenhouses, and utility rights-of-way. This study showed that glyphosate applied once per year can alter plant community composition and soil nutrient dynamics.

In this study, glyphosate had a dramatic effect on survivorship for the introduced CB and redtop plants. Glyphosate application greatly increased survivorship of CB and redtop plants that were protected from the herbicide, and this may have been due to one or more factors such as the lack of competition from neighboring vegetation for light, soil nutrients, or soil moisture. In general, bentgrass plants with less vegetative competition had higher survivorship and produced more tillers and biomass. The only exception was in the agricultural Wasteland plot where no differences were seen because no CB survived in any subplot (sprayed or control). However, the Wasteland plot was different because it was dominated by the invasive species *Phalaris arundinacea* (reedcanary grass) which quickly filled gaps after glyphosate sprays. However, glyphosate-sprayed redtop plants that survived in the Wasteland site did show a higher number of tillers.

Creeping bentrgrass and redtop plants that survived in glyphosate-sprayed subplots showed higher reproductive potential in 2009 and 2010 based on flower number. Germination rates of the collected seed were well above 70%, suggesting that flowering and seed production could support increased dispersal and fitness over time. Furthermore, the large number of flowers suggested a very strong potential for pollen-mediated gene flow, intraspecific hybridization, and/or interspecific hybridization. <u>Thus, if glyphosate-resistant creeping bentgrass were approved for commercial use, glyphosate would likely be a positive selection factor for glyphosate-resistant bentgrasses that would spread through viable seed, tillers, and pollen</u>.

The authors are currently preparing a manuscript for publication. For more information about this study, please contact Dr. Collin Ahrens (collin.ahrens@uconn.edu) or Dr. Carol Auer (carol.auer@uconn.edu).

Species	Treatment	Wasteland	F. Meadow 1	F. Meadow 2	Hayfield 1	Hayfield 2	Total
CB	sprayed	0	100	60	80	40	56
	control	0	0	0	0	0	0
RT	sprayed	40	100	20	60	60	56
	control	0	0	0	20	0	4

Table 1. Percent survival for bentgrass species with or without annual glyphosate treatment. Total survivorship is shown in the last column. CB = creeping bentgrass; RT = redtop

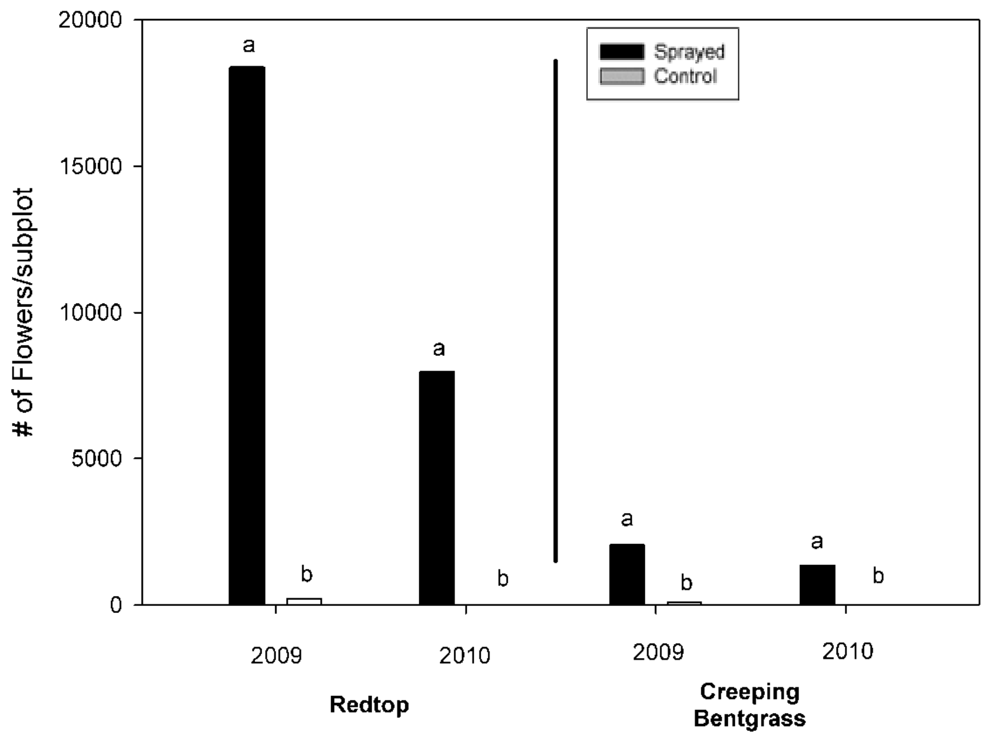

Figure 1. Reproductive potential (number of flowers) for redtop and creeping bentgrass plants with and without glyphosate application. No flowers were produced in the first year of the study (2008). Significant differences are reported at $\alpha < 0.05$.

PUTTING GREEN SPEEDS: A REALITY CHECK!

Dest, W. M., K. Guillard, S.L. Rackliffe, M.-H. Chen, and X. Wang. 2010. Putting green speeds: A reality check! Online. Applied Turfgrass Science doi:10.1094/ATS-2010-0216-01-RS.

Twenty-nine golf courses in Connecticut participated in a study where 448 golfers were asked in a questionnaire to rank the speed of selected greens into one of five categories from slow to fast. These rankings were paired to the same USGA speed chart categories for regular play based on measured Stimpmeter ball-roll distances. Overall, there was no significant (P = 0.72) relationship between golfer rankings of green speed and USGA speed categories. Low-handicap golfers were able to detect increasing trends in green speeds only slightly better than higher-handicap golfers or golfers with no handicap. Overall, the majority of golfers (74%) ranked green speed into slower categories than those determined by the Stimpmeter. However, golfer rankings correctly matched USGA categories in 41.4 to 48.8% of cases when measured speeds were classified as medium to medium-fast, respectively. Regardless of ball-roll distance, 87.5% of respondents rated the putting green speed as satisfactory. The data suggest that use of the Stimpmeter for delineating greens into arbitrary speed categories may be obsolete. Instead, it should be used as a tool to determine "ideal" green speeds at individual golf courses based on golfer preferences, and to ensure relatively uniform green speeds throughout the course.

ILLINOIS SOIL NITROGEN TEST AND SOIL ACTIVE CARBON TEST USED TO PREDICT LAWN TURF COLOR

Guillard, K., T. Morris and X. Geng. 2010. Illinois soil nitrogen test and soil active carbon test used to predict lawn turf color. *In* Abstracts of the ASA-CSSA-SSSA 2010 International Annual Meetings, October 31-November 4, Long Beach, CA.

The Illinois Soil N Test (ISNT) and the Active Soil Carbon Test (ASCT) may predict the responsiveness of turf sites to N fertilization. The ISNT and ASCT are thought to detect the amount of potentially labile N and C in soils, which is correlated to N mineralization and supplying capacity of a soil. If applicable to turf, these tests may be beneficial in guiding N fertilization of turf areas that receive organic amendments. This study was conducted in Connecticut, USA to determine if the ISNT and ASCT could be used to predict color responses of Kentucky bluegrass (Poa pratensis L.) and tall fescue (Festuca arundinacea Schreb.) managed as a lawn. In fall 2007, randomized complete block field experiments were set out and seeded with the two species with varying compost N rates as treatments to produce a wide range of soil N and C concentrations. Compost treatments were repeated and brushed into the same plots in fall 2008 following solid-tine aerification. Soil samples were collected in early May 2009 from each plot and analyzed for concentrations of amino-sugar N and active C. After soil sampling, turf color was measured at approximately two-week intervals from May to October using reflectance meters. Soil amino-sugar N concentrations ranged from 128 to 283 mg/kg, and active C concentrations ranged from 966 to 1221 mg/kg. Significant linear, but weak, relationships were observed for color response of both species to soil amino-sugar and active C concentrations. Maximum turf color response for Kentucky bluegrass and tall fescue has not yet been reached within these ranges of early-season soil amino-sugar N and active C concentrations.

THE EFFECT OF SAND TYPE AND APPLICATION RATE ON TURFGRASS QUALITY, DISEASE SEVERITY, EARTHWORM CASTING, AND SOIL PHYSICAL PROPERTIES ON GOLF COURSE FAIRWAYS

Henderson, J., N. Miller, and B. Tencza 2010. The effect of sand type and application rate on turfgrass quality, disease severity, earthworm casting, and soil physical properties on golf course fairways. *In* Abstracts of the ASA-CSSA-SSSA 2010 International Annual Meetings, October 31- November 4, Long Beach, CA.

Fairway topdressing is a cultural practice that requires a significant budget, considerable labor, time, and commitment to implement properly. Sands that meet the United States Golf Association (USGA) specifications for putting green construction are typically recommended for topdressing fairways. However, due to the strict specifications, these sands are prohibitively expensive when considered for use on larger fairway acreage. The objectives of this research were to: 1) Determine whether particle size distribution and/or application rate will affect turfgrass color, turfgrass quality, turfgrass cover, disease incidence and earthworm activity, and 2) Quantify the effects of particle size distribution and topdressing layer depth on moisture retention, soil temperature, and resistance to surface displacement. This experiment was a 3 × 3 (sand type × application rate) factorial arranged in a random complete block design with three replications on L-93 creeping bentgrass (*Agrostis stolonifera*). The first factor, sand type, had three levels: fine, medium, and coarse. The second factor, application rate, had three levels: 0.001 m^3 m^{-2}, 0.002 m^3 m^{-2}, and 0.003 m^3 m^{-2}. A control was included that received no topdressing. Topdressing applications were applied once per month starting in May and ending in November. Effects from sand topdressing treatments were primarily observed through overall rate responses with higher application rates exhibiting a greater spring greening response, lower dollar spot incidence, less earthworm castings, less moisture retention and higher penetration resistance than lower application rates. Overall sand type effects were observed with moisture retention and penetration resistance. The fine and medium sand treatments held onto water more aggressively than the coarse sand treatments. The fine sand had the greatest resistance to penetration, followed by the medium sand and the coarse sand, respectively.

RATE RESPONSE AND COMPARISON OF PHOSPHONATE MATERIALS ON ALGAE DEVELOPMENT IN PUTTING GREEN TURF

Inguagiato, J., and J. Kaminski. 2010. Rate response and comparison of phosphonate materials on algae development in putting green turf. *In* Abstracts of the ASA-CSSA-SSSA 2010 International Annual Meetings, October 31- November 4, Long Beach, CA.

Algae infestations in putting green turf often require repeat fungicide applications to control. A two year field study was initiated in 2009 on ‘L-93' creeping bentgrass (*Agrostis stolonifera*) turf in Storrs, CT to identify alternative options for algae control. Turf was maintained at 4.0 mm and 3.3 mm in 2009 and 2010, respectively. The area was lightly irrigated two to three times day-1 from July through September each year and periodically covered with shade cloth in 2010 to encourage algae development. Phosphonate materials and application rate were evaluated as a 4 by 6 factorial within a randomized complete block design with four blocks. Phosphonate materials included a phosphite fungicide, phosphite fertilizer, and H_3PO_3/KOH, each containing mono- and di-potassium salts of phosphorous acid, and H_3PO_4/KOH as a phosphorous control. Phosphorous acid and phosphoric acid (H_3PO_x/KOH) were applied at 2.69, 5.43, 8.15, 10.86, 13.58, and 16.29 kg ha^{-1} every 14 days from 16 Jun to 24 Sep 2009 and 20 May to 31 Aug 2010. Algae development was limited in 2009, but turf treated with phosphite containing materials had less algae than H_3PO_4/KOH treated turf on 1 Oct. Phosphite treated turf had 3.6 to 20.8% less algae than H_3PO_4/KOH treated turf in June and July 2010 under increased pressure. Turf treated with 5.43 to 13.58 kg ha^{-1} H_3PO_x /KOH had less algae than turf treated with 2.69 kg ha^{-1} H_3PO_x /KOH regardless of source in October 2009. However, algae development decreased with increasing H_3PO_x /KOH application rate regardless of source by July 2010. These data suggest that preventive phosphite applications can be effectively used to manage algae on putting green turf, regardless of formulation.

ANTHRACNOSE DEVELOPMENT ON ANNUAL BLUEGRASS AFFECTED BY SEEDHEAD AND VEGETATIVE GROWTH REGULATORS

Inguagiato, J. C., J. A. Murphy, and B. B. Clarke. 2010. Anthracnose development on annual bluegrass affected by seedhead and vegetative growth regulators. Online. Applied Turfgrass Science doi:10.1094/ATS-2010-0923-01-RS.

The impact of plant growth regulators on anthracnose (*Colletotrichum cereale*) severity in annual bluegrass (Poa annua) putting greens has been a concern for turf managers. Two field studies assessed the influence of mefluidide (ME; applied twice at 0 or 0.69 fl oz/1000 ft^2) or ethephon (EP; applied twice at 0 or 5.0 fl oz/1000 ft^2) and three application intervals of trinexapac-ethyl (TE; 14 days, 7 days, or not applied) on anthracnose severity and seedhead production of annual bluegrass mowed to a height of 0.125 inch from 2005 to 2007. Growth regulators did not enhance anthracnose, but occasionally and inconsistently reduced disease severity. Mefluidide had little effect on anthracnose, but ethephon reduced disease 3 to 22% compared to non-EP-treated turf. Trinexapac-ethyl applied every 7 or 14 days reduced anthracnose 4 to 29% and 4 to 16% compared to non-TE-treated turf, respectively. Ethephon reduced seedhead cover 12 to 47%, while ME suppressed seedhead cover 12 to 15%. Trinexapac-ethyl-treated turf retained seedheads for longer periods than non-TE-treated turf, especially when applied every 7 days. Few meaningful interactions occurred in anthracnose or seedhead cover between TE and ME or TE and EP. Thus, TE and EP, or ME can be used on annual bluegrass turf to reduce seedheads without intensifying anthracnose, and may occasionally reduce disease severity.

QUANTIFYING SAND PARTICLE SHAPE COMPLEXITY USING A DYNAMIC, DIGITAL IMAGING TECHNIQUE

Miller, N. A., and J. J. Henderson. 2010. Quantifying sand particle shape complexity using a dynamic, digital imaging technique. Agron. J. 102:1407-1414. doi: 10.2134/agronj2010.0097

Sands used to construct athletic fields and golf course putting greens are characterized in laboratory tests to evaluate their suitability before construction. Many of these tests provide quantitative measurements of soil physical properties; however current evaluation procedures for particle shape rely on subjective visual assessments. The objective was to quantify differences in the particle shape complexity of sands using a dynamic, digital image analyzer, the Camsizer, and correlate those values to current quantitative and qualitative methods of particle shape analysis. The Camsizer uses two cameras to capture images of randomly falling particles at a rate of 60 frames s^{-1} These images are analyzed and shape parameters such as sphericity and aspect ratio are calculated. Five monosize sands of varying shape were evaluated, as well as a rounded and angular control. The dynamic method showed significant differences between sphericity and aspect ratio values of all sands, indicating these parameters can be used to quantitatively assess particle shape complexity. The values obtained with the Camsizer and with a well accepted static, quantitative technique that uses light microscopy were correlated for both aspect ratio (r = 0.935) and sphericity (r = 0.982). The Camsizer values also exhibited a positive relationship with the qualitative shape parameters, sphericity, and angularity. The coefficient of variation values for the aspect ratio and sphericity data, as determined by the dynamic method, were significantly lower than the static method or the qualitative analysis. These results indicate that this digital imaging analysis tool provides an accurate, objective means of quantifying particle shape complexity.

FIELD PERFORMANCE OF *METARHIZIUM ANISOPLIAE* AGAINST *POPILLIA JAPONICA* (COLEOPTERA: SCARABAEIDAE) AND *LISTRONOTUS MACULICOLLIS* (COLEOPTERA: CURCULIONIDAE) LARVAE IN TURFGRASS

Ramoutar, D., S.R. Alm, A.I. Legrand. 2010. Field performance of *Metarhizium anisopliae* against *Popillia japonica* (Coleoptera: Scarabaeidae) and *Listronotus maculicollis* (Coleoptera: Curculionidae) larvae in turfgrass. J. Entomol. Sci. 45:20-26.

Japanese beetle, *Popillia japonica* Newman, and annual bluegrass weevil, *Listronotus maculicollis* Kirby, larvae damage turfgrasses in the northeastern U.S. from April to October. Insecticides from several classes are extensively used to manage both species; however, inappropriate use has led to the development of insecticide resistance in both species and has negatively impacted nontarget predators of *P. japonica*, thus warranting research on alternative insect control options. We studied the effects of liquid and granular formulations of *Metarhizium anisopliae* (Metschnikoff) Sorokin strain F52 against *P. japonica* and *L. maculicollis* larvae under field conditions. The liquid formulation provided 31-46% control of *L. maculicollis* larvae, but did not control *P. japonica* larvae. The granular formulation provided 49% control of P. japonica larvae on aerated turf, but did not control these larvae in nonaerated turf nor did it control *L. maculicollis* larvae. Whereas the overall effectiveness of *M. anisopliae* F52 for controlling turfgrass-infesting larvae of *P. japonica* and *L. maculicollis* ranged from none to moderate, it may be useful in areas where insecticide use is restricted.

DO TIPHIID WASPS USE HERBIVORE-INDUCED PLANT VOLATILES FOR FINDING WHITE GRUBS?

Obeysekara, P. and A. Legrand. 2010. Do tiphiid wasps use herbivore-induced plant volatiles for finding white grubs? Entomological Society of America Annual Meeting, San Diego, CA. December 14th, 2010.

Two important Scarab beetle species, the Japanese beetle (*Popillia japonica*) and Oriental beetle (*Anomala orientalis*) are considered as invasive species and have been reported as key pests of urban landscapes and various other agricultural settings in the Northeast. The larvae of Japanese beetles primarily feed on the roots of wide variety of plants, including all cool season grasses and most weeds that are commonly found in turf grass sites. The root-feeding larvae of Oriental beetles, are a major pest of blueberries, ornamental nurseries, and turfgrass. *Tiphia vernalis* Rohwer and *Tiphia popilliavora,* 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 paralyzes it momentarily and attaches an egg in a location that is specific for that species. It is still unclear 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. The work reported here increases our understanding of *Tiphia* wasp host location in turfgrass systems. The objectives of this study were 1. Determine whether females of adult *T. vernalis* and *T. popilliavora* are attracted to plant volatiles from grub-infested plants. 2. Determine whether *T. vernalis* and *T. popilliavora* are attracted to plant volatiles from any given healthy turfgrass species. First, using a Y-tube olfactometer, the response of *T. vernalis* and *T. popilliavora* females toward grub-infested and uninfested turfgrasses was investigated. Wasps were highly attracted to volatiles emitted by grub-infested tall fescue (*Festuca arundinacea* Schreb) and Kentucky bluegrass (*Poa pratensis* L). In contrast, the wasps were not attracted to volatiles emanating from uninfested turfgrasses. As a second objective, the wasps' response to volatiles from uninfested turfgrasses was compared among three important grass species. Both *Tiphia* species showed no preference for volatiles from any particular turfgrass species. Future work will examine the volatile profiles of all the turfgrasses used in this study to better explain the wasp responses.

EVALUATION OF ORNAMENTAL PLANTS AS NECTAR SOURCES FOR *TIPHIA* PARASITOIDS

Legrand, A. 2010. Evaluation of ornamental plants as nectar sources for *Tiphia* parasitoids. Entomological Society of America Annual Meeting. San Diego, CA. December 2010.

Several scarab beetle species are important pests in a number of settings in the Northeast region. Ornamental plants, vegetables, field crops, fruits and turfgrass are attacked by a number of scarab beetles such as the Japanese and Oriental beetles. The Japanese beetle *Popillia japonica* Newman is an exotic pest that has spread gradually and now it is well established in most states east of the Mississippi River. This beetle is considered to be the most widespread and destructive insect pest of turf and landscape plants in eastern United States. It is estimated that this beetle is responsible for more than $450 million each year in costs for control and renovation or replacement of damaged turf and ornamental plants. Similarly, the Oriental beetle *Exomala orientalis* (Waterhouse) is another invasive scarab that as a larva feeds on roots of turfgrass and is a serious pest. It also causes severe damage to strawberries and nursery stock. *Tiphia vernalis* Rohwer and *Tiphia popilliavora* Rohwer. (Hymenoptera: Tiphiidae) were imported from Asia for Japanese beetle control. Moreover, *T. vernalis* and *T. popilliavora* can attack the Oriental beetle as well. These parasitoids feed on the larvae with *T. vernalis* attacking the 3rd instars during spring and *T. popilliavora* attacking 2nd or 3rd instars during late summer. *T. vernalis* is not known to parasitize any native scarab species. Since 1950 the occurrence of *T. vernalis* and *T. popilliavora* in Connecticut had not been monitored and they had been considered to be rare in occurrence. A recent survey by Ramoutar and Legrand (2007) indicated that *T. vernalis* wasps were widely distributed in the state with a peak occurrence around the last week of May.

Conservation biological control involves manipulation of the environment to enhance the survival, fecundity, longevity and behavior of natural enemies as to increase their effectiveness for pest management. One approach in conservation biological control is to provide food resources to natural enemies either through food sprays or by incorporating flowering plants habitats that could provide food resources over a period of time. Many parasitoid wasps species visit flowers to obtain nectar and/or pollen that provide essential nutrients. This in turn improves fecundity, longevity and increases rates of parasitism. Thus, the objective of this study was to identify ornamental plants that can serve as a source of nectar for *Tiphia* wasps in Connecticut. For *T. vernalis*, ornamental plants were selected based on their production of extrafloral nectar. It was hypothesized that this characteristic will be the best suited to the nectar feeding habits of this wasp given the timing of its occurrence. Plants selected included three cultivars of *Paeonia lactiflora*, *Viburnum dentatum* and *Sambucus canadensis*. For *T. popilliavora*, plants were selected based on their flower arrangement, flowering phenology and ornamental use. The plants selected included wild carrot *D. carota, Achillea filipendulina*, three cultivars of *A. millefolium,* and ornamental goldenrod *Solidago cutleri*. *T. vernalis* wasps were observed feeding off the extrafloral nectar on all the plants selected. However, *T. vernalis* were observed extensively feeding from the extrafloral nectar of peonies. Feeding damage by the Japanese beetle was also recorded on all plants tested and peonies were also the best in this regard because the beetles' low preference for these plants. Of the plants selected for summer *Tiphia* only the wild carrot attracted a significant number of *Tiphia* wasps.