University of Connecticut

College of Agriculture, Health and Natural Resources

2018 Annual Turfgrass Research Report

Optimizing Fairway Renovation Strategies to Establish More Sustainable Bentgrasses

UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES
PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

Cover photo: Creeping bentgrass establishment and annual bluegrass contamination influenced by post-plant herbicides in a fairway renovation study. (Photo credits: John C. Inguagiato, UCONN)

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PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

2018 Annual Turfgrass Research Report Summary

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

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

This report is divided into various sections and includes original research results in turf pathology, athletic field and golf turf maintenance, fertility and nutrient management, and cultivar evaluation and improvement. Additionally, abstracts and citations of scientific publications and presentations published in calendar year 2018 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 Turfgrass Science Program

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PREVENTIVE ANTHRACNOSE CONTROL WITH VARIOUS FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2018

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INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. An integrated disease control program including cultural management and fungicides is required to minimize turf loss due to this disease. Rotational fungicide programs utilizing different chemical modes of action and multi-site fungicides have been found to be most effective in providing season-long anthracnose control. Identifying new fungicides with unique modes of action effective against anthracnose is important to continued control of this disease and resistance management. The objective of this study was to examine the efficacy of experimental and commonly used fungicides, with and without post application irrigation, for anthracnose control on an annual bluegrass putting green turf.

MATERIALS & METHODS

A field study was conducted on an annual bluegrass (*Poa annua*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Minimal nitrogen was applied to the study area to encourage anthracnose development. A total of 1.2 lb N 1000-ft^{-2} was applied as water soluble sources from March through 19 August. Overhead irrigation and hand-watering was applied as needed to prevent drought stress. A rotation of Xzemplar (0.26 fl.oz.), Curalan (1.0 oz.), and Emerald (0.18 oz.) was applied every 14-d between 21 May and 24 July to prevent dollar spot development. Conserve SC (1.2 fl. oz.) was applied on 18 May for control of annual bluegrass weevil. Wetting agent Duplex (1.8 fl.oz.) was applied on 12 Jun.

Treatments consisted of commercially available and developmental fungicides. Initial applications were made on 25 May prior to disease developing in the trial area. Subsequent applications were made every 7-, 14- or 21-d through 26 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose was determined visually as the percent area blighted by *C. cereale* from 8 June through 3 August. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best possible quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Anthracnose severity data were arcsine square root-transformed as necessary for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS & DISCUSSION

Anthracnose Severity

Anthracnose symptoms developed from a natural infestation on 8 June and increased to approximately 29% plot area blighted in untreated control plots during June. Beginning in early-July high day and nighttime temperatures and humidity contributed to highly favorable disease conditions. Anthracnose in untreated control plots increased to 64 to 81% plot area blighted during during this time (Table 1). Despite high disease pressure, the majority of treatments evaluated provided excellent anthracnose control (i.e., $\leq$ 3% plot area blighted) through 13 July, however noteable differences among treatments were apparent on 3 August.

Rotational Programs (Syngenta 1 & 2, Bayer, AMVAC), Premion + Par, fungicides containing fosetyl-Al (i.e., QP fosetyl-Al, Signature, Signature Xtra) + chlorothalonil (i.e., QP Chlorothalonil DF, Daconil Ultrex) alternated with tebuconazole (i.e., QP Tebuconazole, Mirage), Mirage, Premion + Par, Navicon, Maxtima, and Traction all provided excellent anthracnose control on 3 August, and throughout the duration of the trial.

Autilus + Par, Tekken, Fame+C, Affirm, and Affirm + Alude all failed to provide acceptable control by 3 August. These treatments generally provided good to excellent anthracnose control prior to this date, with the exception of Affirm-alone, however high rainfall amounts and warm nighttime temperatures may have led to greater degredation of fungicides during this time. This is particularly evident with treatments with extended application intervals (Tekken) and those where contact fungicides provide the majority of control [Fame+C (*C. cereale* at this site is resistant to QoI) and Autilus).

Daonil Ultrex, Exteris StressGard, Affirm, and Tartan StressGard failed to provide acceptable anthracnose control in this trial.

Turf Quality and Phytotoxicity

Turf quality throughout the field was relatively poor through mid-June due to recovery from winter injury, and a cool early spring. From late-June through the duration of the trial turf quality was largely dependent on anthracnose severity and phytotoxcicty. Treatments containing a green pigment genearally improved turf quality compared to untreated control on 8 and 17 June (Table 2). Overall, Syngenta and AMVAC

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rotational programs consistently ranked among the hightest quality treatments during the trial. Unacceptable levels of phytotoxicty (> 2.0) were observed in Premion (8.0 floz.) + Par, Autilus + Par, Tekken, Fame+C, Traction. Phytotoxicity in these treatments was most apparent in late-June and 5 July, as temperatures began to reach 85-93°F. However, phytotoxicity symptoms declined through mid-July.

Table 1. Effect of various fungicides on preventative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

			Anthracnose Incidence							
Treatment	Rate per 1000ft^2	Application Dates[v]	8 Jun	14 Jun	24 Jun	29 Jun	5 Jul	13 Jul	27 Jul	3 Aug
			% plot area blighted							
Navicon	0.82 fl.oz.	ACEGI	0.4[u] de[t]	0.0 c	0.0 e	1.0 def	0.6 d	0.3 c	0.0 d	0.3 fg
Maxtima	0.8 fl.oz	ACEGI	0.5 de	0.3 c	1.1 cd	1.7 de	0.5 d	0.1 c	0.3 d	1.5 fg
Premion	4.0 fl.oz.	ACEGI	0.1 de	0.0 c	0.0 e	0.0 f	0.0 d	0.0 c	0.1 d	1.7 fg
+Harrell's Par	0.37 fl.oz.	ACEGI								
Premion	6.0 fl.oz.	ACEGI	0.4 de	0.0 c	0.0 e	0.1 def	0.0 d	0.0 c	0.0 d	0.7 fg
+Harrell's Par	0.37 fl.oz.	ACEGI								
Premion	8.0 fl.oz.	ACEGI	0.1 de	0.0 c	0.0 e	0.0 ef	0.0 d	0.0 c	0.0 d	2.6 ef
+Harrell's Par	0.37 fl.oz.	ACEGI								
Autilus	6.0 fl.oz.	ACEGI	0.0 e	0.0 c	0.0 e	0.3 ef	0.0 d	0.0 c	4.0 d	16.3 cd
+Harrell's Par	0.37 fl.oz.	ACEGI								
Mirage	1.0 fl.oz	ACEGI	0.1 de	0.0 c	0.0 e	0.1 def	0.0 d	0.0 c	0.0 d	0.3 fg
Tekken	3.0 fl.oz.	ACFJ	1.1 cd	0.0 c	0.0 e	0.0 f	0.8 cd	0.0 c	2.5 d	9.5 de
Tartan Stressgard	2.0 fl.oz.	ACFJ	3.6 ab	6.3 b	11.7 b	13.7 bc	39.8 a	42.5 b	65.0 b	80.0 b
Fame + C	4.0 fl.oz	ACEGI	0.1 de	0.0 c	0.0 e	1.1 def	0.6 d	0.8 c	2.8 d	9.4 de
QP Fosetyl-Al	4.0 oz.	AEI	0.0 e	0.0 c	0.3 cde	2.0 d	3.2 bc	0.3 c	0.1 d	0.2 fg
-QP Chlorothalonil DF	3.23 oz.	AEI								
-QP Tebuconazole	0.6 fl.oz.	CG								
QP Fosetyl-Al	4.0 oz.	AEI	0.1 de	0.0 c	0.0 e	0.1 def	0.1 d	0.0 c	0.0 d	0.0 g
-QP Chlorothalonil DF	3.23 oz.	AEI								
-QP Tebuconazole	0.6 fl.oz.	CG								
-ESTC112	0.184 fl.oz.	ACEG								
Signature Xtra	4.0 oz.	AEI	0.1 de	0.5 c	0.2 de	0.0 ef	0.0 d	0.1 c	0.1 d	0.2 fg
-Daconil Ultrex	3.2 oz.	AEI								
-Mirage	1.0 fl.oz.	CG								
Chipco Signature	4.0 oz.	AEI	0.3 de	0.3 c	0.0 e	0.8 def	0.3 d	0.1 c	0.4 d	0.2 fg
-Daconil Ultrex	3.2 oz.	AEI								
-Mirage	1.0 fl.oz.	CG								
Traction	1.3 fl.oz.	ACEGI	0.1 de	3.8 bc	0.0 e	0.0 f	0.0 d	0.0 c	0.0 d	0.1 fg
Affirm	0.9 oz.	ABCDEFGHIJ	0.3 de	0.0 c	1.3 c	0.9 def	7.3 b	10.5 c	18.8 c	24.4 c
Affirm	0.9 oz.	ABCDEFGHIJ	0.1 de	0.0 c	0.4 cde	0.6 def	3.5 b	4.5 c	3.8 d	10.1 d
+Alude	2.0 fl.oz.	ABCDEFGHIJ								
Exteris Stressgard	4.0 fl.oz.	ACEGI	2.4 bc	3.8 bc	9.5b	17.7 b	35.7 a	60.5 a	85.8 a	91.1 a
Daconil Ultrex	3.2 oz.	ACEGI	0.5 de	0.3 c	0.5 cde	8.2 c	8.3b	9.3 c	7.3 d	11.3 d
Syngenta Program 1	pgm[z]	ACEGI	0.0 e	0.0 c	0.0 e	0.0 f	0.0 d	0.0 c	0.0 d	0.2 gf
Syngenta Program 2	pgm[y]	ACEGI	0.0 e	0.0 c	0.0 e	0.0 f	0.0 d	0.0 c	0.0 d	0.0 g
AMVAC Program	pgm[x]	ACEGI	0.1 de	0.0 c	0.0 e	0.5 def	0.0 d	0.0 c	0.0 d	0.6 fg
Bayer Program	pgm[w]	ACEGI	0.3 de	0.0 c	0.0 e	0.0 f	0.0 d	0.0 c	0.0 d	0.3 fg
Untreated Control			7.0 a	16.3 a	25.9 a	28.8 a	64.1 a	70.0 a	81.3 a	80.5 ab
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	2	8	5	2	2	3	1	8
		14-d	2	8	5	10	2	10	9	16

[z]Daconil Action (3.5 fl.oz.) + Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) was applied on 19 June.

[y]Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Daconil Action (3.5 fl.oz.) was applied on 24 May, 6 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) + Secure Action (0.5 oz.) were applied on 19 June.

[x]Premion (8.0 fl.oz.) + Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 24 May. Daconil Ultrex (3.25 oz.) + Signature Xtra (4.0 oz.) were applied on 6 June and 18 July. Velista (0.3 oz.) + Affirm (4.0 oz.) were applied on 19 June. Premion (4.0 fl.oz.) + Medallion (1.5 fl.oz.) + Harrell's Par (0.37 fl.oz.) were applied on 3 July.

[w]Primo Maxx (0.125 fl.oz.) was applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Mirage (2.0 fl.oz.) was applied on 24 May. Signature Xtra (4.0 oz.) was applied on 6 June, 3 July, and 18 July. Daconil Ultrex (3.2 oz.) was applied on 6 June and 3 July. Mirage (1.0 fl.oz.) was applied on 19 June. Exteris Stressgard (4.0 fl.oz.) was applied on 19 June and 18 July.

[v]A=24 May, B=30 May, C=6 June, D=15 June. E=19 June, F=27 June. G=3 July, H=10 July, I=18 July, J=26 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.

[u]Anthracnose data were arcsine square-root transformed on 8 and 29 June and 3 August. Means are de-transformed for presentation.

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

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Table 2. Effect of various fungicides on turf quality in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per $1000ft^2$	Application Dates[v]	Turf Quality 8 Jun	17 Jun	24 Jun	3 Jul	5 Jul	13 Jul	27 Jul	3 Aug
			-1-9; 6=min acceptable-							
Navicon	0.82 fl.oz.	ACEGI	5.3 d-g[u]	6.3 e-h	6.5 e-h	6.0 d-h	5.5 def	6.3 b-e	6.3 cd	6.0 d-g
Maxtima	0.8 fl.oz	ACEGI	5.3 d-g	6.0 f-i	6.3 f-i	5.0 hij	5.3 efg	6.0 cde	6.3 cd	6.0 d-g
Premion	4.0 fl.oz.	ACEGI	7.5 a	7.5 abc	8.0 bc	5.5 f-j	5.8 def	6.5 a-d	6.5 cd	5.8 e-i
+Harrell's Par	0.37 fl.oz.	ACEGI								
Premion	6.0 fl.oz.	ACEGI	7.0 ab	7.0 b-e	6.8 d-g	5.0 hij	5.0 e-h	6.3 b-e	6.5 cd	6.3 c-f
+Harrell's Par	0.37 fl.oz.	ACEGI								
Premion	8.0 fl.oz.	ACEGI	6.8 abc	6.8 c-f	6.8 d-g	4.8 ij	4.0 hij	5.5 c-f	5.8 de	5.3 g-k
+Harrell's Par	0.37 fl.oz.	ACEGI								
Autilus	6.0 fl.oz.	ACEGI	7.5 a	7.3 a-d	7.5 cd	5.5 f-j	5.0 e-h	5.0 ef	5.5 de	4.5 jk
+Harrell's Par	0.37 fl.oz.	ACEGI								
Mirage	1.0 fl.oz	ACEGI	6.3 bcd	5.8 g-j	5.8 hij	5.3 g-j	5.3 efg	5.5 c-f	7.0 bc	6.0 e-h
Tekken	3.0 fl.oz.	ACFJ	5.0 efg	5.0 jk	4.8 kl	4.5 j	4.8 f-i	6.3 b-e	6.3 cd	5.0 h-k
Tartan Stressgard	2.0 fl.oz.	ACFJ	5.3 d-g	6.0 f-i	5.0 jkl	3.3 k	3.5 jk	3.5 gh	3.3 f	2.0 l
Fame + C	4.0 fl.oz	ACEGI	4.3 g	5.0 jk	5.0 jkl	4.8 ij	5.0 e-h	5.8 c-f	5.5 de	4.8 ijk
QP Fosetyl-Al	4.0 oz.	AEI	5.0 efg	5.3 ijk	5.5 ijk	5.8 e-i	5.5 def	5.8 c-f	7.0 bc	7.3 abc
-QP Chlorothalonil DF	3.23 oz.	AEI								
-QP Tebuconazole	0.6 fl.oz.	CG								
QP Fosetyl-Al	4.0 oz.	AEI	7.0 ab	7.0 b-e	7.3 cde	6.8 cde	7.0 abc	6.8 abc	7.3 bc	8.3 a
-QP Chlorothalonil DF	3.23 oz.	AEI								
-QP Tebuconazole	0.6 fl.oz.	CG								
-ESTC112	0.184 fl.oz.	ACEG								
Signature Xtra	4.0 oz.	AEI	6.3 bcd	6.5 d-g	7.0 def	7.0 cd	7.0 abc	6.8 abc	8.0 ab	6.8 b-e
-Daconil Ultrex	3.2 oz.	AEI								
-Mirage	1.0 fl.oz.	CG								
Chipco Signature	4.0 oz.	AEI	4.8 fg	5.5 h-k	6.5 e-h	6.5 c-f	6.5 bcd	6.8 abc	7.8 ab	7.3 abc
-Daconil Ultrex	3.2 oz.	AEI								
-Mirage	1.0 fl.oz.	CG								
Traction	1.3 fl.oz.	ACEGI	5.8 c-f	5.5 h-k	4.8 kl	4.8 ij	4.3 g-j	4.5 fg	5.5 de	5.5 f-j
Affirm	0.9 oz.	ABCDEFGHIJ	5.8 c-f	6.0 f-i	6.8 d-g	5.8 e-i	5.5 def	5.3 def	4.8 e	4.3 k
Affirm	0.9 oz.	ABCDEFGHIJ	5.8 c-f	6.8 c-f	6.8 d-g	5.8 e-i	6.0 cde	5.8 c-f	5.8 de	4.8 ijk
+Alude	2.0 fl.oz.	ABCDEFGHIJ								
Exteris Stressgard	4.0 fl.oz.	ACEGI	6.0 b-e	6.3 e-h	6.0 ghi	3.3 k	3.8 ijk	3.0 hi	2.0 g	1.5 l
Daconil Ultrex	3.2 oz.	ACEGI	4.8 fg	5.8 g-j	5.8 hij	5.3 g-j	5.0 e-h	5.5 c-f	5.8 de	5.3 g-k
Syngenta Program 1	pgm[z]	ACEGI	7.0 ab	8.0 a	9.0 a	9.0 a	7.3 ab	7.8 a	8.0 ab	7.0 bcd
Syngenta Program 2	pgm[y]	ACEGI	7.0 ab	7.8 ab	8.8 ab	8.3 ab	7.0 abc	7.8 a	8.0 ab	7.8 ab
AMVAC Program	pgm[x]	ACEGI	6.5 abc	7.8 ab	7.5 cd	7.3 bc	7.8 a	7.5 ab	7.8 ab	6.3 c-f
Bayer Program	pgm[w]	ACEGI	6.0 b-e	6.5 d-g	7.3 cde	6.3 c-g	6.0 cde	7.5 ab	8.8 a	6.3 c-f
Untreated Control			4.5 g	4.8 k	4.3 l	2.5 k	2.8 k	1.8 i	2.8 fg	1.5 l
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	2	2	5	6	2	3	1	8
		14-d	2	11	5	14	2	10	9	16

[z]Daconil Action (3.5 fl.oz.) + Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) was applied on 19 June.

[y]Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Daconil Action (3.5 fl.oz.) was applied on 24 May, 6 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) + Secure Action (0.5 oz.) were applied on 19 June.

[x]Premion (8.0 fl.oz.) + Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 24 May. Daconil Ultrex (3.25 oz.) + Signature Xtra (4.0 oz.) were applied on 6 June and 18 July. Velista (0.3 oz.) + Affirm (4.0 oz.) were applied on 19 June. Premion (4.0 fl.oz.) + Medallion (1.5 fl.oz.) + Harrell's Par (0.37 fl.oz.) were applied on 3 July.

[w]Primo Maxx (0.125 fl.oz.) was applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Mirage (2.0 fl.oz.) was applied on 24 May. Signature Xtra (4.0 oz.) was applied on 6 June, 3 July, and 18 July. Daconil Ultrex (3.2 oz.) was applied on 6 June and 3 July. Mirage (1.0 fl.oz.) was applied on 19 June. Exteris Stressgard (4.0 fl.oz.) was applied on 19 June and 18 July.

[v]A=24 May, B=30 May, C=6 June, D=15 June. E=19 June, F=27 June. G=3 July, H=10 July, I=18 July, J=26 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.

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

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Table 3. Effect of various fungicides on phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft²	Application Dates[v]	Phytotoxicity 8 Jun	17 Jun	24 Jun	5 Jul	3 Aug
			----0-5; 2=min acceptable----				
Navicon	0.82 fl.oz.	ACEGI	0.0 d[u]	0.0 b	0.0 d	0.5 ef	0.0 d
Maxtima	0.8 fl.oz	ACEGI	0.0 d	0.0 b	0.0 d	0.3 f	0.0 d
Premion	4.0 fl.oz.	ACEGI	0.0 d	0.0 b	0.0 d	1.3 c-f	0.0 d
+Harrell's Par	0.37 fl.oz.	ACEGI					
Premion	6.0 fl.oz.	ACEGI	0.0 d	0.0 b	0.2 d	1.8 cde	0.3 d
+Harrell's Par	0.37 fl.oz.	ACEGI					
Premion	8.0 fl.oz.	ACEGI	0.0 d	0.0 b	0.2 d	4.5 a	0.3 d
+Harrell's Par	0.37 fl.oz.	ACEGI					
Autilus	6.0 fl.oz.	ACEGI	0.0 d	0.0 b	0.0 d	3.3 ab	0.0 d
+Harrell's Par	0.37 fl.oz.	ACEGI					
Mirage	1.0 fl.oz	ACEGI	0.3 cd	0.0 b	1.3 b	1.1 def	1.0 c
Tekken	3.0 fl.oz.	ACFJ	0.5 bc	2.3 a	4.0 a	2.5 bc	2.7 a
Tartan Stressgard	2.0 fl.oz.	ACFJ	0.8 b	0.5 b	1.1 b	1.3 c-f	0.0 d
Fame + C	4.0 fl.oz	ACEGI	2.3 a	3.0 a	3.2 a	2.3 bcd	0.0 d
QP Fosetyl-Al	4.0 oz.	AEI	0.0 d	0.8 b	1.0 bc	0.5 ef	0.0 d
-QP Chlorothalonil DF	3.23 oz.	AEI					
-QP Tebuconazole	0.6 fl.oz.	CG					
QP Fosetyl-Al	4.0 oz.	AEI	0.0 d	0.0 b	0.0 d	0.5 ef	0.3 d
-QP Chlorothalonil DF	3.23 oz.	AEI					
-QP Tebuconazole	0.6 fl.oz.	CG					
-ESTC112	0.184 fl.oz.	ACEG					
Signature Xtra	4.0 oz.	AEI	0.0 d	0.3 b	0.2 d	0.3 f	0.3 d
-Daconil Ultrex	3.2 oz.	AEI					
-Mirage	1.0 fl.oz.	CG					
Chipco Signature	4.0 oz.	AEI	0.0 d	0.0 b	0.2 d	0.0 f	0.0 d
-Daconil Ultrex	3.2 oz.	AEI					
-Mirage	1.0 fl.oz.	CG					
Traction	1.3 fl.oz.	ACEGI	0.3 cd	0.5 b	3.7 a	4.3 a	1.5 b
Affirm	0.9 oz.	ABCDEFGHIJ	0.0 d	0.0 b	0.0 d	0.0 f	0.0 d
Affirm	0.9 oz.	ABCDEFGHIJ	0.0 d	0.0 b	0.0 d	0.0 f	0.0 d
+Alude	2.0 fl.oz.	ABCDEFGHIJ					
Exteris Stressgard	4.0 fl.oz.	ACEGI	0.0 d	0.0 b	0.0 d	0.3 f	0.0 d
Daconil Ultrex	3.2 oz.	ACEGI	0.5 bc	0.0 b	0.0 d	0.0 f	0.0 d
Syngenta Program 1	pgm[z]	ACEGI	0.0 d	0.0 b	0.0 d	0.8 ef	0.0 d
Syngenta Program 2	pgm[y]	ACEGI	0.0 d	0.0 b	0.0 d	0.8 ef	0.0 d
AMVAC Program	pgm[x]	ACEGI	0.0 d	0.0 b	0.0 d	0.0 f	0.0 d
Bayer Program	pgm[w]	ACEGI	0.3 cd	0.0 b	0.0 d	0.8 ef	0.0 d
Untreated Control			0.0 d	0.0 b	0.4 cd	0.0 f	0.0 d
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	2	2	5	2	8
		14-d	2	11	5	2	16

[z]Daconil Action (3.5 fl.oz.) + Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) was applied on 19 June.

[y]Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Daconil Action (3.5 fl.oz.) was applied on 24 May, 6 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) + Secure Action (0.5 oz.) were applied on 19 June.

[x]Premion (8.0 fl.oz.) + Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 24 May. Daconil Ultrex (3.25 oz.) + Signature Xtra (4.0 oz.) were applied on 6 June and 18 July. Velista (0.3 oz.) + Affirm (4.0 oz.) were applied on 19 June. Premion (4.0 fl.oz.) + Medallion (1.5 fl.oz.) + Harrell's Par (0.37 fl.oz.) were applied on 3 July.

[w]Primo Maxx (0.125 fl.oz.) was applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Mirage (2.0 fl.oz.) was applied on 24 May. Signature Xtra (4.0 oz.) was applied on 6 June, 3 July, and 18 July. Daconil Ultrex (3.2 oz.) was applied on 6 June and 3 July. Mirage (1.0 fl.oz.) was applied on 19 June. Exteris Stressgard (4.0 fl.oz.) was applied on 19 June and 18 July.

[v]A=24 May, B=30 May, C=6 June, D=15 June. E=19 June, F=27 June. G=3 July, H=10 July, I=18 July, J=26 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.

[u]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 4a. Effect of various fungicides on NDVI in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft^2	Application Dates[v]	NDVI 31 May	8 Jun	18 Jun	22 Jun
			----------------------Vegetation Index----------------------			
Navicon	0.82 fl.oz.	ACEGI	0.685	0.706 a-d[u]	0.738 abc	0.725 b-h
Maxtima	0.8 fl.oz	ACEGI	0.678	0.695 b-e	0.733 a-d	0.718 e-i
Premion	4.0 fl.oz.	ACEGI	0.681	0.700 a-e	0.731 a-d	0.718 d-i
+Harrell's Par	0.37 fl.oz.	ACEGI				
Premion	6.0 fl.oz.	ACEGI	0.691	0.713 ab	0.740 ab	0.707 ij
+Harrell's Par	0.37 fl.oz.	ACEGI				
Premion	8.0 fl.oz.	ACEGI	0.673	0.696 b-e	0.719 def	0.712 g-j
+Harrell's Par	0.37 fl.oz.	ACEGI				
Autilus	6.0 fl.oz.	ACEGI	0.673	0.708 abc	0.728 a-f	0.723 b-i
+Harrell's Par	0.37 fl.oz.	ACEGI				
Mirage	1.0 fl.oz	ACEGI	0.681	0.720 a	0.724 b-f	0.710 hij
Tekken	3.0 fl.oz.	ACFJ	0.664	0.711 ab	0.712 f	0.700 j
Tartan Stressgard	2.0 fl.oz.	ACFJ	0.676	0.707 a-d	0.720 c-f	0.714f-j
Fame + C	4.0 fl.oz	ACEGI	0.659	0.686 cde	0.712 ef	0.727 a-g
QP Fosetyl-Al	4.0 oz.	AEI	0.677	0.698 a-e	0.710 f	0.720 c-i
-QP Chlorothalonil DF	3.23 oz.	AEI				
-QP Tebuconazole	0.6 fl.oz.	CG				
QP Fosetyl-Al	4.0 oz.	AEI	0.680	0.712 ab	0.727 a-f	0.732a-e
-QP Chlorothalonil DF	3.23 oz.	AEI				
-QP Tebuconazole	0.6 fl.oz.	CG				
-ESTC112	0.184 fl.oz.	ACEG				
Signature Xtra	4.0 oz.	AEI	0.682	0.711 ab	0.731 a-e	0.718 d-i
-Daconil Ultrex	3.2 oz.	AEI				
-Mirage	1.0 fl.oz.	CG				
Chipco Signature	4.0 oz.	AEI	0.677	0.703 a-d	0.727 a-f	0.718 e-i
-Daconil Ultrex	3.2 oz.	AEI				
-Mirage	1.0 fl.oz.	CG				
Traction	1.3 fl.oz.	ACEGI	0.693	0.711 ab	0.721 c-f	0.716 f-j
Affirm	0.9 oz.	ABCDEFGHIJ	0.687	0.707 a-d	0.738 a-d	0.742 a
Affirm	0.9 oz.	ABCDEFGHIJ	0.697	0.711 ab	0.739 abc	0.737 ab
+Alude	2.0 fl.oz.	ABCDEFGHIJ				
Exteris Stressgard	4.0 fl.oz.	ACEGI	0.681	0.719 a	0.732 a-d	0.736 abc
Daconil Ultrex	3.2 oz.	ACEGI	0.677	0.685 de	0.721 c-i	0.721 c-i
Syngenta Program 1	pgm[z]	ACEGI	0.661	0.694 b-e	0.744 a	0.733 a-e
Syngenta Program 2	pgm[y]	ACEGI	0.671	0.701 a-e	0.744 a	0.726 a-h
AMVAC Program	pgm[x]	ACEGI	0.666	0.679 e	0.737 a-d	0.734 a-d
Bayer Program	pgm[w]	ACEGI	0.652	0.687 cde	0.720 c-f	0.729 a-f
Untreated Control			0.673	0.693 b-e	0.722 b-f	0.709 ij
ANOVA: Treatment (P > F)			0.1024	0.0263	0.0066	0.0001
Days after treatment		7-d	2	2	3	3
		14-d	2	2	12	3

[z]Daconil Action (3.5 fl.oz.) + Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) was applied on 19 June.

[y]Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Daconil Action (3.5 fl.oz.) was applied on 24 May, 6 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) + Secure Action (0.5 oz.) were applied on 19 June.

[x]Premion (8.0 fl.oz.) + Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 24 May. Daconil Ultrex (3.25 oz.) + Signature Xtra (4.0 oz.) were applied on 6 June and 18 July. Velista (0.3 oz.) + Affirm (4.0 oz.) were applied on 19 June. Premion (4.0 fl.oz.) + Medallion (1.5 fl.oz.) + Harrell's Par (0.37 fl.oz.) were applied on 3 July.

[w]Primo Maxx (0.125 fl.oz.) was applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Mirage (2.0 fl.oz.) was applied on 24 May. Signature Xtra (4.0 oz.) was applied on 6 June, 3 July, and 18 July. Daconil Ultrex (3.2 oz.) was applied on 6 June and 3 July. Mirage (1.0 fl.oz.) was applied on 19 June. Exteris Stressgard (4.0 fl.oz.) was applied on 19 June and 18 July.

[v]A=24 May, B=30 May, C=6 June, D=15 June. E=19 June, F=27 June. G=3 July, H=10 July, I=18 July, J=26 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.

[u]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 4b. Effect of various fungicides on NDVI in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft²	Application Dates[v]	NDVI 5 Jul	NDVI 13 Jul	NDVI 19 Jul	NDVI 2 Aug
			------------------------Vegetation Index------------------------			
Navicon	0.82 fl.oz.	ACEGI	0.771 a-e[u]	0.770 ab	0.727 ab	0.796 a
Maxtima	0.8 fl.oz	ACEGI	0.778 abc	0.772 ab	0.723 ab	0.793 a
Premion	4.0 fl.oz.	ACEGI	0.760 c-g	0.763 ab	0.723 ab	0.790 ab
+Harrell's Par	0.37 fl.oz.	ACEGI				
Premion	6.0 fl.oz.	ACEGI	0.752 e-h	0.764 ab	0.714 ab	0.796 a
+Harrell's Par	0.37 fl.oz.	ACEGI				
Premion	8.0 fl.oz.	ACEGI	0.735 h	0.751 abc	0.714 ab	0.781 ab
+Harrell's Par	0.37 fl.oz.	ACEGI				
Autilus	6.0 fl.oz.	ACEGI	0.747 fgh	0.748 bc	0.700 ab	0.763 b
+Harrell's Par	0.37 fl.oz.	ACEGI				
Mirage	1.0 fl.oz	ACEGI	0.771 a-e	0.766 ab	0.726 ab	0.801 a
Tekken	3.0 fl.oz.	ACFJ	0.768 a-e	0.774 ab	0.725 ab	0.778 ab
Tartan Stressgard	2.0 fl.oz.	ACFJ	0.752 e-h	0.727 cd	0.618 c	0.691 c
Fame + C	4.0 fl.oz	ACEGI	0.777 abc	0.771 ab	0.707 ab	0.786 ab
QP Fosetyl-Al	4.0 oz.	AEI	0.778 abc	0.774 ab	0.707 ab	0.796 a
-QP Chlorothalonil DF	3.23 oz.	AEI				
-QP Tebuconazole	0.6 fl.oz.	CG				
QP Fosetyl-Al	4.0 oz.	AEI	0.778 abc	0.767 ab	0.706 ab	0.805 a
-QP Chlorothalonil DF	3.23 oz.	AEI				
-QP Tebuconazole	0.6 fl.oz.	CG				
-ESTC112	0.184 fl.oz.	ACEG				
Signature Xtra	4.0 oz.	AEI	0.773 a-d	0.770 ab	0.710 ab	0.795 a
-Daconil Ultrex	3.2 oz.	AEI				
-Mirage	1.0 fl.oz.	CG				
Chipco Signature	4.0 oz.	AEI	0.781 ab	0.777 a	0.706 ab	0.793 a
-Daconil Ultrex	3.2 oz.	AEI				
-Mirage	1.0 fl.oz.	CG				
Traction	1.3 fl.oz.	ACEGI	0.769 a-e	0.764 ab	0.718 ab	0.800 a
Affirm	0.9 oz.	ABCDEFGHIJ	0.782 ab	0.766 ab	0.699 b	0.781 ab
Affirm	0.9 oz.	ABCDEFGHIJ	0.782 ab	0.768 ab	0.722 ab	0.787 ab
+Alude	2.0 fl.oz.	ABCDEFGHIJ				
Exteris Stressgard	4.0 fl.oz.	ACEGI	0.741 gh	0.720 d	0.616 c	0.636 b
Daconil Ultrex	3.2 oz.	ACEGI	0.759 c-g	0.764 ab	0.706 ab	0.787 ab
Syngenta Program 1	pgm[z]	ACEGI	0.755 d-h	0.769 ab	0.709 ab	0.780 ab
Syngenta Program 2	pgm[y]	ACEGI	0.760 c-g	0.773 ab	0.711 ab	0.792 ab
AMVAC Program	pgm[x]	ACEGI	0.786 a	0.765 ab	0.711 ab	0.789 ab
Bayer Program	pgm[w]	ACEGI	0.764 b-f	0.773 ab	0.734 a	0.788 ab
Untreated Control			0.699 i	0.675 e	0.609 c	0.682 c
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	2	3	1	7
		14-d	2	10	1	15

[z]Daconil Action (3.5 fl.oz.) + Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) was applied on 19 June.

[y]Primo Maxx (0.125 fl.oz.) + UC18-1 (6.0 fl.oz.) were tank-mixed and applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Daconil Action (3.5 fl.oz.) was applied on 24 May, 6 June, 3 July, and 18 July. Velista (0.5 oz.) was applied on 24 May and 3 July. Briskway (0.5 fl.oz.) was applied on 6 June and 18 July. Medallion (1.0 fl.oz.) + Secure Action (0.5 oz.) were applied on 19 June.

[x]Premion (8.0 fl.oz.) + Harrell's Par (0.37 fl.oz.) were tank-mixed and applied on 24 May. Daconil Ultrex (3.25 oz.) + Signature Xtra (4.0 oz.) were applied on 6 June and 18 July. Velista (0.3 oz.) + Affirm (4.0 oz.) were applied on 19 June. Premion (4.0 fl.oz.) + Medallion (1.5 fl.oz.) + Harrell's Par (0.37 fl.oz.) were applied on 3 July.

[w]Primo Maxx (0.125 fl.oz.) was applied on 24 May, 6 June, 19 June, 3 July, and 18 July. Mirage (2.0 fl.oz.) was applied on 24 May. Signature Xtra (4.0 oz.) was applied on 6 June, 3 July, and 18 July. Daconil Ultrex (3.2 oz.) was applied on 6 June and 3 July. Mirage (1.0 fl.oz.) was applied on 19 June. Exteris Stressgard (4.0 fl.oz.) was applied on 19 June and 18 July.

[v]A=24 May, B=30 May, C=6 June, D=15 June. E=19 June, F=27 June. G=3 July, H=10 July, I=18 July, J=26 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.

[u]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 ANTHRACNOSE CONTROL WITH DEVELOPMENTAL FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2018

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INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. An integrated disease control program including cultural management and fungicides is required to minimize turf loss due to this disease. Rotational fungicide programs utilizing different chemical modes of action and multi-site fungicides have been found to be most effective in providing season-long anthracnose control. Identifying new fungicides with unique modes of action effective against anthracnose is important to continued control of this disease and resistance management. The objective of this study was to examine the efficacy of experimental and commonly used fungicides, with and without post application irrigation, for anthracnose control on an annual bluegrass putting green turf.

MATERIALS & METHODS

A field study was conducted on an annual bluegrass (*Poa annua*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Minimal nitrogen was applied to the study area to encourage anthracnose development. A total of 1.2 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from March through 19 August. Overhead irrigation and hand-watering was applied as needed to prevent drought stress. A rotation of Xzemplar (0.26 fl.oz.), Curalan (1.0 oz.), and Emerald (0.18 oz.) was applied every 14-d between 21 May and 24 July to prevent dollar spot development. Conserve SC (1.2 fl. oz.) was applied on 18 May for control of annual bluegrass weevil. Wetting agent Duplex (1.8 fl.oz.) was applied on 12 Jun.

Treatments consisted of commercially available and developmental fungicides. Initial applications were made on 25 May prior to disease developing in the trial area. Subsequent applications were made every 14-d through 18 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal $1000\text{-}ft^{-2}$ at 40 psi. Select treatments received 0.1 inches of post-application irrigation applied individually to plots with a watering can immediately after fungicides were applied. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose was determined visually as the percent area blighted by *C. cereale* from 8 June through 3 August. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best possible quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Anthracnose severity data were log-transformed as necessary for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS AND DISCUSSION

Anthracnose Severity

Anthracnose symptoms developed from a natural infestation on 8 Jun and increased slightly to approximately 15% plot area blighted in untreated control plots during June. Beginning in early-July high day and nighttime temperatures and humidity contributed to highly favorable disease conditions. Anthracnose in untreated control plots increased to 44 to 58% plot area blighted during during this time (Table 1).

Commercially available fungicides Mirage, Torque, and Velista provided excellent (i.e., < 3% plot area blighted) anthracnose control throughout the duration of this trial.

UC18-6 provided excellent anthracnose control through mid-July, regardless of rate. However, rates ≤ 1.0 fl.oz. were 3 to 8% less effective than the 1.6 fl.oz. rate on the last observation date (3 Aug). Anthracnose severity of UC18-5 treated turf was generally no different than the untreated control, regardless of rate.

UC18-8 effects on anthracnose were dependent on rate, post-application irrigation, and timing. UC18-8 without post-application irrigation provided excellent anthracnose control through June, regardless of rate. During early July, plots treated with the high rate (0.41 fl.oz.) maintained lower plot area blighted compared to the low rate (0.33 fl.oz.). However, both rates had similar disease levels by late-July, which were less than untreated control, but greater than commercially available fungicides. Irrigation of 0.1 inch immediately after treatment reduced efficacy of UC18-8 applied at 0.41 fl.oz. compared to the same rate without irrigation. An irrigation effect was less apparent at the low rate (0.33 fl.oz.), although this may be due to the reduced efficacy of this fungicide applied at lower rates.

Turf Quality and Phytotoxicity

Turf quality was largely dependent on anthracnose severity, although phytotoxcicty was also a factor in some treatments (Table 2). Torque applied every 14-d throughout the trial resulted in stunted, dark green, coarse leaf texture typical of repeat applications of DMI fungicides, most noteably on 24 Jun and 5 Jul (Table 3). UC18-6 applied at rates ≥ 1.0 fl.oz. had similar phytotoxic symptoms, particularly at the highest rate on 5 Jul. No other treaatments in this study were observed to have noteable phytotoxicity.

Table 1. Effect of various fungicides on preventative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018

Treatment[z]	Rate per 1000ft^2	8 Jun	15 Jun	24 Jun	29 Jun	5 Jul	13 Jul	27 Jul	3 Aug
		Anthracnose Incidence							
		% plot area blighted							
UC18-6	0.5 fl.oz.	0.1[y] cd[x]	0.7 de	0.0 d	0.6 de	0.4 ef	0.2 g	5.1 de	8.2 ef
UC18-6	0.8 fl.oz.	0.5 cd	0.2 de	0.0 d	1.0 de	0.6 ef	2.9 cd	1.1 ef	3.3 efg
UC18-6	1.0 fl.oz.	0.7 cd	0.0 e	0.0 d	0.0 e	0.8 ef	0.6 d-g	1.0 ef	3.2 efg
UC18-6	1.6 fl.oz.	0.1 cd	0.0 e	0.0 d	0.0 e	0.0 f	0.3 fg	0.0 f	0.0 h
UC18-5	0.138 oz.	6.3 ab	3.8 bc	14.4 ab	14.6 a	32.9 ab	34.4 a	35.4 ab	52.5 ab
UC18-5	0.275 oz.	7.7 ab	13.0 a	13.2 ab	10.8 ab	44.3 a	35.8 a	42.1 a	59.4 a
UC18-5	0.55 oz.	5.7 ab	6.4 ab	12.2 ab	15.1 a	40.4 a	33.4 a	37.4 ab	50.0 ab
Mirage	1.0 fl.oz.	0.0 d	0.0 e	0.0 d	0.0 e	0.0 f	0.3 fg	0.2 f	0.4 gh
UC18-8	0.33 fl.oz.	1.0 c	0.7 de	1.6 c	1.6 cd	9.2 cd	8.1 bc	11.5 cd	22.0 cd
UC18-8	0.41 fl.oz.	1.4 c	0.2 de	0.1 cd	0.2 e	3.1 de	2.2 def	8.3 d	10.7 de
UC18-8	0.33 fl.oz.	1.3 c	1.5 cd	7.0 b	4.6 bc	20.0 bc	17.4 ab	23.7 bc	34.9 bc
+Post-App Irrigation	0.1 in.								
UC18-8	0.41 fl.oz.	4.9 b	4.7 bc	8.2 ab	5.1 b	19.0 bc	18.4 ab	23.6 bc	32.4 c
+Post-App Irrigation	0.1 in.								
Torque	0.6 fl.oz.	0.1 cd	0.0 e	0.0 d	0.0 e	0.0 f	0.5 efg	0.3 ef	0.8 gh
Torque	0.6 fl.oz.	0.0 d	0.0 e	0.0 d	0.0 e	0.0 f	0.4 efg	0.0 f	0.0 h
+Post-App Irrigation	0.1 in.								
Velista	0.5 oz.	0.1 cd	0.6 de	0.0 d	0.0 e	0.5 ef	2.3 de	0.7 ef	0.4 gh
Velista	0.5 oz.	1.5 c	0.5 de	0.1 cd	0.1 e	7.0 d	1.6 d-g	0.8 ef	2.3 fgh
+Post-App Irrigation	0.1 in.								
Untreated Control		10.7 a	12.8 a	15.3 a	14.7 a	43.6 a	40.6 a	45.0 a	57.6 a
ANOVA: Treatment ($P > F$)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		1	8	5	10	16	8	9	16

[z]Treatments were initiated on 25 May prior to disease developing in the trial area and were repeated every 14-d thereafter. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft^{-2} at 40 psi.

[y]Anthracnose data were automatically log-transformed. Means are de-transformed for presentation.

[x]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. Effect of various fungicides on turf quality in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018

		Turf Quality						
Treatment[z]	Rate per 1000ft^2	8 Jun	15 Jun	24 Jun	5 Jul	13 Jul	27 Jul	3 Aug
		------------------------------------- 1-9; 6=min acceptable -----------------------------------						
UC18-6	0.5 fl.oz.	5.8 b-f[y]	6.8 a-d	7.0 abc	6.0 a-d	7.0 a	6.3 abc	5.5 cd
UC18-6	0.8 fl.oz.	6.0 a-e	6.5 bcd	6.0 c-f	5.5 bcd	6.3 abc	6.3 abc	6.0 a-d
UC18-6	1.0 fl.oz.	6.0 a-e	7.0 abc	6.8 a-d	6.0 a-d	5.8 bcd	6.8 abc	5.8 bcd
UC18-6	1.6 fl.oz.	6.5 abc	6.8 a-d	6.5 b-e	5.8 a-d	5.3 cd	6.8 abc	7.3 a
UC18-5	0.138 oz.	4.8 ef	6.0 cde	5.0 f	4.0 ef	4.0 ef	4.5 f	2.8 gh
UC18-5	0.275 oz.	4.5 f	5.0 e	5.0 f	3.8 f	3.8 ef	4.3 f	2.3 h
UC18-5	0.55 oz.	5.0 def	5.8 de	5.5 ef	3.5 f	4.0 ef	4.8 ef	3.0 gh
Mirage	1.0 fl.oz.	7.3 a	7.8 a	7.3 ab	6.0 a-d	6.3 abc	7.3 a	6.8 abc
UC18-8	0.33 fl.oz.	5.8 b-f	6.8 a-d	6.5 b-e	5.5 bcd	5.8 bcd	5.8 cde	4.8 def
UC18-8	0.41 fl.oz.	6.0 a-e	7.3 ab	7.0 abc	6.0 a-d	6.8 ab	6.0 bcd	5.3 de
UC18-8	0.33 fl.oz.	5.3 c-f	6.6 a-d	6.6 a-e	5.1 cde	5.3 cd	4.7 ef	4.0 efg
+Post-App Irrigation	0.1 in.							
UC18-8	0.41 fl.oz.	4.8 ef	5.3 e	5.5 ef	5.0 de	4.8 de	5.0 def	3.8 fg
+Post-App Irrigation	0.1 in.							
Torque	0.6 fl.oz.	6.8 ab	6.8 a-d	6.3 b-e	5.5 bcd	5.8 bcd	6.8 abc	7.0 ab
Torque	0.6 fl.oz.	6.3 a-d	6.5 bcd	5.8 def	6.5 ab	6.0 abc	7.0 ab	7.3 a
+Post-App Irrigation	0.1 in.							
Velista	0.5 oz.	7.0 ab	7.0 abc	7.8 a	6.8 a	6.8 ab	7.0 ab	7.3 a
Velista	0.5 oz.	6.5 abc	7.5 ab	7.8 a	6.3 abc	7.0 a	7.0 ab	6.0 a-d
+Post-App Irrigation	0.1 in.							
Untreated Control		4.5 f	5.0 e	5.0 f	3.5 f	3.5 f	4.5 f	2.3 h
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		1	8	5	16	8	9	16

[z]Treatments were initiated on 25 May prior to disease developing in the trial area and were repeated every 14-d thereafter. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft^{-2} at 40 psi.

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

Table 3. Effect of various fungicides on phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2018

Treatment[z]	Rate per 1000ft^2	Phytotoxicity				
		8 Jun	15 Jun	24 Jun	5 Jul	3 Aug
		---- 0-5; 2=max acceptable ----				
UC18-6	0.5 fl.oz.	0.0	0.0	0.4 cd[y]	0.4 cd	0.0
UC18-6	0.8 fl.oz.	0.0	0.0	0.2 cd	0.4 cd	0.0
UC18-6	1.0 fl.oz.	0.0	0.0	0.7 bc	1.4 ab	0.0
UC18-6	1.6 fl.oz.	0.0	0.0	1.7 a	3.0 a	0.0
UC18-5	0.138 oz.	0.0	0.0	0.0 d	0.0 d	0.0
UC18-5	0.275 oz.	0.0	0.0	0.0 d	0.0 d	0.0
UC18-5	0.55 oz.	0.0	0.0	0.0 d	0.0 d	0.0
Mirage	1.0 fl.oz.	0.0	0.0	0.0 d	0.6 bcd	0.0
UC18-8	0.33 fl.oz.	0.0	0.0	0.0 d	0.0 d	0.0
UC18-8	0.41 fl.oz.	0.0	0.0	0.0 d	0.0 d	0.0
UC18-8	0.33 fl.oz.	0.0	0.0	0.0 d	0.4 cd	0.0
+Post-App Irrigation	0.1 in.					
UC18-8	0.41 fl.oz.	0.0	0.0	0.0 d	0.4 cd	0.0
+Post-App Irrigation	0.1 in.					
Torque	0.6 fl.oz.	0.0	0.0	1.2 ab	1.4 ab	0.0
Torque	0.6 fl.oz.	0.0	0.0	1.6 a	0.7 bc	0.0
+Post-App Irrigation	0.1 in.					
Velista	0.5 oz.	0.0	0.0	0.0 d	0.0 d	0.0
Velista	0.5 oz.	0.0	0.0	0.0 d	0.0 d	0.0
+Post-App Irrigation	0.1 in.					
Untreated Control		0.0	0.0	0.0 d	0.0 d	0.0
ANOVA: Treatment (P > F)		1.0000	1.0000	0.0001	0.0001	1.0000
Days after treatment		1	8	5	16	16

[z]Treatments were initiated on 25 May prior to disease developing in the trial area and were repeated every 14-d thereafter. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

[y]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 BROWN PATCH CONTROL WITH FUNGICIDES ON A COLONIAL BENTGRASS FAIRWAY TURF, 2018

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INTRODUCTION

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

MATERIALS & METHODS

A field study was conducted on an 'SR-7150' colonial bentgrass (*Agrostis capillaris*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. A total of 1.2 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from April through August. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of fungicides applied individually, or as tank mixes. Initial applications were made on 8 June prior to disease developing in the trial area. Subsequent applications were made at specified treatment intervals through 16 August. All treatments were applied using a handheld CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal $1000\text{-}ft^{-2}$ at 40 psi.

Brown patch was assessed visually as a percentage of the plot area blighted by *Rhizoctonia solani*. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS AND DISCUSSION

Brown Patch Incidence

Brown patch developed in the trial area beginning in the end of July, with untreated plots showing 4.3% plot area blighted. The disease developed rapidly, with 17% of untreated plots blighted as of 31 July, and 42% as of 7 August.

Plots treated with Tekken (a premix of isofetamid (an SDHI) and tebuconazole) on either a 21-d or 28-d basis showed complete control of disease, and plots treated with Torque (tebuconazole) also showed virtually no disease for the duration of the trial.

Table 1. Brown Patch severity influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

			Brown Patch Incidence					
Treatment[z]	Rate per $1000ft^2$	Int	29 Jun	6 Jul	27 Jul	31 Jul	3 Aug	7 Aug
			----------------------- % plot area blighted -----------------------					
Tekken	3.0 fl.oz.	21-d	0.0	0.0	0.0 c[y]	0.0 d	0.0 d	0.0 d
Tekken	3.0 fl.oz.	28-d	0.0	0.0	0.0 c	0.0 d	0.0 d	0.0 d
Exteris Stressgard	4.0 fl.oz.	21-d	0.0	0.0	1.2 b	8.9 b	12.0 b	16.1 b
Compass	0.166 oz.	21-d	0.0	0.0	0.1 c	4.4 c	6.7 c	6.4 c
Torque	0.6 fl.oz.	21-d	0.0	0.0	0.0 c	0.2 d	0.0 d	0.2 d
Untreated			0.0	0.0	4.3 a	17.4 a	23.2 a	42.8 a
ANOVA: Treatment (P > F)			1.0000	1.0000	0.0001	0.0001	0.0001	0.0001
Days after treatment		21-d	8	1	22	26	29	4
		28-d	8	15	8	12	15	19

[z]Treatments were initiated on 8 June, prior to disease development. Treatments were reapplied at specified intervals.
[y]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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PREVENTIVE DOLLAR SPOT CONTROL WITH VARIOUS FUNGICIDES ON A CREEPING BENTGRASS PUTTING GREEN TURF, 2018

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INTRODUCTION

Dollar spot is a common disease of cool-season turfgrasses caused by the fungal pathogen *Sclerotinia homoeocarpa*. On golf course fairways it is characterized by light, straw-colored spots that may coalesce into larger irregularly shaped areas. It is particularly active during periods of warm daytime temperatures (80°F), cool nighttime temperatures (60°F), and high humidity. It can be managed in part with cultural practices such as maintaining moderate nitrogen fertility, reducing leaf wetness period. However, the use of fungicides is often still necessary on high priority areas such as greens, tees and fairways. The objective of this study was to evaluate the efficacy of rotational fungicide programs as well as using new and existing fungicides in controlling dollar spot on a creeping bentgrass putting green turf.

MATERIALS & METHODS

A field study was conducted on a 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Nitrogen was applied at a total of 1.45 lb N 1000-ft^{-2} as water soluble sources from April through August. Tempo SC was applied on 19 July to control cutworms. To help alleviate dry surface conditions, the wetting agent Duplex was applied on 12 June, and OARS was applied on 24 July. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new fungicide formulations and currently available products applied individually, as tank mixes, and/or in rotational program. Initial applications were made on 18 May, prior to disease developing in the trial area. Subsequent applications were made at specified intervals through 7 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual disease foci within each plot. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. NDVI measurements were taken with a FieldScout TCM 500 NDVI meter (Spectrum Technologies, Aurora, IL). All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS AND DISCUSSION

Dollar Spot Incidence

Despite favorable conditions for disease development, dollar spot never substantially manifested in the trial area. Disease peaked at 7 dollar spot infection centers (DSIC) in untreated control plots on 3 August (Table 1). Dollar spot was virtually non-existent (<1 DSIC plot^{-1}) on all treated plots for the duration of the trial.

Brown Patch Severity

Brown patch (Table 2) developed in the trial area in early August, with the epidemic peaking at 18% plot area blighted on untreated plots on 7 August. Although most of the treatments provided near-complete control of the disease, brown patch severity was slightly higher (~5.5% plot area blighted) on plots treated with Pinpoint (21-d) and Secure (14-d). Plots treated with Secure Action, a new formulation of Secure containing both fluazinam and acibenzolar-S-methyl, showed less disease than plots treated with Secure (1.3% vs. 5.5%), however in both treatments the overall disease severity was low.

Turf Quality, Phytotoxicity, and NDVI

Due to a lack of disease, turf quality (Table 3) was generally high throughout the trial area. Some phytotoxicity (Table 4) was observed in Rotational Program 3 during late May through mid-June, likely due to the inclusion of Premion, a PCNB-based fungicide, in the first application. The yellowing remained visible for much of the duration of the trial, although the severity was never unacceptable and steadily faded through July.

Although some statistical differences in NDVI (Table 5) were detected on 5 July, the lack of disease and uniformally high turf quality make it unlikely that the differences in NDVI are of practical significance.

Table 1. Dollar spot incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft^2	Application Dates[z]	Dollar Spot Incidence								
			25 May	8 Jun	15 Jun	22 Jun	1 Jul	5 Jul	13 Jul	3 Aug	7 Aug
			# of dollar spot infection centers 18 ft^{-2}								
Fame + C	4.0 fl.oz.	ACEGIKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b[y]	0.3 bc
PinPoint	0.31 fl.oz.	ADGJM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1 b	0.5 bc
Tekken	3.0 fl.oz.	ADGJM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 c
Tekken	3.0 fl.oz.	ACEGIKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 c
Traction	1.3 fl.oz.	ACEGIKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 c
Rotator	0.5 fl.oz.	ACEGIKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6 b	0.0 c
Secure	0.5 fl.oz.	ACEGIKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0 b	1.0 b
Secure Action	0.5 fl.oz.	ACEGIKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 c
Mirage	2.0 fl.oz.	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 c
-Banol	4.0 fl.oz.	A									
-Exteris StressGard	3.0 fl.oz.	CI									
-Chipco 26GT	4.0 fl.oz.	EK									
-Signature Xtra	4.0 oz.	EK									
-Segway	0.6 fl.oz.	G									
-Mirage	2.0 fl.oz[y]	GM									
Mirage	2.0 fl.oz.	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 c
-Exteris StressGard	3.0 fl.oz.	CI									
-Chipco 26GT	4.0 fl.oz.	EK									
-Signature Xtra	4.0 oz.	EK									
-Mirage	2.0 fl.oz.	GM									
Signature Xtra	4.0 oz.	ACEGIKM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 b	0.0 c
-Premion	6.0 fl.oz.	A									
-Secure	0.5 fl.oz.	CI									
-Tourney	0.18 oz.	E									
-Lexicon	0.34 fl.oz.	GM									
-Daconil Ultrex	3.2 oz.	K									
Untreated			0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3 a	2.3 a
ANOVA: Treatment ($P > F$)			1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0002	0.0004
Days after treatment		14-d	7	6	3	10	5	9	3	14	18
		21-d	7	3	10	17	5	9	17	16	20
		28-d	7	21	3	10	19	23	3	24	28

[z]Application dates were as follows: A=18 May, C=30 May, D=5 Jun, E=12 Jun, G=26 Jun, I=10 Jul, J=18 Jul, K=24 Jul, M=7 Aug

[y]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. Brown Patch and Algae Severity influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft²	Application Dates[z]	Brown Patch Incidence 13 Jul	1 Aug	3 Aug	7 Aug	Algae Severity 26 Jul
			% plot area blighted				0-5; 2=max acceptable
Fame + C	4.0 fl.oz.	ACEGIKM	0.0	0.0 b[y]	0.0 b	0.0 d	0.3 f
PinPoint	0.31 fl.oz.	ADGJM	0.0	0.0 b	0.3 b	5.5 b	2.3 a-e
Tekken	3.0 fl.oz.	ADGJM	0.0	0.0 b	0.0 b	0.0 d	2.3 a-e
Tekken	3.0 fl.oz.	ACEGIKM	0.0	0.0 b	0.0 b	0.0 d	2.5 a-d
Traction	1.3 fl.oz.	ACEGIKM	0.0	0.0 b	0.0 b	0.0 d	3.3 a
Rotator	0.5 fl.oz.	ACEGIKM	0.0	0.6 b	0.0 b	0.8 cd	2.8 abc
Secure	0.5 fl.oz.	ACEGIKM	0.0	0.3 b	0.0 b	5.5 b	1.5 de
Secure Action	0.5 fl.oz.	ACEGIKM	0.0	0.0 b	0.0 b	1.3 c	3.0 ab
Mirage	2.0 fl.oz.	A	0.0	0.0 b	0.0 b	0.0 d	1.5 de
-Banol	4.0 fl.oz.	A					
-Exteris StressGard	3.0 fl.oz.	CI					
-Chipco 26GT	4.0 fl.oz.	EK					
-Signature Xtra	4.0 oz.	EK					
-Segway	0.6 fl.oz.	G					
-Mirage	2.0 fl.oz[y]	GM					
Mirage	2.0 fl.oz.	A	0.0	0.0 b	0.0 b	0.0 d	1.8 cde
-Exteris StressGard	3.0 fl.oz.	CI					
-Chipco 26GT	4.0 fl.oz.	EK					
-Signature Xtra	4.0 oz.	EK					
-Mirage	2.0 fl.oz.	GM					
Signature Xtra	4.0 oz.	ACEGIKM	0.0	0.0 b	0.0 b	0.2 cd	1.3 ef
-Premion	6.0 fl.oz.	A					
-Secure	0.5 fl.oz.	CI					
-Tourney	0.18 oz.	E					
-Lexicon	0.34 fl.oz.	GM					
-Daconil Ultrex	3.2 oz.	K					
Untreated			0.0	5.9 a	1.5 a	18.6 a	2.0 b-e
ANOVA: Treatment (P > F)			1.0000	0.0008	0.0002	0.0001	0.0001
Days after treatment		14-d	3	12	14	18	2
		21-d	17	14	16	20	8
		28-d	3	22	24	28	16

[z]Application dates were as follows: A=18 May, C=30 May, D=5 Jun, E=12 Jun, G=26 Jun, I=10 Jul, J=18 Jul, K=24 Jul, M=7 Aug

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

Table 3. Turf Quality influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft^2	Application Dates[z]	Turf Quality							
			25 May	8 Jun	15 Jun	22 Jun	1 Jul	5 Jul	13 Jul	27 Jul
			1-9; 6=min acceptable							
Fame + C	4.0 fl.oz.	ACEGIKM	6.3	6.8	6.0 c	7.3	7.0	8.0	7.0 c	7.8 a-d
PinPoint	0.31 fl.oz.	ADGJM	6.8	7.0	6.8 bc	8.0	7.0	8.0	7.8 bc	6.8 de
Tekken	3.0 fl.oz.	ADGJM	5.5	6.8	6.5 bc	7.5	7.3	7.5	7.5 bc	7.0 cde
Tekken	3.0 fl.oz.	ACEGIKM	6.3	7.8	6.5 bc	7.5	6.3	8.3	7.3 bc	6.8 de
Traction	1.3 fl.oz.	ACEGIKM	6.0	7.3	6.0 c	7.3	6.5	7.8	7.0 c	6.3 e
Rotator	0.5 fl.oz.	ACEGIKM	6.5	7.5	7.0 abc	8.0	6.8	8.5	8.0 ab	6.3 e
Secure	0.5 fl.oz.	ACEGIKM	6.5	8.0	7.3 ab	8.3	7.8	8.8	8.0 ab	7.3 b-e
Secure Action	0.5 fl.oz.	ACEGIKM	6.0	7.3	6.5 bc	7.5	6.5	8.0	7.3 bc	7.0 cde
Mirage	2.0 fl.oz.	A	6.8	8.3	8.0 a	8.5	7.5	8.5	8.8 a	8.5 a
-Banol	4.0 fl.oz.	A								
-Exteris StressGard	3.0 fl.oz.	CI								
-Chipco 26GT	4.0 fl.oz.	EK								
-Signature Xtra	4.0 oz.	EK								
-Segway	0.6 fl.oz.	G								
-Mirage	2.0 fl.oz[y]	GM								
Mirage	2.0 fl.oz.	A	6.0	8.0	7.3 ab	7.5	7.8	7.8	8.8 a	8.0 abc
-Exteris StressGard	3.0 fl.oz.	CI								
-Chipco 26GT	4.0 fl.oz.	EK								
-Signature Xtra	4.0 oz.	EK								
-Mirage	2.0 fl.oz.	GM								
Signature Xtra	4.0 oz.	ACEGIKM	6.3	7.3	6.8 bc	7.3	7.0	7.8	7.3 bc	8.3 ab
-Premion	6.0 fl.oz.	A								
-Secure	0.5 fl.oz.	CI								
-Tourney	0.18 oz.	E								
-Lexicon	0.34 fl.oz.	GM								
-Daconil Ultrex	3.2 oz.	K								
Untreated			6.5	7.5	6.8 bc	7.8	7.3	7.8	8.0 ab	6.8 de
ANOVA: Treatment (P > F)			0.3353	0.2069	0.0427	0.3620	0.2690	0.4739	0.0001	0.0009
Days after treatment		14-d	7	6	3	10	5	9	3	3
		21-d	7	3	10	17	5	9	17	9
		28-d	7	21	3	10	19	23	3	17

[z]Application dates were as follows: A=18 May, C=30 May, D=5 Jun, E=12 Jun, G=26 Jun, I=10 Jul, J=18 Jul, K=24 Jul, M=7 Aug

[y]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. Phytotoxicity influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per $1000ft^2$	Application Dates[z]	Phytotoxicity 25 May	8 Jun	15 Jun	22 Jun	1 Jul	5 Jul	13 Jul	3 Aug
			---------- 0-5; 2=max acceptable ----------							
Fame + C	4.0 fl.oz.	ACEGIKM	0.0 b[y]	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
PinPoint	0.31 fl.oz.	ADGJM	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
Tekken	3.0 fl.oz.	ADGJM	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
Tekken	3.0 fl.oz.	ACEGIKM	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
Traction	1.3 fl.oz.	ACEGIKM	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
Rotator	0.5 fl.oz.	ACEGIKM	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
Secure	0.5 fl.oz.	ACEGIKM	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
Secure Action	0.5 fl.oz.	ACEGIKM	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
Mirage	2.0 fl.oz.	A	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
-Banol	4.0 fl.oz.	A								
-Exteris StressGard	3.0 fl.oz.	CI								
-Chipco 26GT	4.0 fl.oz.	EK								
-Signature Xtra	4.0 oz.	EK								
-Segway	0.6 fl.oz.	G								
-Mirage	2.0 fl.oz[y]	GM								
Mirage	2.0 fl.oz.	A	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
-Exteris StressGard	3.0 fl.oz.	CI								
-Chipco 26GT	4.0 fl.oz.	EK								
-Signature Xtra	4.0 oz.	EK								
-Mirage	2.0 fl.oz.	GM								
Signature Xtra	4.0 oz.	ACEGIKM	1.5 a	0.6 a	1.4 a	0.8 a	0.8 a	0.5 a	0.5 a	0.0
-Premion	6.0 fl.oz.	A								
-Secure	0.5 fl.oz.	CI								
-Tourney	0.18 oz.	E								
-Lexicon	0.34 fl.oz.	GM								
-Daconil Ultrex	3.2 oz.	K								
Untreated			0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b	0.0
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0010	0.0228	0.0228	0.0071	0.0071	1.0000
Days after treatment		14-d	7	6	3	10	5	9	3	14
		21-d	7	3	10	17	5	9	17	16
		28-d	7	21	3	10	19	23	3	24

[z]Application dates were as follows: A=18 May, C=30 May, D=5 Jun, E=12 Jun, G=26 Jun, I=10 Jul, J=18 Jul, K=24 Jul, M=7 Aug

[y]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. NDVI influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft^2	Application Dates[z]	NDVI 25 May	NDVI 21 Jun	NDVI 5 Jul
			---------------- Vegetation Index		--------------
Fame + C	4.0 fl.oz.	ACEGIKM	0.716	0.749	0.796 d[y]
PinPoint	0.31 fl.oz.	ADGJM	0.718	0.751	0.802 a-d
Tekken	3.0 fl.oz.	ADGJM	0.720	0.752	0.800 bcd
Tekken	3.0 fl.oz.	ACEGIKM	0.720	0.742	0.804 a-d
Traction	1.3 fl.oz.	ACEGIKM	0.712	0.754	0.803 a-d
Rotator	0.5 fl.oz.	ACEGIKM	0.715	0.760	0.810 a
Secure	0.5 fl.oz.	ACEGIKM	0.723	0.752	0.808 ab
Secure Action	0.5 fl.oz.	ACEGIKM	0.706	0.756	0.808 abc
Mirage	2.0 fl.oz.	A	0.725	0.761	0.808 ab
-Banol	4.0 fl.oz.	A			
-Exteris StressGard	3.0 fl.oz.	CI			
-Chipco 26GT	4.0 fl.oz.	EK			
-Signature Xtra	4.0 oz.	EK			
-Segway	0.6 fl.oz.	G			
-Mirage	2.0 fl.oz[y]	GM			
Mirage	2.0 fl.oz.	A	0.720	0.752	0.808 ab
-Exteris StressGard	3.0 fl.oz.	CI			
-Chipco 26GT	4.0 fl.oz.	EK			
-Signature Xtra	4.0 oz.	EK			
-Mirage	2.0 fl.oz.	GM			
Signature Xtra	4.0 oz.	ACEGIKM	0.705	0.749	0.806 abc
-Premion	6.0 fl.oz.	A			
-Secure	0.5 fl.oz.	CI			
-Tourney	0.18 oz.	E			
-Lexicon	0.34 fl.oz.	GM			
-Daconil Ultrex	3.2 oz.	K			
Untreated			0.717	0.754	0.800 cd
ANOVA: Treatment (P > F)			0.7054	0.3024	0.0254
Days after treatment		14-d	7	9	9
		21-d	7	16	9

[z]Application dates were as follows: A=18 May, C=30 May, D=5 Jun, E=12 Jun, G=26 Jun, I=10 Jul, J=18 Jul, K=24 Jul, M=7 Aug

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

PREVENTIVE DOLLAR SPOT CONTROL WITH VARIOUS FUNGICIDES ON A CREEPING BENTGRASS FAIRWAY TURF, 2018

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INTRODUCTION

Dollar spot is a common disease of cool-season turfgrasses caused by the fungal pathogen *Sclerotinia homoeocarpa*. On golf course fairways it is characterized by light, straw-colored spots that may coalesce into larger irregularly shaped areas. It is particularly active during periods of warm daytime temperatures (80°F), warm nighttime temperatures (60°F), and high humidity. It can be managed in part with cultural practices such as maintaining moderate nitrogen fertility and reducing leaf wetness period. However, the use of fungicides is often still necessary on high priority areas such as greens, tees and fairways. The objective of this study was to evaluate the efficacy of new and experimental fungicides in controlling dollar spot on a creeping bentgrass fairway turf.

MATERIALS & METHODS

A field study was conducted on a 'Ninety-six Two' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage dollar spot development. A total of 0.4 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from May through August. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new, experimental, and exisiting fungicide formulations, applied individually, as tank mixes, and/or in rotational programs. Initial applications for most treatments were made on 17 May prior to disease developing in the trial area, except for treatments (Table 1a + 1b) applied curatively on 15 June and then again on 8 August. Subsequent applications were made at specified intervals through 9 August. All treatments were applied using a handheld CO_2 powered spray boom outfitted with a single AI9504E or AI9508E flat fan nozzle calibrated to deliver 1.0 gal or 2.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual dollar spot infection centers within each plot from 1 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. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Dollar spot data were log-transformed, and means were detransformed for presentation.

RESULTS AND DISCUSSION

Dollar Spot Incidence

Dollar spot developed from a natural infestation on 1 June and increased rapidly through the month with 123 dollar spot infection centers (DSIC) in untreated control plots forming by 22 June and 223 DSIC in UTC plots as of 1 July (Table 1a + 1b). Drier weather conditions contributed to a reduction in severity through July, with UTC plots averaging 141 DSIC as of 13 July, before rapidly increasing again with 167 DSIC as of 26 July, 213 DSIC as of 3 Aug, and 305 DSIC as of the final rating date on 13 Aug.

Residual Control

Maxtima (0.4 oz.), a new DMI fungicide with a significantly reduced growth regulator effect, Navicon, a new DMI + Strobilurin fungicide, Xzemplar (0.26 oz.), and Torque (0.6 oz.) were individually applied at the trial initiation and then reapplied every 21-d through 27 June for a total of 3 applications, after which reapplication was ceased for these treatments. Navicon provided excellent control of disease (<2 DSIC $plot^{-1}$) through 3 August, 37 days after the last fungicide application and provided acceptable (<25 DSIC $plot^{-1}$) control through the end of the trial, demonstrating a prolonged period of efficacy even during severe disease conditions. Maxtima and Xzemplar provided excellent-to-good (<10 DSIC $plot^{-1}$) control through 3 August, though disease increased to unacceptable (>25 DSIC $plot^{-1}$) thereafter. Torque provided acceptable levels of control through 26 July, 29 days after the last fungicide application with disease incidence rapidly increasing afterwards. For all of these treatments, it is possible that the initial three applications were beneficial in preventing the inoculum from increasing early on, allowing extended residual efficacy once treatments ceased. Reapplication later in the season may still be necessary, however, depending on the fungicide used and the severity of the epidemic.

Preventive Control

Maxtima (0.4 oz.), Torque (0.6 oz), and Xzemplar (0.26 oz.) were also applied every 21-d for the entirety of the trial. Maxtima and Xzemplar both provided excellent control for the duration of the trial, while Torque generally provided acceptable control until the epidemic increased in severity in early to mid-August. Xzemplar also provided good-to-excellent control of disease when applied at a lower rate (0.21 oz.) every 21-d and provided excellent control when applied every 14-d at the 0.26 oz. rate. When applied every 28-d, Xzemplar (0.26 oz.) generally provided good control, although disease tended to increase in these plots towards the end of the reapplication intervals and was unacceptable as of 9 August with over 50 DSIC $plot^{-1}$.

In addition to Xzemplar, several other SDHI fungicides were evaluated including Exteris Stressgard (an SDHI + strobilurin), Posterity (a new SDHI fungicide), Tekken (an SDHI + DMI). Velista, and Emerald. Exteris was applied at 4.0 and 5.0 fl.oz. rates on a 14-d and 21-d interval, respectively. Both rates and intervals provided good-to-excellent control for the duration of the trial with no more than 10 DSIC plot^{-1}. Posterity (0.16 oz., 21-d) and Tekken (3.0 oz, 21-d) also provided excellent control throughout the trial, however when applied on a 28-d interval, Tekken (3.0 oz.) was more inconsistent and often unacceptable, especially towards the end of the reapplication interval. Emerald (0.18 oz., 21-d) provided acceptable control however treated plots often had more disease relative to the more effective SDHI's discussed above, peaking at 22 DSIC plot^{-1} on July 1. Velista (0.5 oz., 21-d) provided acceptable control through July 26, however disease increased rapidly into August, peaking at 115 DSIC plot^{-1} on 9 August, indicating that this treatment may need a shorter reapplication interval under severe conditions.

Traction (a DMI + fluazinam) provided excellent control when applied every 14-d, and generally provided acceptable control when applied every 21-d except for 9 August (45 DSIC plot^{-1}), which was at the end of a reapplication interval and during a peak of the disease epidemic. Pinpoint, a new strobilurin with activity on dollar spot, also provided good control when applied on a 14-d interval until 9 August, with disease peaking at 64 DSIC plot^{-1}. However, when tank-mixed with Tourney, Pinpoint provided near-complete control for the duration of the trial.

Civitas One (8.5 fl.oz., 21-d) was generally indistinguishable from the untreated control, making it unlikely that this product is efficacious as a stand-alone treatment under high disease pressure.

Curative Control

Several treatments were applied after the onset of disease in order to evaluate their curative efficacy. Maxtima (0.4 oz.), Xzemplar (0.26 oz.), and Torque (0.6 oz.) were individually applied on 15 June to previously untreated plots. Disease peaked in these treatments on 18 June, with and average of 85, 113, and 102 DSIC plot^{-1} in each treatment respectively (Table 1). As of 1 July (16 days after treatment (DAT)), disease incidence was reduced to 31, 59, and 70 DSIC plot^{-1} respectively, representing a 63% decrease in disease for Maxtima, a 48% decrease for Xzemplar, and a 31% decrease for Torque. Disease continued to decline, with Torque bottoming out at 47 DSIC plot^{-1} on 13 July (28 DAT), a 53% decrease from the peak. Maxtima and Xzemplar showed the least disease on 26 July, with 5.5 and 3.5 DSIC plot^{-1} respectively, representing a 93% decrease in disease for plots treated with Maxtima and a 97% decrease in disease for plots treated with Xzemplar following a single treatment application 41 days prior. Disease increased rapidly in these plots in subsequent ratings, demonstrating the need for a follow-up fungicide application when disease is being treated curatively.

Turf Quality and NDVI

There was no phytoxicity observed at any point during the trial, so Turf Quality (Table 2) was primarily influenced by disease incidence. As of 1 July, turf quality was especially high on plots treated with Maxtima, Xzemplar, Navicon, Tekken (21-d), Exteris Stressgard, Posterity, Traction, Tourney, and Pinpoint + Tourney. Quality remained especially high on plots treated with Exteris Stressgard for the duration of the trial, likely due to the combination of its efficacy and the formulation's green pigment.

Although some differences in NDVI (Table 3) were observed, it is likely that these differences are largely a function of disease incidence, with low-performing treatments consistently having the lowest values.

Table 1a. Dollar spot incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Int	1 Jun	8 Jun	15 Jun	18 Jun	22 Jun	1 Jul	6 Jul
			Dollar Spot Incidence						
			# of dollar spot infection centers 18 ft^{-2}						
Maxtima	0.4 fl.oz.	21-d[y]	0.0[w] g[v]	1.6 ijk	0.4 lm	0.9 efg	0.0 e	0.9 i-l	0.3 jkl
Xzemplar	0.26 fl.oz.	21-d[y]	0.2 fg	1.6 ijk	1.1 j-m	1.0 efg	1.0 e	1.1 i-l	0.3 jkl
Torque	0.6 fl.oz.	21-d[y]	2.4 c-f	12.5 c-f	4.4 f-j	8.2 bcd	4.8 e	17.4 def	13.4 efg
Navicon	0.85 fl.oz.	21-d[y]	0.2 fg	1.8 h-k	0.4 lm	0.4 fg	0.0 e	0.3 kl	0.2 kl
Maxtima	0.4 fl.oz.	cur.[x]	13.7 ab	39.6 ab	59.9 a	85.3 a	79.0 c	33.6 cd	31.6 cde
Xzemplar	0.26 fl.oz.	cur.[x]	15.5 ab	47.1 a	74.4 a	113.3 a	97.5 b	65.3 bc	59.0 bcd
Torque	0.6 fl.oz.	cur.[x]	7.5 abc	30.8 a-d	64.6 a	102.5 a	73.0 c	72.0 bc	69.9 bc
Tekken	3.0 fl.oz.	21-d	0.9 efg	9.9 efg	4.7 e-i	2.4 def	1.3 e	0.4 kl	0.3 jkl
Xzemplar	0.21 fl.oz.	21-d	1.2 d-g	6.9 fgh	2.2 g-l	2.8 def	2.5 e	1.7 ijk	1.7 ijk
Tekken	3.0 fl.oz.	28-d	2.2 c-f	15.1 b-f	48.6 ab	63.8 a	40.8 d	24.5 de	25.4 def
Xzemplar	0.26 fl.oz.	28-d	0.0 g	1.2 ijk	7.5 c-f	17.5 b	9.0 e	2.4 hij	2.0 ij
Exteris Stressgard	4.0 fl.oz.	14-d	0.0 g	0.2 jk	0.2 m	1.2 efg	1.0 e	5.7 gh	1.9 ij
Exteris Stressgard	5.0 fl.oz.	21-d	1.3 d-g	10.3 d-g	3.1 f-k	1.6 efg	2.8 e	1.7 ijk	1.6 ijk
Posterity	0.16 fl.oz.	21-d	0.0 g	1.4 ijk	0.9 klm	0.6 fg	0.3 e	0.9 i-l	0.4 jkl
Velista	0.5 oz.	21-d	1.5 d-g	14.9 b-f	13.5 cde	11.1 bc	8.0 e	10.9 efg	9.7 gh
Emerald	0.18 oz.	21-d	1.5 d-g	14.9 b-f	20.2 bc	19.5 b	17.3 e	22.2 def	20.5 efg
Traction	1.3 fl.oz.	14-d	0.0 g	0.7 ijk	1.1 klm	1.2 efg	0.5 e	0.2 kl	0.0 l
Traction	1.3 fl.oz.	21-d	0.6 efg	14.9 b-f	3.6 f-k	1.4 efg	1.3 e	1.3 ijk	1.3 i-l
Pinpoint	0.28 fl.oz.	14-d	0.0 g	2.0 hij	5.3 e-h	8.8 bcd	15.8 e	13.6 efg	12.1 fg
Tourney	0.28 oz.	14-d	0.0 g	0.9 ijk	2.5 f-l	3.0 def	3.0 e	3.3 hi	3.6 hi
Pinpoint +Tourney	0.28 fl.oz. 0.28 oz.	14-d	0.0 g	0.0 k	1.3 i-m	0.9 efg	0.8 e	0.2 kl	0.3 jkl
Xzemplar	0.26 fl.oz.	14-d	0.0 g	0.2 jk	1.6 h-m	0.0 g	1.0 e	0.6 jkl	0.0 l
Civitas One	8.5 fl.oz.	21-d	6.7 abc	32.8 abc	67.2 a	92.7 a	84.3 bc	142.2 ab	138.4 ab
Torque	0.6 fl.oz.	21-d	6.7 abc	29.9 a-e	16.9 cd	19.1 b	10.3 e	16.2 def	15.2 efg
Banner Maxx II	1.0 fl.oz.	21-d	4.9 bcd	32.2 abc	17.6 cd	11.2 bc	10.8 e	22.1 def	19.6 efg
Tartan	1.0 fl.oz.	21-d	2.6 cde	9.7 efg	6.8 d-g	4.3 cde	2.8 e	9.1 fg	8.8 gh
Maxtima	0.4 fl.oz.	21-d	0.2 fg	3.2 ghi	0.9 klm	0.6 fg	0.3 e	0.0 l	0.0 l
Untreated Control			17.0 a	50.8 a	65.4 a	123.4 a	121.5 a	223.2 a	214.0 a
ANOVA: Treatment (P > F)			0.0478	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	2	9	16	3	7	4	9
		21-d	15	2	9	12	16	4	9
		28-d	15	23	30	3	7	16	21

[z]Treatments were initiated on 17 May, unless otherwise noted, and were reapplied at specified intervals for the duration of the trial.

[y]Treatments were initiated on 17 May and reapplied on 6 and 27 June for a total of 3 applications.

[x]Treatments were applied curatively on 15 June and 8 August, after the onset of disease.

[w]Dollar spot data were log-transformed. Means are de-transformed for presentation.

[v]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 1b. Dollar spot incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Int	Dollar Spot Incidence				
			13 Jul	26 Jul	3 Aug	9 Aug	13 Aug
			-------------------- # of dollar spot infection centers 18 ft^{-2} --------------------				
Maxtima	0.4 fl.oz.	21-d[y]	0.2[w] gh[v]	0.0 h	2.1 ghi	24.7 ijk	28.3 fgh
Xzemplar	0.26 fl.oz.	21-d[y]	0.0 h	0.2 gh	2.8 gh	37.2 hij	44.2 e-h
Torque	0.6 fl.oz.	21-d[y]	5.2 cde	4.2 c	54.0 cd	143.9 cde	136.6 bcd
Navicon	0.85 fl.oz.	21-d[y]	0.2 gh	0.0 h	1.4 ghi	17.9 jk	24.0 ghi
Maxtima	0.4 fl.oz.	cur.[x]	13.9 c	5.5 c	94.2 a-d	188.0 bc	127.7 bcd
Xzemplar	0.26 fl.oz.	cur.[x]	14.0 c	3.5 cd	28.6 de	154.0 cd	86.2 cde
Torque	0.6 fl.oz.	cur.[x]	47.7 b	57.1 b	141.7 abc	236.1 b	205.5 abc
Tekken	3.0 fl.oz.	21-d	0.6 fgh	0.2 gh	0.0 i	0.5 lm	0.2 m
Xzemplar	0.21 fl.oz.	21-d	0.7 fgh	0.0 h	0.9 ghi	0.2 lm	0.0 m
Tekken	3.0 fl.oz.	28-d	10.7 c	1.6 de	63.2 bcd	141.2 cde	97.8 cde
Xzemplar	0.26 fl.oz.	28-d	0.6 fgh	0.0 h	5.1 fg	54.1 ghi	23.9 ghi
Exteris Stressgard	4.0 fl.oz.	14-d	1.1 fgh	0.0 h	0.2 hi	1.3 lm	0.4 m
Exteris Stressgard	5.0 fl.oz.	21-d	0.9 fgh	0.0 h	1.3 ghi	10.8 kl	3.7 kl
Posterity	0.16 fl.oz.	21-d	0.0 h	0.3 fgh	0.3 hi	0.7 lm	1.1 lm
Velista	0.5 oz.	21-d	7.0 cd	0.3 fgh	28.9 de	115.2 de	83.6 cde
Emerald	0.18 oz.	21-d	9.7 c	1.4 def	1.9 ghi	7.6 klm	5.4 jk
Traction	1.3 fl.oz.	14-d	0.6 fgh	0.0 h	0.2 hi	0.4 lm	0.0 m
Traction	1.3 fl.oz.	21-d	1.6 efg	0.2 gh	1.7 ghi	45.1 hij	17.9 hi
Pinpoint	0.28 fl.oz.	14-d	7.7 c	1.2 efg	2.4 gh	64.1 fgh	46.1 efg
Tourney	0.28 oz.	14-d	2.4 def	0.2 gh	2.8 gh	17.5 jk	11.0 ij
Pinpoint +Tourney	0.28 fl.oz. 0.28 oz.	14-d	0.4 fgh	0.0 h	0.0 i	0.2 lm	0.3 m
Xzemplar	0.26 fl.oz.	14-d	0.0 h	0.0 h	0.0 i	0.0 m	0.0 m
Civitas One	8.5 fl.oz.	21-d	129.4 a	118.3 a	210.3 ab	340.5 a	395.2 a
Torque	0.6 fl.oz.	21-d	5.4 cde	0.7 e-h	29.7 de	103.5 def	85.4 cde
Banner Maxx II	1.0 fl.oz.	21-d	8.5 c	0.9 e-h	14.6 ef	95.4 efg	61.1 def
Tartan	1.0 fl.oz.	21-d	1.3 fgh	1.6 de	31.9 de	123.9 cde	80.9 de
Maxtima	0.4 fl.oz.	21-d	0.0 h	0.0 h	0.0 i	1.4 lm	1.1 lm
Untreated Control			141.3 a	167.7 a	213.7 a	239.4 b	305.2 ab
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	2	15	8	1	12
		21-d	2	8	16	1	12
		28-d	2	15	23	1	12

[z]Treatments were initiated on 17 May, unless otherwise noted, and were reapplied at specified intervals for the duration of the trial.
[y]Treatments were initiated on 17 May and reapplied on 6 and 27 June for a total of 3 applications.
[x]Treatments were applied curatively on 15 June and 8 August, after the onset of disease.
[w]Dollar spot data were log-transformed. Means are de-transformed for presentation.
[v]Means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$)

Table 2. Turf quality influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Int	Turf Quality 8 Jun	1 Jul	13 Jul	27 Jul	13 Aug
			---------------------------- 1-9; 6=min acceptable				--------------------------
Maxtima	0.4 fl.oz.	21-d[y]	7.3 bc[w]	8.3 ab	7.8 ab	7.5 bc	5.3 ef
Xzemplar	0.26 fl.oz.	21-d[y]	7.0 bc	8.0 ab	7.3 bcd	6.5 def	5.0 fg
Torque	0.6 fl.oz.	21-d[y]	5.8 d-g	6.5 cde	5.8 ghi	5.3 g	3.5 ij
Navicon	0.85 fl.oz.	21-d[y]	6.8 bcd	8.5 a	7.5 bc	7.3 cd	6.0 de
Maxtima	0.4 fl.oz.	cur.[x]	4.8 ghi	5.3 f	5.3 i	5.3 g	3.8 hi
Xzemplar	0.26 fl.oz.	cur.[x]	4.5 hi	4.0 g	5.3 i	5.8 fg	4.5 fgh
Torque	0.6 fl.oz.	cur.[x]	4.5 hi	4.0 g	4.3 j	4.0 h	2.8 j
Tekken	3.0 fl.oz.	21-d	5.3 f-i	8.0 ab	7.0 b-e	7.0 cde	7.0 bc
Xzemplar	0.21 fl.oz.	21-d	6.3 c-f	7.8 ab	6.8 c-f	7.0 cde	7.0 bc
Tekken	3.0 fl.oz.	28-d	5.3 f-i	5.8 ef	5.5 hi	6.3 ef	3.8 hi
Xzemplar	0.26 fl.oz.	28-d	6.5 b-e	8.0 ab	7.0 b-e	7.3 cd	5.3 ef
Exteris Stressgard	4.0 fl.oz.	14-d	9.0 a	7.8 ab	8.5 a	8.3 ab	8.5 a
Exteris Stressgard	5.0 fl.oz.	21-d	6.5 b-e	8.0 ab	8.5 a	9.0 a	7.3 bc
Posterity	0.16 fl.oz.	21-d	7.5 b	8.0 ab	7.5 bc	7.3 cd	7.3 bc
Velista	0.5 oz.	21-d	4.8 ghi	7.3 bcd	6.3 e-h	7.0 cde	4.5 fgh
Emerald	0.18 oz.	21-d	4.5 hi	5.8 ef	5.8 ghi	7.3 cd	6.5 cd
Traction	1.3 fl.oz.	14-d	7.3 bc	8.5 a	7.5 bc	7.0 cde	7.8 ab
Traction	1.3 fl.oz.	21-d	5.3 f-i	8.0 ab	7.3 bcd	7.5 bc	6.0 de
Pinpoint	0.28 fl.oz.	14-d	6.8 bcd	6.5 cde	5.5 hi	6.8 cde	5.3 ef
Tourney	0.28 oz.	14-d	6.5 b-e	7.5 abc	6.5 d-g	7.3 cd	6.0 de
Pinpoint +Tourney	0.28 fl.oz. 0.28 oz.	14-d	7.5 b	8.0 ab	7.0 b-e	7.0 cde	7.0 bc
Xzemplar	0.26 fl.oz.	14-d	7.3 bc	8.3 ab	7.0 b-e	7.5 bc	7.5 b
Civitas One	8.5 fl.oz.	21-d	5.0 ghi	2.5 h	2.5 k	2.3 i	1.3 k
Torque	0.6 fl.oz.	21-d	4.5 hi	6.3 def	6.5 d-g	6.8 cde	4.0 hi
Banner Maxx II	1.0 fl.oz.	21-d	4.3 i	6.0 ef	6.0 f-i	6.5 def	4.5 fgh
Tartan	1.0 fl.oz.	21-d	5.5 e-h	7.3 bcd	6.5 d-g	7.0 cde	4.3 ghi
Maxtima	0.4 fl.oz.	21-d	6.8 bcd	8.5 a	7.5 bc	7.5 bc	7.3 bc
Untreated Control			4.5 hi	2.0 h	2.3 k	1.8 i	1.8 k
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	9	4	2	1	12
		21-d	2	4	2	9	12
		28-d	23	16	2	16	12

[z]Treatments were initiated on 17 May, unless otherwise noted, and were reapplied at specified intervals for the duration of the trial.
[y]Treatments were initiated on 17 May and reapplied on 6 and 27 June for a total of 3 applications.
[x]Treatments were applied curatively on 15 June and 8 August, after the onset of disease.
[w]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. Normalized difference vegetative index influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

			NDVI					
Treatment[z]	Rate per 1000ft^2	Int	25 May	8 Jun	21 Jun	5 Jul	19 Jul	2 Aug
			------ Vegetation Index ------					
Maxtima	0.4 fl.oz.	21-d[y]	0.661 ef[w]	0.669 a-f	0.677	0.696 a-e	0.707 a-e	0.759 a
Xzemplar	0.26 fl.oz.	21-d[y]	0.680 ab	0.660 def	0.664	0.686 c-g	0.707 a-e	0.755 ab
Torque	0.6 fl.oz.	21-d[y]	0.667 b-f	0.671 a-d	0.681	0.691 b-f	0.704 c-f	0.745 ab
Navicon	0.85 fl.oz.	21-d[y]	0.669 b-f	0.676 abc	0.688	0.705 a	0.716 abc	0.759 a
Maxtima	0.4 fl.oz.	cur.[x]	0.672 a-f	0.656 ef	0.671	0.697 a-d	0.705 b-f	0.753 ab
Xzemplar	0.26 fl.oz.	cur.[x]	0.677 abc	0.664 c-f	0.655	0.675 g	0.704 c-f	0.744 ab
Torque	0.6 fl.oz.	cur.[x]	0.665 c-f	0.659 def	0.667	0.688 b-g	0.694 efg	0.721 c
Tekken	3.0 fl.oz.	21-d	0.677 a-d	0.668 a-f	0.669	0.687 b-g	0.699 d-g	0.756 a
Xzemplar	0.21 fl.oz.	21-d	0.670 a-f	0.666 b-f	0.674	0.687 b-g	0.703 c-f	0.754 ab
Tekken	3.0 fl.oz.	28-d	0.668 b-f	0.678 abc	0.679	0.685 d-g	0.702 c-g	0.749 ab
Xzemplar	0.26 fl.oz.	28-d	0.666 b-f	0.665 b-f	0.668	0.698 abc	0.702 c-g	0.758 a
Exteris Stressgard	4.0 fl.oz.	14-d	0.681 ab	0.678 abc	0.689	0.705 a	0.719 ab	0.758 a
Exteris Stressgard	5.0 fl.oz.	21-d	0.668 b-f	0.682 a	0.685	0.698 a-d	0.721 a	0.750 ab
Posterity	0.16 fl.oz.	21-d	0.668 b-f	0.671 a-e	0.511	0.690 b-f	0.711 a-d	0.752 ab
Velista	0.5 oz.	21-d	0.667 b-f	0.655 f	0.683	0.694 a-e	0.703 c-f	0.750 ab
Emerald	0.18 oz.	21-d	0.661 def	0.670 a-e	0.676	0.691 b-f	0.707 a-e	0.748 ab
Traction	1.3 fl.oz.	14-d	0.666 b-f	0.679 abc	0.674	0.693 a-f	0.708 a-e	0.752 ab
Traction	1.3 fl.oz.	21-d	0.677 a-d	0.669 a-f	0.679	0.689 b-f	0.701 c-g	0.756 a
Pinpoint	0.28 fl.oz.	14-d	0.658 f	0.667 a-f	0.679	0.687 b-g	0.703 c-f	0.745 ab
Tourney	0.28 oz.	14-d	0.659 f	0.668 a-f	0.672	0.683 efg	0.698 d-g	0.748 ab
Pinpoint +Tourney	0.28 fl.oz. 0.28 oz.	14-d	0.671 a-f	0.667 a-f	0.673	0.695 a-e	0.707 a-e	0.756 a
Xzemplar	0.26 fl.oz.	14-d	0.676 a-e	0.663 c-f	0.661	0.685 d-g	0.709 a-d	0.761 a
Civitas One	8.5 fl.oz.	21-d	0.662 c-f	0.657 def	0.663	0.660 g	0.676 hi	0.695 d
Torque	0.6 fl.oz.	21-d	0.663 c-f	0.657 def	0.675	0.680 fg	0.687 gh	0.745 ab
Banner Maxx II	1.0 fl.oz.	21-d	0.671 a-f	0.672 a-d	0.685	0.694 a-f	0.690 fgh	0.735 bc
Tartan	1.0 fl.oz.	21-d	0.664 c-f	0.663 c-f	0.666	0.699 ab	0.701 c-g	0.743 ab
Maxtima	0.4 fl.oz.	21-d	0.684 a	0.680 ab	0.692	0.699 abc	0.706 a-e	0.755 ab
Untreated Control			0.660 f	0.660 def	0.667	0.653 h	0.671 i	0.691 d
ANOVA: Treatment (P > F)			0.0478	0.0083	0.3993	0.0001	0.0001	0.0001
Days after treatment		14-d	8	9	6	8	8	7
		21-d	8	2	15	8	1	15
		28-d	8	23	6	20	8	22

[z]Treatments were initiated on 17 May, unless otherwise noted, and were reapplied at specified intervals for the duration of the trial.
[y]Treatments were initiated on 17 May and reapplied on 6 and 27 June for a total of 3 applications.
[x]Treatments were applied curatively on 15 June and 8 August, after the onset of disease.
[w]Means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05)

PREVENTIVE DOLLAR SPOT CONTROL WITH VARIOUS NEW AND EXPERIMENTAL FUNGICIDES APPLIED AT VARIOUS RATES AND INTERVALS ON A CREEPING BENTGRASS FAIRWAY TURF, 2018

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INTRODUCTION

Dollar spot is a common disease of cool-season turfgrasses caused by the fungal pathogen *Sclerotinia homoeocarpa*. On golf course fairways it is characterized by light, straw-colored spots that may coalesce into larger irregularly shaped areas. It is particularly active during periods of warm daytime temperatures (80°F), warm nighttime temperatures (60°F), and high humidity. It can be managed in part with cultural practices such as maintaining moderate nitrogen fertility and reducing leaf wetness period. However, the use of fungicides is often still necessary on high priority areas such as greens, tees and fairways. The objective of this study was to evaluate the efficacy of new and experimental fungicides in controlling dollar spot on a creeping bentgrass fairway turf.

MATERIALS & METHODS

A field study was conducted on a 'Nintey-six Two' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage dollar spot development. A total of 0.4 lb N 1000-ft^{-2} was applied as water soluble sources from May through August. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new, experimental, and exisiting fungicide formulations, applied individually, as tank mixes, and/or in rotational programs. Initial applications for most treatments were made on 17 May prior to disease developing in the trial area. Subsequent applications were made at specified intervals through 9 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E or AI9508E flat fan nozzle calibrated to deliver 1.0 gal or 2.0 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual dollar spot infection centers within each plot from 1 June to 9 August. Brown patch was assessed visually as a percentage of the plot area blighted by *Rhizoctonia solani*. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Dollar spot data were log-transformed, and means were detransformed for presentation.

RESULTS AND DISCUSSION

Dollar Spot Incidence

Dollar spot developed from a natural infestation on 1 June and increased rapidly through the month with 109 dollar spot infection centers (DSIC) in untreated control plots forming by 22 June (Table 1a + 1b). Disease pressure remained high through the beginning of July with untreated plots showing over 200 DSIC plot^{-1} on 5 July. Drier weather conditions contributed to a reduction in severity through the remainder of July, with control plots averaging 147 DSIC on 13 July and 90 DSIC on 26 July, before increasing again through the beginning of August with 188 DSIC plot^{-1} on untreated plots on 9 August.

All treatments provided good (<10 DSIC plot^{-1}) dollar spot control through 22 June. On 5 July (the peak of the epidemic on untreated plots), plots treated individually with Posterity, Secure (14-d), Secure Action (14-d), UC18-2, and UC18-3 showed excellent control of dollar spot, averaging less than 3 DSIC plot^{-1}. In addition, plots treated with a tank mix UC18-2 + UC18-4 showed virtually no disease (<1 DSIC plot^{-1}) at all rates and intervals as of this date.

Secure Action, a new fungicide consisting of fluazinam + acibenzolar-S-methyl, and Secure (fluazinam alone) both effectively controlled dollar spot when applied on a 14-d basis for the duration of the trial. When applied on a 21-d basis, however, plots treated with Secure often displayed unacceptable (>25 DSIC plot^{-1}) levels of disease, especially during the early July and early August peaks of the epidemic, averaging over 60 DSIC plot^{-1} as of 6 July. Conversely, Secure Action performed well on a 21-d basis, providing good (<10 DSIC plot^{-1}) control for the entirety of the trial until August 9th, although control was still acceptable as of this date. The addition of acibenzolar-S-methyl in Secure Action may activate key plant defense mechanisms, allowing for extended reapplication intervals when compared to Secure.

Posterity, a new SDHI fungicide, was applied individually on a 21-d interval, as well as as part of a rotation with Daconil Action and Secure Action. When applied individually it provided excellent control of disease for the duration of the trial, with plots averaging less than 1 DSIC. The roational progams (which included an application of Primo Maxx at every application) also provided good control of disease, with plots generally averaging less than 11 DSIC plot^{-1}, and often displayed virtually no disease.

Plots treated with UC18-2 and UC18-4, either individually or as a tank mix, continued to display excellent control of disease for the duration of the trial at all rates and intervals.

Brown Patch Severity

Brown patch developed throughout the trial during mid-July, affording an opportunity to assess treatments for efficacy on the disease. The disease was most severe on 3 August, with untreated plots displaying over 61% blighted turf (Table 2). Plots treated with Secure or Secure Action (including rotational programs) as well as plots treated with UC18-3 showed excellent control of disease, averaging less than 3% blighted turf. When applied alone, plots treated with Posterity or UC18-2 did not adequately control brown patch regardless of rate or interval, and all Posterity and UC18-2 treatments were statistically indistinguishable from untreated control plots as of 3 August. When tank-mixed with UC18-4, UC18-2-treated plots performed much better, averaging less than 10% blighted turf on 3 August.

Turf Quality and NDVI

There was no phytoxicity observed at any point during the trial, so Turf Quality (Table 3) was primarily influenced by disease incidence. As of 5 July, all treatments had acceptable quality except for Secure applied on a 21-d interval, which was exhibiting high levels of dollar spot at that time. As of 26 July, quality remained acceptable in plots that were generally free of disease, while plots treated with Posterity or UC18-2 were generally unacceptable due to severe brown patch. Quality was particularly high on plots treated with Secure or Secure Action (including rotational programs), as well as plots treatd with UC18-3 as of this date.

NDVI was generally a function of disease incidence, with untreated control plots consistently showing the lowest readings.

Table 1a. Dollar spot incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Int	Dollar Spot Incidence 1 Jun	8 Jun	18 Jun	22 Jun	5 Jul
			---------------- # of dollar spot infection centers 18 ft^{-2} ----------------				
Primo Maxx	0.2 fl.oz.	14-d	0.0[x] c[w]	0.0 d	0.0 g	0.0 e	0.4 e
-Posterity	0.1 fl.oz.						
-Daconil Action	2.0 fl.oz.						
-Secure Action	0.5 fl.oz.						
Primo Maxx	0.2 fl.oz.	21-d	0.0 c	0.0 d	0.0 g	0.2 e	11.0 c
-Posterity	0.16 fl.oz.						
-Daconil Action	2.0 fl.oz.						
-Secure Action	0.5 fl.oz.						
Primo Maxx	0.2 fl.oz.	14-d	0.0 c	0.4 d	0.0 g	0.0 e	0.0 e
-Posterity	0.1 fl.oz.						
-Daconil Action	2.0 fl.oz.						
-Secure Action	0.5 fl.oz.						
Posterity	0.16 fl.oz.[y]	21-d	0.0 c	0.3 d	0.0 g	0.0 e	0.2 e
Secure Action	0.5 fl.oz.	14-d	0.0 c	0.0 d	0.0 g	0.0 e	0.3 e
Secure Action	0.5 fl.oz.	21-d	0.1 c	2.8 c	0.4 efg	0.0 e	15.2 c
Secure	0.5 fl.oz.	14-d	0.0 c	0.0 d	3.2 cd	1.0 cd	2.7 d
Secure	0.5 fl.oz.	21-d	2.0 b	16.2 b	1.1 ef	1.6 c	63.6 b
UC18-2	0.104 fl.oz.	14-d	0.0 c	0.0 d	8.1 b	4.6 b	0.9 e
UC18-2	0.104 fl.oz.	14-d	0.0 c	0.0 d	0.0 g	0.0 e	0.0 e
+UC18-4	0.5 fl.oz.						
UC18-2	0.0785 fl.oz.	14-d	0.0 c	0.0 d	0.0 g	0.0 e	0.6 e
+UC18-4	0.24 fl.oz.						
UC18-2	0.118 fl.oz.	21-d	0.0 c	0.6 d	0.4 efg	0.3 de	0.3 e
UC18-2	0.118 fl.oz.	21-d	0.0 c	0.2 d	0.0 g	0.0 e	0.4 e
+UC18-4	0.5 fl.oz.						
UC18-2	0.157 fl.oz.	21-d	0.0 c	0.2 d	0.2 fg	0.0 e	0.3 e
UC18-2	0.157 fl.oz.	21-d	0.0 c	0.2 d	0.2 fg	0.0 e	0.0 e
+UC18-4	0.5 fl.oz.						
UC18-2	0.118 fl.oz.	21-d	0.0 c	0.0 d	0.2 fg	0.0 e	0.3 e
+UC18-4	0.359 fl.oz.						
UC18-3	0.21 fl.oz.	21-d	0.0 c	0.0 d	0.2 fg	0.0 e	0.0 e
UC18-2	0.157 fl.oz.	28-d	0.0 c	0.2 d	5.2 bc	1.3 c	0.4 e
UC18-2	0.157 fl.oz.	28-d	0.0 c	0.0 d	0.2 fg	0.0 e	0.0 e
+UC18-4	0.5 fl.oz.						
UC18-2	0.209 fl.oz.	28-d	0.0 c	0.3 d	0.7 efg	0.2 e	0.3 e
UC18-2	0.209 fl.oz.	28-d	0.0 c	0.4 d	0.0 g	0.4 de	0.2 e
+UC18-4	0.5 fl.oz.						
UC18-3	0.21 fl.oz.	28-d	0.0 c	0.0 d	1.3 de	1.0 cd	2.8 d
UC18-3	0.26 fl.oz.	28-d	0.0 c	0.2 d	1.1 ef	0.2 e	0.4 e
Untreated			13.9 a	44.5 a	112.2 a	109.5 a	202.8 a
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	1	9	3	7	6
		21-d	16	1	11	15	6
		28-d	16	25	3	7	20

[z]Treatments were initiated on 17 May prior to disease developing in the trial area. Subsequent 14-d applications were made on 30 May, 15 and 29 June, 12 and 26 July, and 8 August. 21-d applications were made 7 and 29 June, 18 July, and 8 August. 28-d applications were made 15 June, 12 July, and 9 August. All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft-2 at 40 psi, unless otherwise noted.

[y]Treatment applied with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

[x]Dollar Spot data was log transformed. Means are detransformed for presentation.

[w]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 1b. Dollar spot incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft²	Int	Dollar Spot Incidence 13 Jul	26 Jul	3 Aug	9 Aug
			-------- # of dollar spot infection centers 18 ft^{-2} ---------			
Primo Maxx	0.2 fl.oz.	14-d	0.7[x] e[w]	0.0 b	0.0 c	0.0 d
-Posterity	0.1 fl.oz.					
-Daconil Action	2.0 fl.oz.					
-Secure Action	0.5 fl.oz.					
Primo Maxx	0.2 fl.oz.	21-d	3.7 cd	0.0 b	0.3 c	0.2 d
-Posterity	0.16 fl.oz.					
-Daconil Action	2.0 fl.oz.					
-Secure Action	0.5 fl.oz.					
Primo Maxx	0.2 fl.oz.	14-d	0.2 e	0.0 b	0.8 c	0.2 d
-Posterity	0.1 fl.oz.					
-Daconil Action	2.0 fl.oz.					
-Secure Action	0.5 fl.oz.					
Posterity	0.16 fl.oz.[y]	21-d	0.3 e	0.0 b	0.0 c	0.2 d
Secure Action	0.5 fl.oz.	14-d	0.4 e	0.0 b	0.0 c	0.0 d
Secure Action	0.5 fl.oz.	21-d	6.0 c	0.0 b	6.8 bc	24.5 b
Secure	0.5 fl.oz.	14-d	2.6 d	0.0 b	0.0 c	1.1 d
Secure	0.5 fl.oz.	21-d	56.3 b	2.5 b	14.5 b	38.3 b
UC18-2	0.104 fl.oz.	14-d	0.3 e	0.0 b	0.0 c	0.0 d
UC18-2	0.104 fl.oz.	14-d	0.0 e	0.0 b	0.0 c	0.0 d
+UC18-4	0.5 fl.oz.					
UC18-2	0.0785 fl.oz.	14-d	0.0 e	0.0 b	0.0 c	0.0 d
+UC18-4	0.24 fl.oz.					
UC18-2	0.118 fl.oz.	21-d	0.0 e	0.0 b	0.0 c	0.2 d
UC18-2	0.118 fl.oz.	21-d	0.2 e	0.0 b	0.0 c	0.4 d
+UC18-4	0.5 fl.oz.					
UC18-2	0.157 fl.oz.	21-d	0.0 e	0.0 b	0.0 c	0.0 d
UC18-2	0.157 fl.oz.	21-d	0.0 e	0.0 b	0.0 c	0.2 d
+UC18-4	0.5 fl.oz.					
UC18-2	0.118 fl.oz.	21-d	0.6 e	0.0 b	0.0 c	0.0 d
+UC18-4	0.359 fl.oz.					
UC18-3	0.21 fl.oz.	21-d	0.2 e	0.0 b	0.3 c	0.8 d
UC18-2	0.157 fl.oz.	28-d	0.3 e	0.0 b	0.0 c	1.2 d
UC18-2	0.157 fl.oz.	28-d	0.0 e	0.0 b	0.0 c	0.9 d
+UC18-4	0.5 fl.oz.					
UC18-2	0.209 fl.oz.	28-d	0.2 e	0.0 b	0.0 c	0.0 d
UC18-2	0.209 fl.oz.	28-d	0.0 e	0.0 b	0.0 c	1.1 d
+UC18-4	0.5 fl.oz.					
UC18-3	0.21 fl.oz.	28-d	0.6 e	0.0 b	3.8 bc	21.7 b
UC18-3	0.26 fl.oz.	28-d	0.2 e	0.0 b	0.8 c	5.3 c
Untreated			147.4 a	89.8 a	134.5 a	188.5 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	1	15	8	1
		21-d	14	8	16	1
		28-d	1	15	23	1

[z]Treatments were initiated on 17 May prior to disease developing in the trial area. Subsequent 14-d applications were made on 30 May, 15 and 29 June, 12 and 26 July, and 8 August. 21-d applications were made 7 and 29 June, 18 July, and 8 August. 28-d applications were made 15 June, 12 July, and 9 August. All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft-2 at 40 psi, unless otherwise noted.

[y]Treatment applied with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

[x]Dollar Spot data was log transformed. Means are detransformed for presentation.

[w]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. Brown patch severity influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Int	Brown Patch Severity 13 Jul	26 Jul	3 Aug
			----------- % plot area blighted		----------
Primo Maxx	0.2 fl.oz.	14-d	0.0 e[x]	0.0 d	0.0 e
-Posterity	0.1 fl.oz.				
-Daconil Action	2.0 fl.oz.				
-Secure Action	0.5 fl.oz.				
Primo Maxx	0.2 fl.oz.	21-d	0.0 e	0.0 d	0.0 e
-Posterity	0.16 fl.oz.				
-Daconil Action	2.0 fl.oz.				
-Secure Action	0.5 fl.oz.				
Primo Maxx	0.2 fl.oz.	14-d	0.0 e	0.0 d	0.0 e
-Posterity	0.1 fl.oz.				
-Daconil Action	2.0 fl.oz.				
-Secure Action	0.5 fl.oz.				
Posterity	0.16 fl.oz.[y]	21-d	2.0 b-e	15.8 ab	47.1 a
Secure Action	0.5 fl.oz.	14-d	0.0 e	0.0 d	0.0 e
Secure Action	0.5 fl.oz.	21-d	0.0 e	0.0 d	5.8 cde
Secure	0.5 fl.oz.	14-d	0.3 e	0.0 d	0.5 de
Secure	0.5 fl.oz.	21-d	0.6 de	0.0 d	6.4 cde
UC18-2	0.104 fl.oz.	14-d	5.6 ab	36.1 a	67.8 a
UC18-2	0.104 fl.oz.	14-d	0.0 e	0.4 cd	0.4 de
+UC18-4	0.5 fl.oz.				
UC18-2	0.0785 fl.oz.	14-d	0.6 de	1.7 c	9.1 cd
+UC18-4	0.24 fl.oz.				
UC18-2	0.118 fl.oz.	21-d	6.6 ab	27.2 a	66.1 a
UC18-2	0.118 fl.oz.	21-d	0.2 e	0.0 d	8.8 cd
+UC18-4	0.5 fl.oz.				
UC18-2	0.157 fl.oz.	21-d	5.2 abc	27.1 a	59.7 a
UC18-2	0.157 fl.oz.	21-d	0.0 e	0.0 d	2.7 de
+UC18-4	0.5 fl.oz.				
UC18-2	0.118 fl.oz.	21-d	0.0 e	0.0 d	16.0 bc
+UC18-4	0.359 fl.oz.				
UC18-3	0.21 fl.oz.	21-d	0.6 de	0.0 d	0.0 e
UC18-2	0.157 fl.oz.	28-d	0.6 de	7.6 b	38.1 ab
UC18-2	0.157 fl.oz.	28-d	1.8 b-e	0.0 d	8.8 cd
+UC18-4	0.5 fl.oz.				
UC18-2	0.209 fl.oz.	28-d	3.2 a-d	21.1 a	67.8 a
UC18-2	0.209 fl.oz.	28-d	0.4 de	0.0 d	6.0 cde
+UC18-4	0.5 fl.oz.				
UC18-3	0.21 fl.oz.	28-d	0.2 e	0.0 d	2.2 de
UC18-3	0.26 fl.oz.	28-d	1.1 cde	0.4 cd	2.8 cde
Untreated			9.7 a	26.8 a	61.5 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001
Days after treatment		14-d	1	15	8
		21-d	14	8	16
		28-d	1	15	23

[z]Treatments were initiated on 17 May prior to disease developing in the trial area. Subsequent 14-d applications were made on 30 May, 15 and 29 June, 12 and 26 July, and 8 August. 21-d applications were made 7 and 29 June, 18 July, and 8 August. 28-d applications were made 15 June, 12 July, and 9 August. All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft-2 at 40 psi, unless otherwise noted.

[y]Treatment applied with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

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

Table 3. Turf Quality influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per $1000ft^2$	Int	Turf Quality 5 Jul	13 Jul	26 Jul
			--------- 1-9; 6=min acceptable ---------		
Primo Maxx	0.2 fl.oz.	14-d	7.5 b[x]	7.5 abc	8.0 a
-Posterity	0.1 fl.oz.				
-Daconil Action	2.0 fl.oz.				
-Secure Action	0.5 fl.oz.				
Primo Maxx	0.2 fl.oz.	21-d	6.5 c	6.5 de	8.0 a
-Posterity	0.16 fl.oz.				
-Daconil Action	2.0 fl.oz.				
-Secure Action	0.5 fl.oz.				
Primo Maxx	0.2 fl.oz.	14-d	8.5 a	7.5 abc	8.0 a
-Posterity	0.1 fl.oz.				
-Daconil Action	2.0 fl.oz.				
-Secure Action	0.5 fl.oz.				
Posterity	0.16 fl.oz.[y]	21-d	8.3 ab	7.5 abc	5.0 de
Secure Action	0.5 fl.oz.	14-d	8.3 ab	7.3 bcd	7.8 ab
Secure Action	0.5 fl.oz.	21-d	6.3 c	6.3 e	7.3 ab
Secure	0.5 fl.oz.	14-d	7.8 ab	6.5 de	7.3 ab
Secure	0.5 fl.oz.	21-d	3.5 d	5.0 f	7.0 abc
UC18-2	0.104 fl.oz.	14-d	7.5 b	7.0 cde	4.5 e
UC18-2	0.104 fl.oz.	14-d	8.3 ab	7.5 abc	7.8 ab
+UC18-4	0.5 fl.oz.				
UC18-2	0.0785 fl.oz.	14-d	8.0 ab	8.0 ab	6.8 bc
+UC18-4	0.24 fl.oz.				
UC18-2	0.118 fl.oz.	21-d	7.5 b	7.3 bcd	4.0 e
UC18-2	0.118 fl.oz.	21-d	8.3 ab	8.0 ab	7.0 abc
+UC18-4	0.5 fl.oz.				
UC18-2	0.157 fl.oz.	21-d	7.8 ab	7.3 bcd	4.8 e
UC18-2	0.157 fl.oz.	21-d	8.3 ab	7.5 abc	6.8 bc
+UC18-4	0.5 fl.oz.				
UC18-2	0.118 fl.oz.	21-d	8.3 ab	7.8 abc	6.8 bc
+UC18-4	0.359 fl.oz.				
UC18-3	0.21 fl.oz.	21-d	7.8 ab	7.5 abc	7.5 ab
UC18-2	0.157 fl.oz.	28-d	8.0 ab	7.0 cde	6.0 cd
UC18-2	0.157 fl.oz.	28-d	7.8 ab	7.5 abc	7.3 ab
+UC18-4	0.5 fl.oz.				
UC18-2	0.209 fl.oz.	28-d	7.8 ab	7.3 bcd	4.5 e
UC18-2	0.209 fl.oz.	28-d	8.3 ab	8.3 a	7.3 ab
+UC18-4	0.5 fl.oz.				
UC18-3	0.21 fl.oz.	28-d	7.5 b	7.0 cde	8.0 a
UC18-3	0.26 fl.oz.	28-d	7.8 ab	7.8 abc	7.5 ab
Untreated			2.0 e	2.3 g	1.5 f
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0001
Days after treatment		14-d	6	1	15
		21-d	6	14	8
		28-d	20	1	15

[z]Treatments were initiated on 17 May prior to disease developing in the trial area. Subsequent 14-d applications were made on 30 May, 15 and 29 June, 12 and 26 July, and 8 August. 21-d applications were made 7 and 29 June, 18 July, and 8 August. 28-d applications were made 15 June, 12 July, and 9 August. All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft-2 at 40 psi, unless otherwise noted.

[y]Treatment applied with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

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

Table 4. NDVI influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Int	25 May	8 Jun	21 Jun	5 Jul	19 Jul	2 Aug
			NDVI					
			---------- Vegetation Index ----------					
Primo Maxx	0.2 fl.oz.	14-d	0.672	0.669 cd[x]	0.673 b-e	0.702 abc	0.720 a-d	0.774 ab
-Posterity	0.1 fl.oz.							
-Daconil Action	2.0 fl.oz.							
-Secure Action	0.5 fl.oz.							
Primo Maxx	0.2 fl.oz.	21-d	0.666	0.685 a	0.680 ab	0.702 abc	0.729 ab	0.777 a
-Posterity	0.16 fl.oz.							
-Daconil Action	2.0 fl.oz.							
-Secure Action	0.5 fl.oz.							
Primo Maxx	0.2 fl.oz.	14-d	0.665	0.670 cd	0.691 a	0.712 a	0.730 a	0.772 ab
-Posterity	0.1 fl.oz.							
-Daconil Action	2.0 fl.oz.							
-Secure Action	0.5 fl.oz.							
Posterity	0.16 fl.oz.[y]	21-d	0.678	0.667 d	0.661 fg	0.690 cde	0.702 gh	0.746 efg
Secure Action	0.5 fl.oz.	14-d	0.678	0.684 ab	0.671 b-f	0.704 ab	0.718 a-f	0.772 ab
Secure Action	0.5 fl.oz.	21-d	0.673	0.677 a-d	0.675 b-e	0.688 de	0.712 c-g	0.771 abc
Secure	0.5 fl.oz.	14-d	0.678	0.674 bcd	0.668 c-g	0.693 b-e	0.708 c-g	0.757 b-f
Secure	0.5 fl.oz.	21-d	0.675	0.684 ab	0.678 bcd	0.692 b-e	0.714 c-g	0.762 a-e
UC18-2	0.104 fl.oz.	14-d	0.673	0.667 d	0.665 efg	0.689 cde	0.702 gh	0.743 fgh
UC18-2	0.104 fl.oz.	14-d	0.679	0.680 abc	0.672 b-f	0.700 a-d	0.720 a-e	0.769 abc
+UC18-4	0.5 fl.oz.							
UC18-2	0.0785 fl.oz.	14-d	0.677	0.679 abc	0.676 b-e	0.704 ab	0.714 c-g	0.764 a-f
+UC18-4	0.24 fl.oz.							
UC18-2	0.118 fl.oz.	21-d	0.667	0.667 d	0.666 d-g	0.696 b-e	0.706 fg	0.736 gh
UC18-2	0.118 fl.oz.	21-d	0.679	0.679 abc	0.676 b-e	0.696 b-e	0.720 abc	0.768 abc
+UC18-4	0.5 fl.oz.							
UC18-2	0.157 fl.oz.	21-d	0.680	0.670 cd	0.665 efg	0.690 cde	0.708 d-g	0.755 c-f
UC18-2	0.157 fl.oz.	21-d	0.679	0.675 a-d	0.673 b-e	0.690 b-e	0.716 b-f	0.766 abc
+UC18-4	0.5 fl.oz.							
UC18-2	0.118 fl.oz.	21-d	0.677	0.675 a-d	0.676 b-e	0.690 b-e	0.714 c-g	0.763 a-e
+UC18-4	0.359 fl.oz.							
UC18-3	0.21 fl.oz.	21-d	0.675	0.675 a-d	0.675 b-e	0.687 de	0.713 c-g	0.765 a-d
UC18-2	0.157 fl.oz.	28-d	0.675	0.671 cd	0.660 fg	0.698 bcd	0.705 fg	0.747 d-g
UC18-2	0.157 fl.oz.	28-d	0.673	0.680 abc	0.679 abc	0.691 b-e	0.710 c-g	0.769 abc
+UC18-4	0.5 fl.oz.							
UC18-2	0.209 fl.oz.	28-d	0.674	0.674 a-d	0.674 b-e	0.686 de	0.708 d-g	0.740 fgh
UC18-2	0.209 fl.oz.	28-d	0.670	0.680 abc	0.672 b-f	0.694 b-e	0.719 a-e	0.777 a
+UC18-4	0.5 fl.oz.							
UC18-3	0.21 fl.oz.	28-d	0.682	0.676 a-d	0.669 b-f	0.693 b-e	0.707 a-e	0.763 a-e
UC18-3	0.26 fl.oz.	28-d	0.668	0.671 cd	0.666 d-g	0.683 e	0.712 c-g	0.768 abc
Untreated			0.669	0.670 cd	0.656 g	0.660 f	0.693 h	0.726 h
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	8	9	6	6	7	7
		21-d	8	1	14	6	20	15
		28-d	8	25	6	20	7	22

[z]Treatments were initiated on 17 May prior to disease developing in the trial area. Subsequent 14-d applications were made on 30 May, 15 and 29 June, 12 and 26 July, and 8 August. 21-d applications were made 7 and 29 June, 18 July, and 8 August. 28-d applications were made 15 June, 12 July, and 9 August. All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft-2 at 40 psi, unless otherwise noted.

[y]Treatment applied with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

[x]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)

ASSESSING THE PHYTOSAFETY OF VARIOUS DMI FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2018

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INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. An integrated disease control program including cultural management and fungicides is required to minimize turf loss due to this disease. Rotational fungicide programs utilizing different chemical modes of action and multi-site fungicides have been found to be most effective in providing season-long anthracnose control. The DMI class of fungicides can be efficacious in controlling the disease, however repeated applications of these fungicides can lead to growth regulation and turf discoloration. In addition, the use of plant growth regulators may compound the phytotoxic effect. The objective of this study was to examine the efficacy of various tebuconazole-based DMI fungicides applied with and without a plant growth regulator on anthracnose control, and to assess the phytosafety of these materials on annual bluegrass putting green turf.

MATERIALS & METHODS

A field study was conducted on an annual bluegrass (*Poa annua*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Minimal nitrogen was applied to the study area to encourage anthracnose development. A total of 1.2 lb N 1000-ft^{-2} was applied as water soluble sources from March through 19 August. Overhead irrigation and hand-watering was applied as needed to prevent drought stress. Conserve SC (1.2 fl. oz.) was applied on 18 May for control of annual bluegrass weevil. Wetting agent Duplex (1.8 fl.oz.) was applied on 12 Jun.

Treatments consisted of various tebuconazole-based fungicides applied both with and without Primo Maxx (trinexapac-ethyl), a plant growth regulator. Initial applications were made on 24 May prior to disease developing in the trial area. Subsequent applications were made every 14-d through 18 July. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose was determined visually as the percent area blighted by *C. cereale* from 8 June to 27 July. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best possible quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. Dark Green Color Index (DGCI) was assessed using digital image analysis conducted in the Turf Analyzer software (Green Research Services LLC, Arkansas, USA) using default threshold settings. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test.

RESULTS AND DISCUSSION

Anthracnose Severity

Anthracnose symptoms first appeared on 8 June and increased from 3% to 12% plot area blighted in untreated control plots as of 29 June (Table 1). Anthracnose symptoms increased further during July, with UTC plots reaching 65% plot area blighted as of 27 July.

All treated plots, with the exception of plots receiving Primo Maxx alone, provided excellent control of anthracnose for the duration of the trial. Primo Maxx plots were statistically no different from untreated control plots.

Turf Quality, DGCI, and Phytotoxicity

Turf quality (Table 2) on treated plots was primarily influenced by phytotoxicity (Table 3) stemming from the repeated application of a DMI fungicide. Phytotoxicity was particularly severe on plots treated with Torque + Primo Maxx, which had unacceptable (>2) levels of phytotoxicity on the 24 June, 13 July, and 26 July rating dates, leading to poor turf quality ratings. Plots treated with Torque alone also exhibited moderate phytotoxicty on these dates and throughout the trial, however it was not as severe as on plots tank-mixed with Primo.

Plots treated with Mirage (both with and without Primo) generally had acceptable levels of phytotoxicity and turf quality, and quality ratings in these plots was consistently numerically the highest out of any of the treatments. Although phytotoxicity in these plots was somewhat higher when Primo was tank-mixed with the treatment, it was never unacceptable. DGCI ratings (Table 4) in these plots were also consistently among the highest in the trial, likely due to the inclusion of Stressgard, a green pigment, in Mirage's formulation.

Plots treated with Tebuconazole 3.6F also exhibited phytotoxicity, although unlike the above treatments, the addition of Primo to this treatment did not consistently make the phytotoxicity worse.

Untreated plots and plots treated with Primo Maxx alone generally had the poorest turf quality and DGCI ratings, likely due to the presence of anthracnose. There was no phytotoxicity observed in plots treated with Primo Maxx alone.

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Table 1. Anthracnose incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Anthracnose Incidence					
		8 Jun	15 Jun	24 Jun	29 Jun	13 Jul	27 Jul
		% plot area blighted					
Primo Maxx	0.125 fl.oz.	3.7[y] a[x]	6.3 a	13.8 a	10.6 a	38.8 a	59.2 a
Mirage Stressgard	1.08 fl.oz.	0.0 c	0.0 c	0.0 b	0.0 b	0.0 c	0.3 bc
Mirage Stressgard - Primo Maxx	1.08 fl.oz. 0.125 fl.oz.	0.6 c	0.7 bc	0.0 b	0.0 b	0.0 c	0.3 bc
Torque	0.6 fl.oz.	0.0 c	0.3 c	0.0 b	0.0 b	0.0 c	0.2 bc
Torque +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	0.3 c	0.0 c	0.0 b	0.0 b	0.0 c	0.0 c
Tebuconazole 3.6 F	0.6 fl.oz.	1.7 b	1.0 bc	0.0 b	0.0 b	0.6 b	0.2 bc
Tebuconazole 3.6 F +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	0.2 c	0.6 c	0.0 b	0.0 b	0.0 c	0.9 b
Untreated		3.7 a	3.9 ab	11.4 a	12.0 a	43.8 a	65.2 a
ANOVA: Treatment ($P > F$)		0.0001	0.0089	0.0001	0.0001	0.0001	0.0001
Days after treatment		3	10	5	10	10	9

[z] Treatments were initiated on 24 May prior to disease developing in the trial area and were repeated every 14-d thereafter. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

[y] Anthracnose data were automatically log-transformed. Means are de-transformed for presentation.

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

Table 2. Turf Quality influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment	Rate per 1000ft^2	Turf Quality							
		8 Jun	17 Jun	24 Jun	29 Jun	3 Jul	13 Jul	26 Jul	3 Aug
		1-9; 6=minimum acceptable							
Primo Maxx	0.125 fl.oz.	5.8 b[y]	6.3 ab	5.0 cd	4.5 c	3.8 c	3.0 e	2.5 c	3.0 b
Mirage Stressgard	1.08 fl.oz.	7.5 a	7.0 a	6.5 ab	6.5 a	5.8 ab	6.8 a	6.3 a	5.5 a
Mirage Stressgard - Primo Maxx	1.08 fl.oz. 0.125 fl.oz.	6.8 a	6.5 a	6.8 a	6.8 a	6.0 a	6.5 ab	6.3 a	5.8 a
Torque	0.6 fl.oz.	5.8 b	6.3 ab	5.8 abc	5.8 ab	5.0 ab	5.8 bc	6.0 ab	5.3 a
Torque +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	5.8 b	5.0 c	4.3 d	5.0 bc	4.8 bc	4.8 d	5.0 b	5.5 a
Tebuconazole 3.6 F	0.6 fl.oz.	5.8 b	5.3 bc	5.3 cd	5.3 bc	5.0 ab	5.5 cd	5.8 ab	5.0 a
Tebuconazole 3.6 F +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	5.8 b	6.0 abc	5.5 bc	5.8 ab	5.8 ab	5.5 cd	5.5 ab	5.3 a
Untreated		5.8 b	6.0 abc	4.8 cd	4.5 c	3.8 c	2.8 e	3.0 c	3.0 b
ANOVA: Treatment ($P > F$)		0.0026	0.0354	0.0005	0.0007	0.0014	0.0001	0.0001	0.0013
Days after treatment		3	12	5	10	14	10	8	15

[z] Treatments were initiated on 24 May prior to disease developing in the trial area and were repeated every 14-d thereafter. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

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

Table 3. Phytotoxicity influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

		Phytotoxicity					
Treatment[z]	Rate per 1000ft^2	17 Jun	24 Jun	29 Jun	13 Jul	26 Jul	3 Aug
		------------------------------ 0-5; 2=max acceptable ----------------------------					
Primo Maxx	0.125 fl.oz.	0.0	0.0 c[y]	0.0 d	0.0 d	0.0 e	0.0 c
Mirage Stressgard	1.08 fl.oz.	0.0	0.5 c	0.5 c	1.3 c	1.0 d	1.0 b
Mirage Stressgard - Primo Maxx	1.08 fl.oz. 0.125 fl.oz.	0.0	0.5 c	0.8 bc	1.8 bc	1.8 bc	1.8 a
Torque	0.6 fl.oz.	0.0	1.5 b	1.0 b	1.5 bc	1.3 cd	1.0 b
Torque +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	0.0	3.8 a	1.5 a	3.0 a	2.8 a	2.0 a
Tebuconazole 3.6 F	0.6 fl.oz.	0.0	2.3 b	0.8 bc	2.0 b	1.3 cd	1.3 b
Tebuconazole 3.6 F +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	0.0	2.0 b	1.0 b	1.8 bc	2.0 b	1.3 b
Untreated		0.0	0.0 c	0.0 d	0.0 d	0.0 e	0.0 c
ANOVA: Treatment (P > F)		1.0000	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		12	5	10	10	8	15

[z] Treatments were initiated on 24 May prior to disease developing in the trial area and were repeated every 14-d thereafter. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

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

Table 4. Dark Green Color Index influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

		DGCI					
Treatment[z]	Rate per 1000ft^2	8 Jun	18 Jun	29 Jun	13 Jul	27 Jul	10 Aug
		-- Color Index --					
Primo Maxx	0.125 fl.oz.	0.3750 cde[y]	0.3721 d	0.4100 de	0.4266	0.4351 c	0.4545
Mirage Stressgard	1.08 fl.oz.	0.3863 ab	0.3880 ab	0.4249 a-d	0.4333	0.4559 ab	0.4444
Mirage Stressgard - Primo Maxx	1.08 fl.oz. 0.125 fl.oz.	0.3933 a	0.3926 a	0.4349 a	0.4412	0.4640 a	0.4450
Torque	0.6 fl.oz.	0.3714 def	0.3818 bc	0.4194 bcd	0.4312	0.4522 ab	0.4404
Torque +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	0.3795 bcd	0.3871 abc	0.4341 ab	0.4402	0.4556 ab	0.4435
Tebuconazole 3.6 F	0.6 fl.oz.	0.3700 ef	0.3799 c	0.4184 cd	0.4362	0.4474 bc	0.4372
Tebuconazole 3.6 F +Primo Maxx	0.6 fl.oz. 0.125 fl.oz.	0.3811 bc	0.3877 ab	0.4297 abc	0.4409	0.4621 a	0.4426
Untreated		0.3624 f	0.3705 d	0.4018 e	0.4211	0.4183 d	0.4529
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0984	0.0001	0.0676
Days after treatment		3	13	10	10	9	23

[z] Treatments were initiated on 24 May prior to disease developing in the trial area and were repeated every 14-d thereafter. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-^{2} at 40 psi.

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

OVERSEEDING STRATEGIES FOR NON-IRRIGATED, PESTICIDE-FREE ATHLETIC FIELDS, 2018

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INTRODUCTION

Athletic field managers have perceived reduced playing surface quality as a result of severe pesticide restrictions in Connecticut (Bartholomew et al., 2015). Considering these restrictions, there is a need for proven alternative methods that can increase turfgrass cover and reduce weed pressure without the use of pesticides. Aggressive and repetitive overseeding has been recommended as a critically important tool of the municipal turf manager to utilize in lieu of pesticides (Elford et al., 2008; Minner et al., 2008; Stier et al., 2008; Miller and Henderson, 2012; Henderson et al. 2013). However, many questions remain regarding the best turfgrass species, cultivar and seeding rate for overseeding in a non-irrigated situation.

The goal of this research is to develop the most effective overseeding strategies for non-irrigated, pesticide-free athletic fields in New England. The specific objectives are to determine the effects of turfgrass species, cultivar, and overseeding rate on turfgrass cover retention and demonstrate the effectiveness of aggressive overseeding.

MATERIALS AND METHODS

These studies, spanning two years, are currently being conducted on-site at multiple locations across Connecticut. These include Hebron Elementary School, Lebanon Middle School, and Shetucket Park in Windham, CT. The research area at each location was carefully placed in high wear portions of each non-irrigated athletic field.

The study was arranged in a 3 × 2 × 2 factorial in a randomized complete block design with three replications. The first factor, turfgrass species, had three levels: 1) perennial ryegrass (PRG, *Lolium perenne* L.), 2) tall fescue (TF, *Festuca arundinacea* Schreb.), and 3) Kentucky bluegrass (KBG, *Poa pratensis* L.). The second factor, overseeding rate, was either low or high, which is detailed in Table 1. The third factor, cultivar, had two levels: 1) previously tested cultivars that have met the Turfgrass Water Conservation Alliance (TWCA) criteria, and 2) untested cultivars that have not been certified with the TWCA criteria. Individual plots were 1.8 m x 2.7 m.

Two overseeding timings were selected per year (spring and fall) to take advantage of traditionally cooler temperatures and more frequent rainfall. The first overseeding treatments were applied on 20 September 2016, and were repeated on four more occasions; 1 May 2017, 23 August 2017, 9 May 2018, 7 September 2018. Before each overseeding event, initial qualitative assessments were taken of the total percentage green cover and turfgrass cover. Plots were core cultivated with a Toro 648 ProCore walk-behind unit (The Toro Company, Bloomington, MN) in one direction using 1.3 cm hollow-core tines on 5.1 cm spacing to a depth of 6.4 cm. The cores were broken-up and returned within their individual plots with a leaf rake. Seed was applied using handheld shakers in multiple directions. The seed was gently incorporated into the soil with the backside of a leaf rake. The research area was then rolled to ensure good seed to soil contact. Finally, the plot area was fertilized with a starter fertilizer (14-25-12) at the rate of 49 kg P_2O_5 ha^{-1}. Additional nitrogen was applied at a rate of 49 kg N ha^{-1} using a plastic-coated urea (43-0-0); bringing the total nitrogen applied at each overseeding event to 73 kg N ha^{-1}.

Data was collected at 2 and 4 weeks following overseeding events and monthly throughout the growing season. The total percent green cover included turfgrass and weed populations but excluded bare soil. Percent turf cover was measured exclusively for desirable turfgrass while percent weed cover was the difference between percent green and turf cover. Plots were rated for their overall color and quality based on a scale from 1 to 9, where 1 represented the lowest quality, 6 was the minimum acceptable quality, and 9 was the optimum quality. Starting in the spring 2017, Digital image analysis (DIA) was used to quantify dark green color and percent cover (Karcher and Richardson, 2005). The digital images were scanned by Sigma Scan software (Cranes Software International Ltd. Chicago, IL. 1991). Surface hardness was quantified using a Clegg Impact Hammer (2.25 kg). Soil volumetric water content was measured using a portable TDR probe (Spectrum Technologies, Inc. Plainfield, IL, VWC).

An analysis of variance was completed to test for significant treatment effects (P <0.05) using the Mixed procedure in SAS statistical software 9.4 (SAS Institute. Cary, NC. 2004). Least square means were separated based on Fisher's protected least significant difference (LSD) test.

RESULTS AND DISCUSSION

The results demonstrate that species selection was the most important factor determining successful overseeding compared to cultivar and rate. Perennial ryegrass is the most suitable turfgrass species for overseeding non-irrigated, pesticide-free athletic fields in southern New England. Regardless of rates, cultivars, and seasons, overseeding with PRG resulted in 70.3 to 121.7% higher turf cover and less than half the weed cover than TF, KBG and control (Figure 1 and 2). Across all variables, PRG was higher in color and quality than the other treatments and maintained a minimum color rating of 6 (1 to 9 scale) despite a non-irrigated setting (Figure 3 and 4). In addition, PRG was at least four times higher in DSI than the remaining treatments across rates, cultivars, and seasons (Figure 5). The results indicated that cultivars and rates had few meaningful differences compared to species, and therefore less likely to influence successful overseeding practices.

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Table 1. Turfgrass species, cultivars and seeding rates evaluated at the three locations.

Species†	Cultivar		Rate§ Low	High
			-------- kg ha^{-1} --------	
KBG	TWCA‡	Full Moon	146	292
KBG	Non-TWCA	Brooklawn	146	292
PRG	TWCA	Manhattan 5	391	782
PRG	Non-TWCA	Divine	391	782
TF	TWCA	Falcon 4	391	782
TF	Non-TWCA	Aztec	391	782

† PRG, perennial ryegrass; TF, tall fescue; KBG, Kentucky bluegrass;

‡ Turfgrass Water Conservation Alliance.

§ Low rates were based on recommended overseeding rates while the high rate is double the recommended rate.

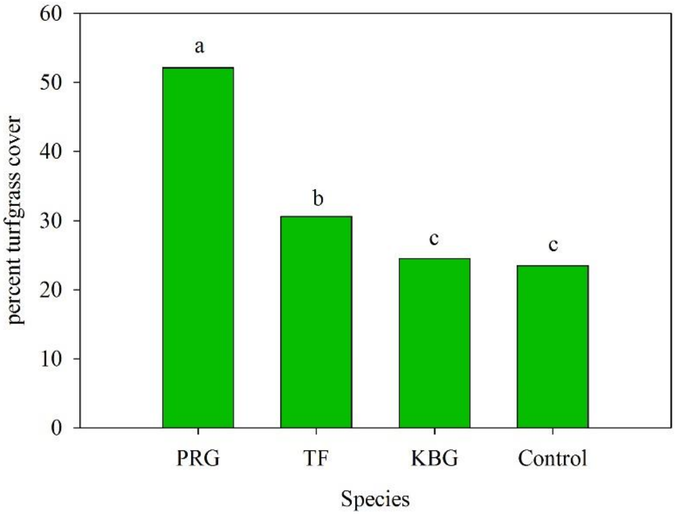

Figure 1. The effect of turfgrass species on qualitative percent turfgrass cover across rates, cultivars, and seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (*P*<0.05).

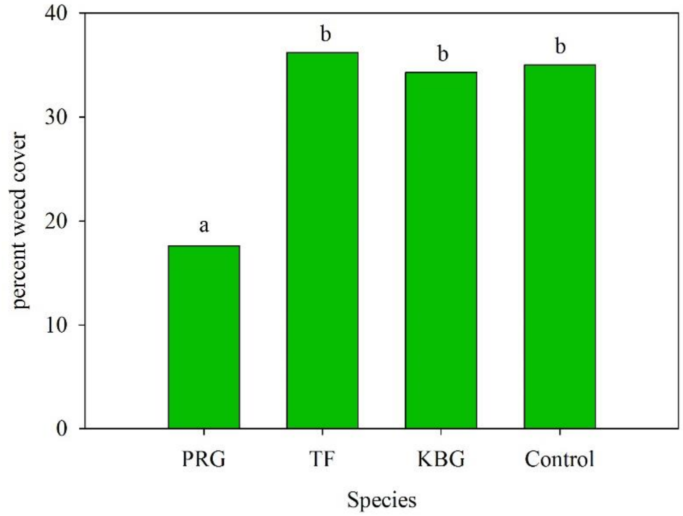

Figure 2. The effect of turfgrass species on qualitative percent weed cover across rates, cultivars, and seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (*P*<0.05).

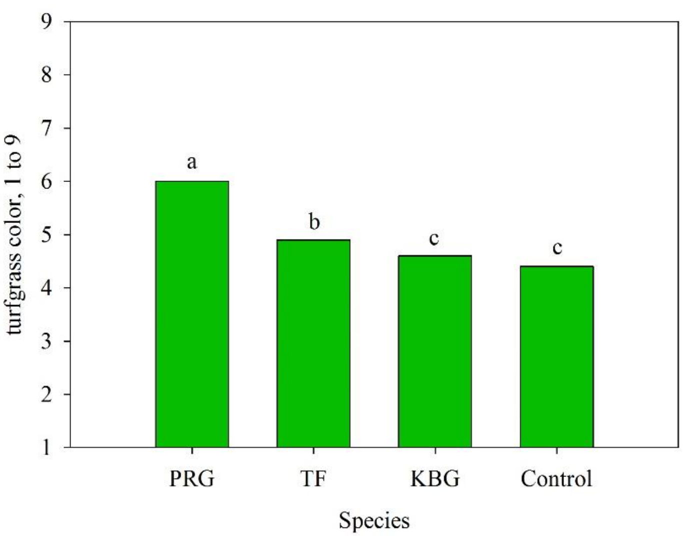

Figure 3. The effects of turfgrass species on qualitative turfgrass color across rates, cultivars, and seasons. Data points with the same letter are not statistically different to Fisher's protected LSD (*P*<0.05).

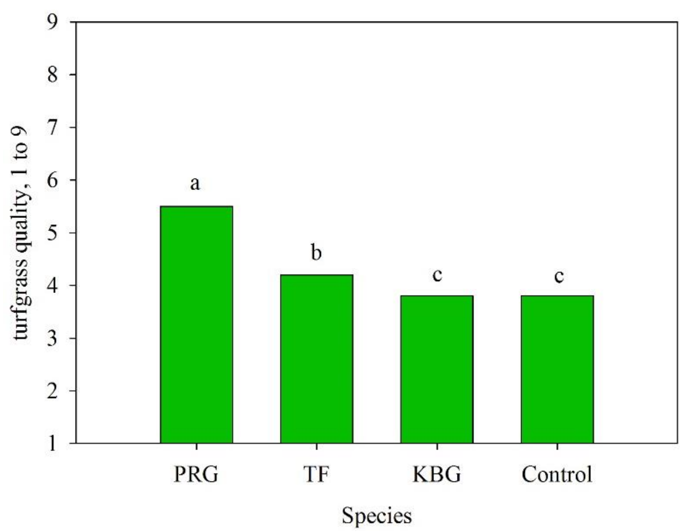

Figure 4. The effects of turfgrass species on qualitative turfgrass quality across rates, cultivars, and seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (*P* <0.05).

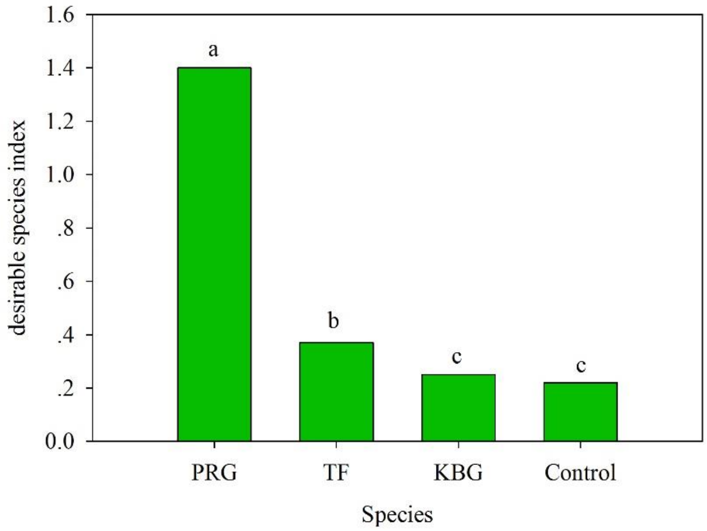

Figure 5. The effects of turfgrass species on desirable species index across rates, cultivars, and seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (P <0.05)

ORGANIC TURF AND NO-PESTICIDE TURF DEMONSTRATION FOR HOME LAWNS AND ATHLETIC FIELDS, 2018

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INTRODUCTION

As of 1 July 2010, the state of Connecticut banned the use of all lawn care pesticides at public and private schools that service pre-K through 8th grades (State of Connecticut, 2009). This legislation has caused great concern for athletic field managers due to the nature of the traffic athletic fields endure and the liability associated with their use. However, very little research based information is available regarding managing athletic fields without the use of pesticides. This demonstration site was established to evaluate various systems of management.

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

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

The objectives were to; 1) reduce nitrogen and phosphorus applications, 2) identify advantages and disadvantages of each management system, and 3) create a hands-on demonstration site and education resource for training industry professionals how to manage turfgrass without pesticides.

MATERIALS AND METHODS

The research area was divided into two separate studies, an athletic field and home lawn, with each measuring 58 m × 30 m. Both studies were arranged as a randomized complete block design with three replications. Individual plots measured 6 m × 9 m.

The athletic field research area was seeded with a mixture of 35% ‘America’ Kentucky bluegrass (*Poa pratensis* L.), 35% ‘Granite’ Kentucky bluegrass, 15% ‘Karma’ perennial ryegrass (*Lolium perenne* L.), and 15% ‘Fiesta 4’ perennial ryegrass (% by weight). The home lawn research area was seeded with a mixture of 30% ‘America’ Kentucky bluegrass, 30% ‘Granite’ Kentucky bluegrass, 10% ‘Karma’ perennial ryegrass, 10% ‘Fiesta 4’ perennial ryegrass, 10% ‘Winward’ Chewings fescue (*Festuca rubra* L. ssp. *commutata*), and 10% ‘Garnet’ creeping red fescue (*Festuca rubra* L.) (% by weight). The eight treatments or “systems” evaluated for each study were: 1) Organic High (OH), 2) Organic Low (OL), 3) Pesticide-free High (PFH), 4) Pesticide-free Low (PFL), 5) Calendar Based (CAL), 6) Integrated Pest Management (IPM), 7) Integrated System Management (ISM), and 8) None (mow only control).

The home lawn plots were mowed once per week at 8.9 cm with a zero-turn rotary mower (Scag Power Equipment, Mayville, WI). The athletic field plots were mowed at 6.6 cm two times per week with a zero-turn rotary mower (Scag Power Equipment, Mayville, WI). Fields were irrigated with a watering reel as needed.

Each management system received applications of fertilizer, insect and weed control appropriate for each treatment. The athletic field received 190 kg N ha^{-1} $year^{-1}$ to the listed treatments; CAL, OH, PFH, IPM, and ISM. Treatments OL and PFL received 98 kg N ha^{-1} $year^{-1}$. The home lawn’s OL and PFL received 49 kg N ha^{-1} $year^{-1}$, while the CAL, OH, PFH, IPM, and ISM received 140 kg N ha^{-1} $year^{-1}$. Fertilizer totals were applied throughout 2016 & repeated in the 2017 growing season.

A Cady Traffic Simulator was used on the athletic field portion of the study to provide simulated athletic field wear to the field (Henderson et al. 2005) (Figure 1). The athletic fields received traffic events 2-3 times per week with a total of 98 events in the past two years. Each traffic event consisted of two perpendicular passes.

Figure 1. The Cady Traffic Simulator was used on the athletic field research area to simulate traffic.

Data collection for the home lawn study included; turfgrass color ratings, turfgrass quality ratings, turfgrass density ratings, percent green cover, volumetric water content (VWC) (Spectrum Technologies, Inc. Plainfield, IL), normalized difference vegetative index (NDVI) (Spectrum Technologies, Inc. Plainfield, IL), and percent weed cover. Surface hardness and rotational traction were also quantified. Turfgrass color, quality, and density were rated based on a scale from 1 to 9, where 1 represented the lowest rating, 6 was the minimum acceptable rating, and 9 was the optimum rating. This qualitative assessment was done once per month.

Digital image analysis was used to quantify color and percent green cover (Karcher and Richardson, 2005). These images were taken in controlled light conditions by using a light box. Three images were taken of each plot. The digital images were scanned by Sigma Scan software (Cranes Software International Ltd. Chicago, IL. 1991). NDVI data was collected by taking the average of 15 readings per plot for data analysis. VMC data was collected by taking the average of 12 readings per plot for data analysis. The DIA, VWC, and NDVI were taken every month starting in May.

Weed counts for each plot were obtained by using a grid with 240 intersections. The sum of intersections with weeds below each intersection was calculated as a percentage based on the 240 total intersections. The frame was counted in six separate locations within each plot to get an accurate number of weeds. Weed counts were conducted five times throughout the year in 2016 and 2017.

Lastly, surface hardness was quantified with a 2.25 kg Clegg Impact Soil Tester (Lafayette Instrument Co., Lafayette, IN) and averaged from 18 locations per plot (ASTM, 2010). Rotational traction was measured monthly using a 47.8 kg Canaway traction apparatus (Canaway and Bell, 1986) and averaged from six locations per plot.

An analysis of variance was completed to test for significant treatment effects (P <0.05) using the Mixed procedure in SAS statistical software 9.4 (SAS Institute. Cary, NC. 2013). Least square means were separated based on Fisher's protected least significant difference (LSD) test.

RESULTS AND DISCUSSION

Despite receiving an average of 50 traffic events per growing season from 2016 to 2018, every treatment maintained a minimally acceptable color rating of (6 of 9) with the exception of MO across seasons (Figure 2). During the spring, only CAL, IPM, ISM and PFH were significantly higher in quality than MO (Figure 3). Additionally, the fall season resulted in significant differences in surface hardness between athletic field treatments (Figure 4). The MO treatment was significantly higher in surface hardness than every treatment with the exception of OL and PFL (Figure 4). This is likely a result of less frequent core aeration on these treatments.

The athletic field IPM and ISM treatments had fewer weeds than OH, OL, PFH, PFL, and MO across seasons (Figure 5). The OH and PFH were similar to the lowest performing treatments in weed cover, however, it is important to note that these treatments were also similar to CAL across seasons (Figure 5). This suggests that reoccurring herbicide applications (i.e. CAL treatments) provided no advantage in weed populations compared to pesticide-free and organic management strategies from July through Nov. The athletic field, however, has an unusually low crabgrass weed pressure which could impact these results.

In the home lawn study, CAL treatments outperformed OH, OL, PFH, PFL and MO across seasons for color, quality, and DSI (Figures 6, 7, and 8). In most circumstances, CAL, IPM and ISM treatments had higher ratings than the remaining treatments for color, quality, and DSI (Figure 6, 7, and 8). The DSI values for CAL, IPM and ISM were typically double or more than the remaining treatments (Figure 8). This suggests that these treatments are more suitable as a management strategy to produce the highest level of desirable turfgrass. The lower scores for OH, OL, PFH, PFL and MO can be attributed to their weed populations (Figure 9). The percent weed cover for every non-pesticide treatment was approximately 30% or more across seasons and therefore reduced turfgrass quality and DSI (Figure 9).

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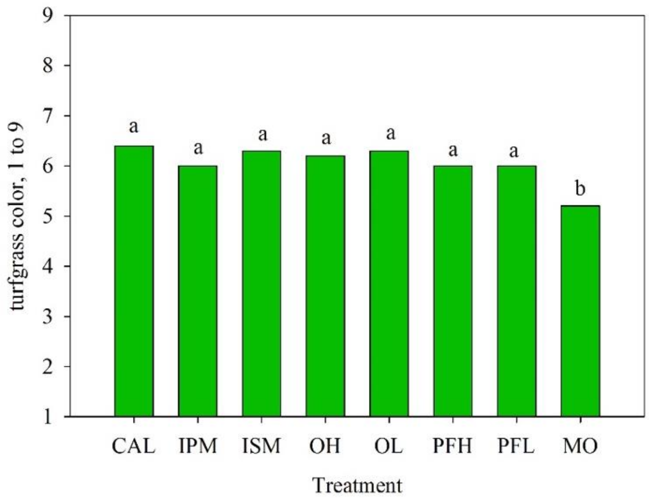

Figure 2. The effect of management strategies on athletic field qualitative turfgrass color when averaged across seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (*P* <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

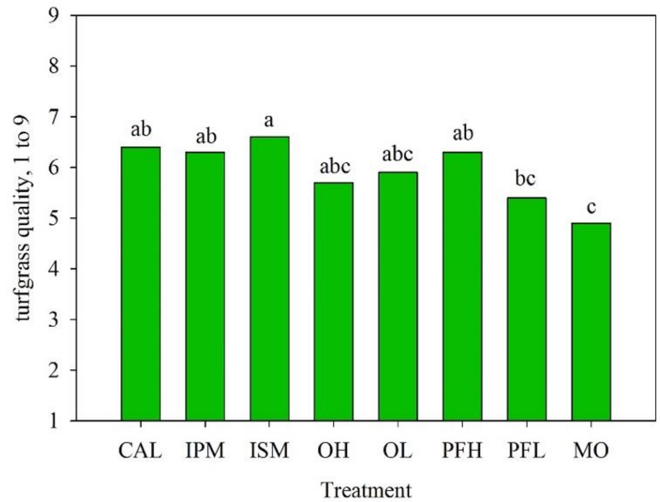

Figure 3. The effect of management strategies on athletic field qualitative turfgrass quality within the months of May and June (spring season only). Data points with the same letter are not statistically different according to Fisher's protected LSD (*P* <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

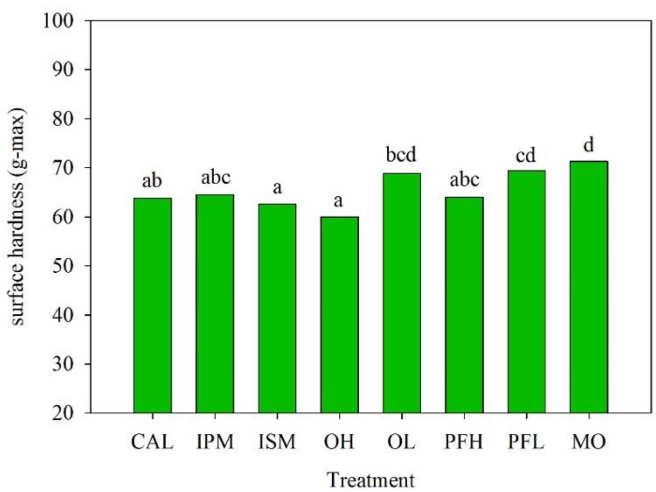

Figure 4. The effect of management strategies on athletic field surface hardness within the months of September, October and November (fall season only). Data points with the same letter are not statistically different according to Fisher's protected LSD (*P* <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

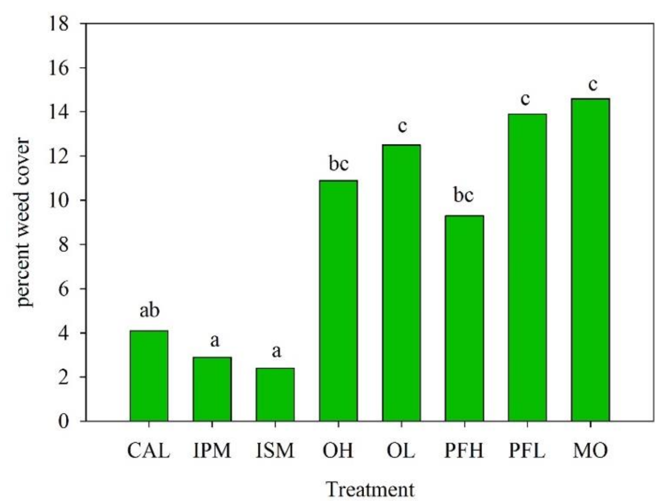

Figure 5. The effect of management strategies on athletic field quantitative percent weed cover across seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (*P* <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

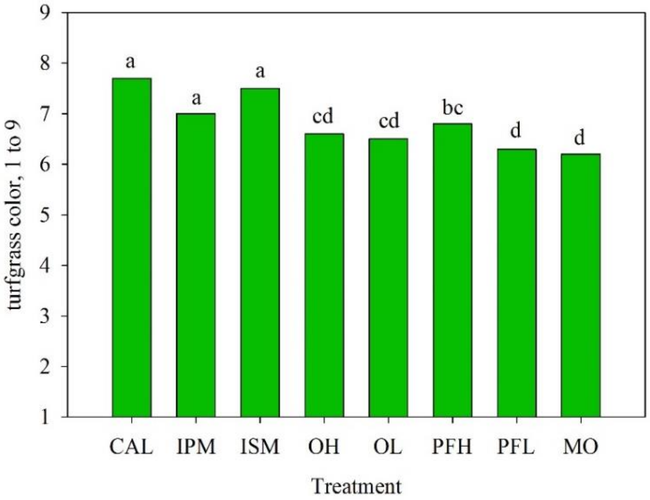

Figure 6. The effect of management strategies on home lawn qualitative turfgrass color across seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (P <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

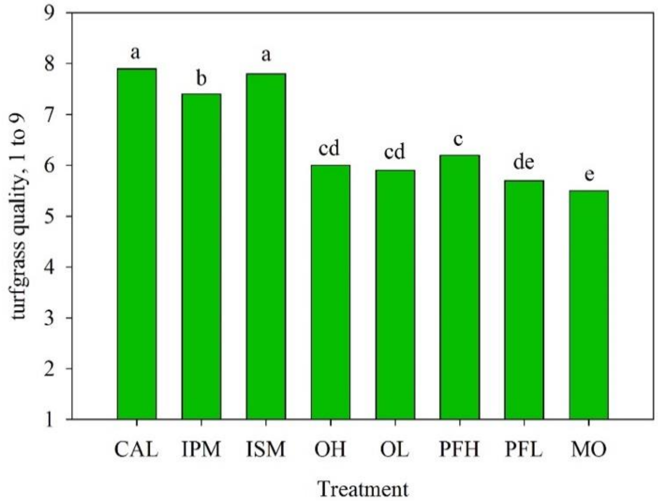

Figure 7. The effect of management strategies on home lawn qualitative turfgrass quality across seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (P <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

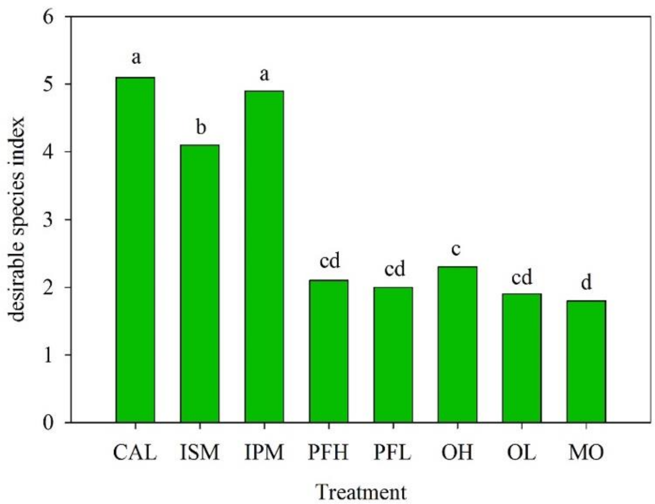

Figure 8. The effect of management strategies on home lawn desirable species index across seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (P <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

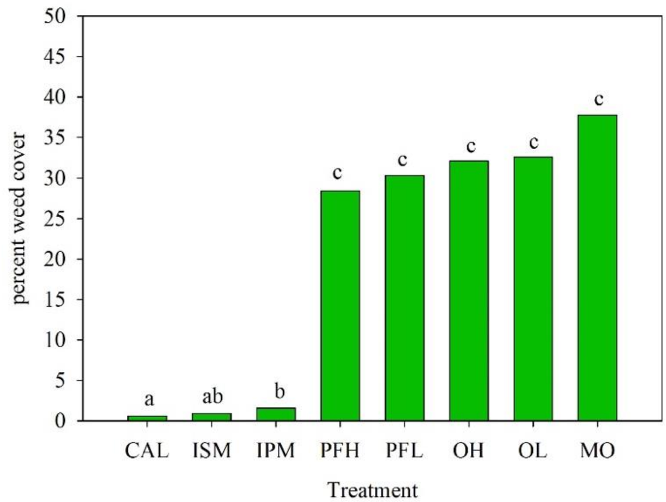

Figure 9. The effect of management strategies on home lawn quantitative percent weed cover across seasons. Data points with the same letter are not statistically different according to Fisher's protected LSD (P <0.05). Integrated Systems Management (ISM), Integrated Pest Management (IPM), Calendar (CAL), Organic High (OH), Organic Low (OL), Pesticide Free High (PFH), Pesticide Free Low (PFL).

OPTIMIZING CREEPING BENTGRASS ESTABLISHMENT AND CONTROLLING ANNUAL BLUEGRASS IN GOLF COURSE FAIRWAY RENOVATIONS, 2018

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INTRODUCTION

Fairways represent the largest area of intensely managed turf on golf courses, with a median acreage of 24.8 acres for 18-hole facilities throughout the United States (Gelernter et al., 2017). Fairways in the Northeast region commonly contain mixtures of older creeping bentgrass (CBG; Agrostis stolonifera L.) cultivars such as ‘Penncross’ and annual bluegrass (ABG; Poa annua L.)(Gelernter et al., 2017). ABG is a common weedy species with prolific seeding and tolerance to low mowing heights. It is undesirable due to its high susceptibility to diseases, and poor heat and drought tolerance. Annual bluegrass requires frequent fungicide applications due to its poor tolerance to many diseases, as well as increased irrigation during drought conditions to prevent wilt and turf loss. Older mixed fairways also have large ABG seedbanks which enables this weedy species to persist. Newer cultivars of CBG are more tolerant to turf diseases such as dollar spot (Clarireedia jacksonii) which can reduce fungicide inputs. Transitioning to newer improved bentgrasses can potentially reduce maintenance costs and pesticide, nutrient and water inputs.

Renovating fairways is challenging, requiring course closure, eradication of the previous turf stand and a significant economic investment. Due to these challenges, golf courses maybe reluctant to convert fairways despite the benefits. Several studies have examined individual components of fairway renovations.

Renovation month has been determined to be an important factor influencing ABG contamination. Traditionally, fairway renovations have been done in mid-September. However, this timing coincides with the peak ABG germination period in the Northeast, and can result in significant contamination of the new stand. ABG performs poorly when subjected to drought and heat stress and does not germinate in temperatures over 80˚F (Sprague, 1930). Conversely, bentgrass has been found to establish more rapidly during June-August compared to September and October (Murphy et al., 2005). Rapid establishment allows for any ABG seed to be crowded out during germination (Murphy et al, 2005).

Soil fumigants have also been studied as means to manage ABG seed bank populations prior to seeding. Dazomet (Basamid) is a non-selective soil sterilant labeled for use on golf courses. Higher rates of dazomet produce better control of ABG (Branham et al., 2004; Park and Landschoot, 2003). However, its use is limited due to cost and considerations regarding its application.

Chemical control of ABG early during establishment of newly seeded fairways is important to maximize benefits of improved turf stands. Bispyribac-sodium (Velocity) is a class B, acetolactate synthase inhibitor belonging to the pyrimidinyl carboxy herbicide family (Shimizu et al., 2002). Applications made at 3 and 5 weeks after seed emergence at 0.02 oz/1000 ft2 are both efficacious for controlling ABG and minimize CBG injury (Branham and Sharp, 2011). Paclobutrazol (Trimmit) is a plant growth regulator which has been commonly used in the turfgrass industry. Paclobutrazol acts as an early-gibberellin biosynthesis inhibitor, which prevents plant cell elongation and causes shortened internodes (Corbett, 1984). Creeping bentgrass metabolizes and degrades paclobutrazol more rapidly then ABG which allows for ABG to be more regulated over multiple applications when compared to CBG (Branham and Beasley, 2007). Ethofumesate (Prograss) inhibits the conversion of fatty acids into alkalines which in turn, inhibits waxy cuticle growth (Corbett et al, 1984). Kaminski and Dernoeden (2004) found that applying ethofumesate to CBG at 2 weeks after seed emergence led to permanent decreased turf quality and cover. However, applying ethofumesate after seedling maturity at 4 or 7 weeks after seed emergence did not lead to long term reduced cover or quality (Kaminski and Dernoeden, 2004). Bensulide (Bensumec) is a preemergent herbicide that has shown benefit in reducing ABG in mature stands of turf. When applied at 2 WASE, bensulide did not reduce CBG cover compared to untreated and quality was also unchanged (Kaminski and Dernoeden, 2004). Bensulide has been found to be generally safe for CBG seedlings when applied after 2 weeks after seed emergence (Hart et al., 2004; Kaminski and Dernoeden, 2004).

Previous research shows that renovation timing, fumigants and post-germination ABG control can improve renovation success. However, no studies have evaluated combined effects of renovation timing, method of eradication, and post renovation herbicidal control of ABG in a comprehensive approach to develop best management practices for golf course fairway renovations. Our objective is to identify eradication methods and herbicides over different renovation timings which optimize CBG establishment and minimize ABG contamination in golf course fairways.

MATERIALS AND METHODS

A 2 year field study was conducted at the Plant Science Research and Education Facility in Storrs, CT. Experimental runs were initiated on 3 Jul 2017 and 2 Jul 2018. The study was conducted on a 30:70 mixed CBG and ABG fairway turf on a Woodbridge, fine sandy loam. The field was initially seeded with ‘Penntrio’ CBG blend at 1 lb 1000 ft-2 in August 2015. Thereafter, aeration cores containing ABG seed harvested from Wethersfield Country Club (Wethersfield, CT) were distributed over the field in September 2015, April 2016 and September 2016. Cores containing ABG seed were verticut into the existing CBG to establish a mixed population turf stand and ABG seedbank. Turf was mowed at 0.5 inch three days wk-1. Nitrogen was applied every 14 days at 0.2 lbs. 1000 ft2 from June to November 2017 and 2018. Light, frequent irrigation was applied during establishment; and as needed to avoid drought stress thereafter. Broadleaf weeds were controlled with Trimec Bentgrass formulation applied at 1.7 fl.oz. 1000 ft2 on 22 September in 2017, and Quicksilver to July renovated strips on 12 July and July and August renovated strips on 16 and 25 August in 2017 and on 8 and 15 August in 2018 at 0.028 fl.oz. 1000 ft2.

Experimental and Treatment Design

The study was conducted as a split-strip plot design arranged as a 2 × 3 × 7 factorial. The main plot factor was eradicant which consisted of glyphosate-only or glyphosate followed by dazomet in 6 × 21 ft. plots with a 5 ft. border. The main factor plots were divided into horizontal and vertical strips. The horizontal factor was renovation month consisting of July, August and September in strips 6 × 42 ft. The vertical factor consisted of six herbicides (Table 1) and a non-herbicidal control assigned to strips measuring 3 × 28 ft.

Glyphosate (Roundup Pro Concentrate) was applied to each renovation month strip, once on 5 July, 4 August or 5 September 2017 and 2 July, 5 August or 3 September 2018. It was applied at 4.8 pts acre-1 using a CO2 pressured boom sprayer fit with AI11005 nozzles calibrated to deliver 1 gal 1000 ft2 at 40 psi. The following day, plots within each corresponding renovation month were core cultivated with 0.5 in. diameter hollow, tines on a 1.5 by 2.0 in. spacing to a 2.0 in. depth. Cultivation occurred 5 days later in Sept 2018 due to excess precipitation. Cores were then pulverized and incorporated with a rotary mower. Immediately afterwards, Dazomet (Basamid) was applied at 260 lb/acre with a drop spreader calibrated to distribute the material over the target area in four passes. Thereafter, dazomet was water incorporated with 1.0 inch of irrigation and subsequently irrigated according to label recommendations.

Herbicides were applied at recommended rates and intervals for newly seeded CBG. Initial application timing was based on the date at which germination had uniformly occurred throughout the plots, generally 5-12 days after seeding. This occurred on 19 July, 21 August and 20 September 2017 and 18 July, 23 August and 30 September, 2018 for each renovation month respectfully. All herbicides except paclobutrazol were applied with a handheld CO2 pressurized sprayer outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000 ft-2 at 40 psi. Paclobutrazol was applied with the same sprayer calibrated to deliver 2.0 gal 1000 ft-2 with an AI9508E nozzle to target the application to the crown and surface roots for optimal uptake. Bensulide was water incorporated with 0.5 inch of irrigation after application.

Seeding and Establishment

Plots were seeded with a blend of '007' and '13M' (1:1, by weight), six days after glyphosate was applied during each renovation. Seed was applied using a slit seeder (Turfco Triwave 45) calibrated to deliver 0.5 lb. 1000 ft-2 in a single pass. Renovation month strips were seeded in two directions resulting in an overall seeding rate of 1.0 lb. 1000 ft-2. An above-ground, irrigation system with low volume heads, on a 9 ft. spacing, was positioned around each renovation month strip to water incorporate dazomet and ensure optimal soil surface moisture for seed germination and establishment. Granular starter fertilizer (16-28-12) was applied at 1 lb P /1000 ft2 to each renovation strip at seeding. Thereafter, N was applied at 0.25 lbs. 1000 ft2 as urea every 14-d through mid-November. Subdue Maxx at 1 floz 1000 ft2 was applied one week after seeding to protect against damping off, (caused by, Pythium spp). Mowing resumed one week after seed emergence at 0.5 inch, three days wk-1.

Data Collection and Statistical Analysis

Creeping bentgrass and annual bluegrass populations were reported as percent plot area containing each species using the line-intercept grid count method (Gaussoin and Branham, 1989). Percent green cover was assessed using digital image analysis. An image of each subplot was taken within a 1.5 × 2.0 ft. aluminum lightbox containing LED bulbs which excluded ambient light and provided for a consistent exposure for all photos. The number of green pixels within each image was determined using Turf Analyzer v.1.0.4 and divided by the total number of pixels in the image. Two photographs were taken from each experimental unit with the average used for statistical analysis. Percent green cover was determined weekly from one week before renovation until mid-November.

All data were subjected to an analysis of variance using the Glimmix procedure in SAS v.9.4 (Statistical Analysis System) and least square means were separated using Fisher's protected least significant difference test (α=0.05).

RESULTS & DISCUSSION

Percent Green Cover

Turf establishment reported as percent green cover varied based on an interaction between preplant eradicant and renovation timing at 3 weeks after seeding (P=0.0003). July and August had 32-50% greater cover compared to September, regardless of eradicant. When compared across eradicants, July and August did not differ. However, renovations in September had 19% greater cover when dazomet was applied compared to glyphosate-only. This suggests establishment rate is greater in July and August compared to September, but that dazomet can enhance establishment rate in September.

Creeping bentgrass population

Spring creeping bentgrass populations from 2017 renovations were dependent on a 3-way interaction between renovation month, pre-plant eradicant and post-plant herbicide (P=0.04). Dazomet generally increased CBG 13-35% compared to glyphosate-only, regardless of renovation month. However, use of the post-plant herbicides, bispyribac-sodium, paclobutrazol, bensulide+paclobutrazol in July, and bispyribac-sodium in August resulted in equivalent amounts of CBG, regardless of the pre-plant eradicant (Figure 1, 2).

Efficacy of post-plant herbicide varied within and across renovation timings. Within glyphosate-only, bispyribac-sodium, paclobutrazol and bensulide+paclobutrazol applied following the July renovation resulted in 89-98% CBG compared to 54% in no herbicide treated turf. All other herbicides did not differ from no herbicide for July renovations. Similar herbicide effects on CBG populations were observed during August renovations. Bispyribac-sodium resulted in the greatest CBG establishment (93%) at the time. Paclobutrazol and bensulide+paclobutrazol were slightly (15-18%) less effective than bispyribac-sodium, and were 19-22% less effective compared to the July timing. September ethofumesate applications at both rates resulted in 18-24% greater CBG compared to July and August timings and 74-80% CBG overall. Bispyribac-sodium was equivilant to ethofumesate percentages (83%). Paclobutrazol in September renovations, only received two applications and was slightly less effective (63-72%) than bispyribac-sodium and ethofumesate (1.47 fl.oz.). It is important to note that despite reducing ABG, bispyribac-sodium and ethofumesate (1.47 fl.oz.) applied during the September renovation resulted in unacceptable sustained bare soil of 3-8% in the glyphosate-only, September renovated plots. This injury was mitigated when dazomet was applied.

Within glyphosate+dazomet, the effect of herbicide within month was similar to glyphosate-only. Dazomet+glyphosate generally resulted in 13-35% greater CBG the following spring except during the July renovation when bispyribac-sodium and paclobutrazol were applied.

SUMMARY

Fairway renovations are large projects which require coordination between golfing and agronomic schedules. Previous research, as well as results of this study demonstrate that July renovation timings generally result in the greatest CBG populations the following spring. However, preliminary data from this study suggest that combination of pre-plant eradication of existing turf and proper post-establishment herbicide selection can improve August and September renovation success. Renovations in July allow for the greatest flexibility for herbicides to maximize CBG populations and plot coverage. July renovations are also the best choice if dazomet cannot be used. Herbicide options include paclobutrazol or bispyribac-sodium for July. August renovations provide similar flexibility to July for post-plant herbicide applications with either bispyribac-sodium or paclobutrazol. August renovations likely benefit from dazomet applications to provide similar CBG populations compared to July. September renovations are limited due to ABG competition and lack of post-establishment herbicides. Applications of dazomet during September renovation increases CBG populations and potentially improve the phytosafety of herbicides applications. Ethofumesate at 1.1 fl.oz. appeared to result in the greatest spring CBG population and turf cover among herbicides evaluated. Results of 2018 study treatments will be evaluated to confirm or refute this preliminary data.

Table 1: Herbicides evaluated for control of annual bluegrass during fairway renovations to establish creeping bentgrass in Storrs, CT during 2017.

Active Ingredient	Formulation	Trade Name	Rate (1000 ft^2)	Interval	Manufacturer
ethofumesate	1.5 EC	Prograss	1.1 floz.	3 + 6 WASE†	Bayer, Hanover, NJ
ethofumesate	1.5 EC	Prograss	1.47 floz.	3 + 6 WASE	Bayer, Hanover, NJ
bispyribac-sodium	17.6 SG	Velocity	0.069 oz.	3 + 5 WASE	Valent, Walnut Creek, CA
bensulide	4 LF	Bensumec	5.5 floz.	2 WASE	PBI Gordon Professional, Kansas City, MO
paclobutrazol	2 SC	Trimmit	0.367 floz.	4 WASE; 14-d	Syngenta, Wilmington, DE
bensulide	4 LF	Bensumec	5.5 floz.	2 WASE	PBI Gordon Professional, Kansas City, MO
+ paclobutrazol	2 SC	+ Trimmit	0.367 floz.	4 WASE; 14-d	Syngenta, Wilmington, DE

†Weeks after seed emergence; WASE.

Table 2: Percent green cover at 3 weeks after seeding due to the interaction of pre-plant eradicant and renovation month for the 2018 study at the Plant Science Research and Education Facility in Storrs, CT. (*P*=0.0003). Means within each renovation month followed by the same lowercase letter are not statistically different. Means within each eradicant type followed by the same uppercase letter are not statistically different.

		% Green Cover 3 Weeks after Seeding		
		July	August	September
Eradicant	Kg a.i. per ha	----------------------Percent Cover	-----------------	
glyphosate	3.39	99.00 a†A‡	98.74 aA	46.94 bB
glyphosate + dazomet	3.39 2.22	99.73 aA	98.69 aA	66.53 aB

†Means followed by the same lowercase letter within each renovation timing are not statistically different based on Fisher's protected LSD (α = 0.05).

‡Means followed by the same uppercase letter within each herbicide treatment are not statistically different based on Fisher's protected LSD (α = 0.05).

Figure 1: Population of creeping bentgrass influenced by pre-plant eradicant, post-plant herbicide and renovation month, sliced by pre-plant eradicant on 19 May 2018 for the 2017 trial at the Plant Science Research and Education Facility in Storrs, CT. (*P*=0.0444). Means followed by the same lowercase letter within each renovation month are not statistically different. Means followed by the same uppercase letter within each post-seeding herbicide are not statistically different.

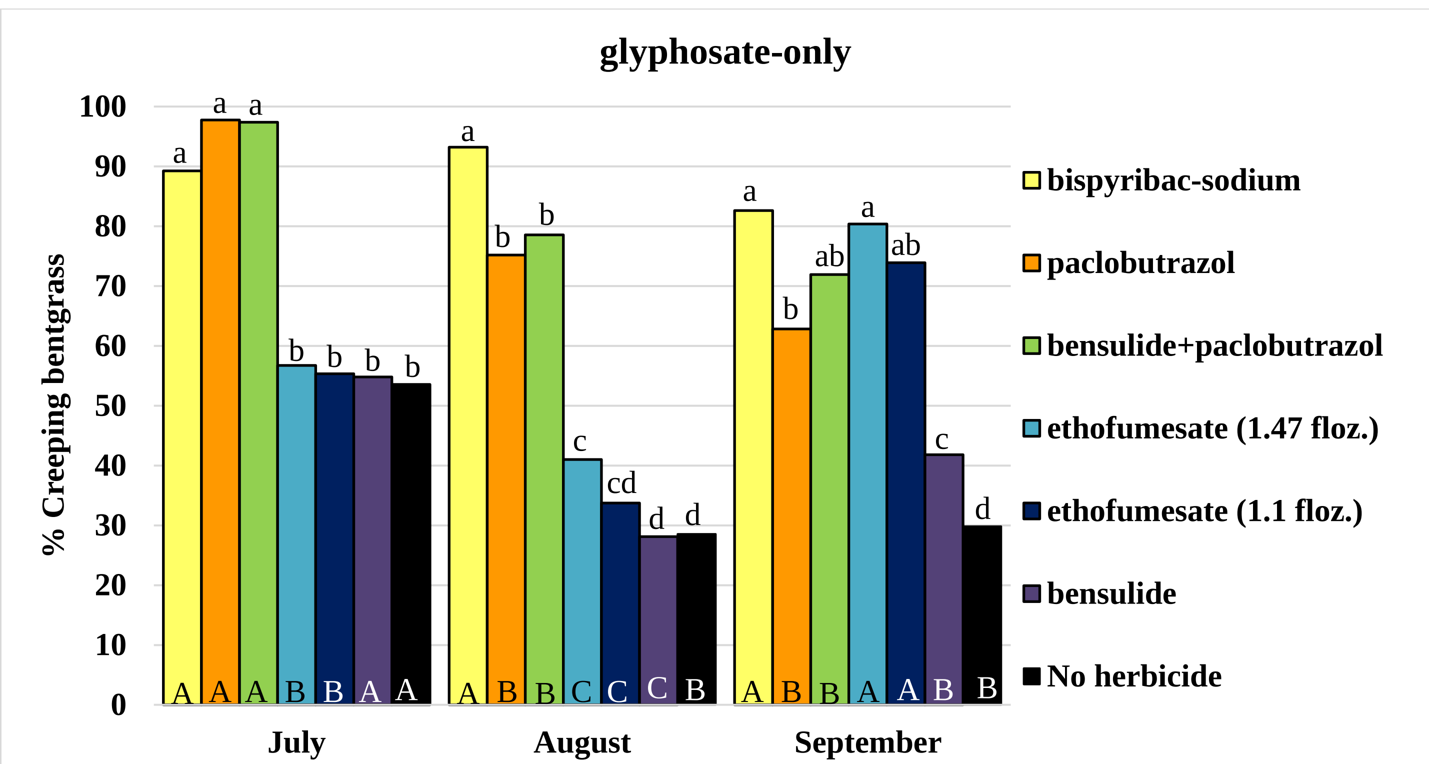
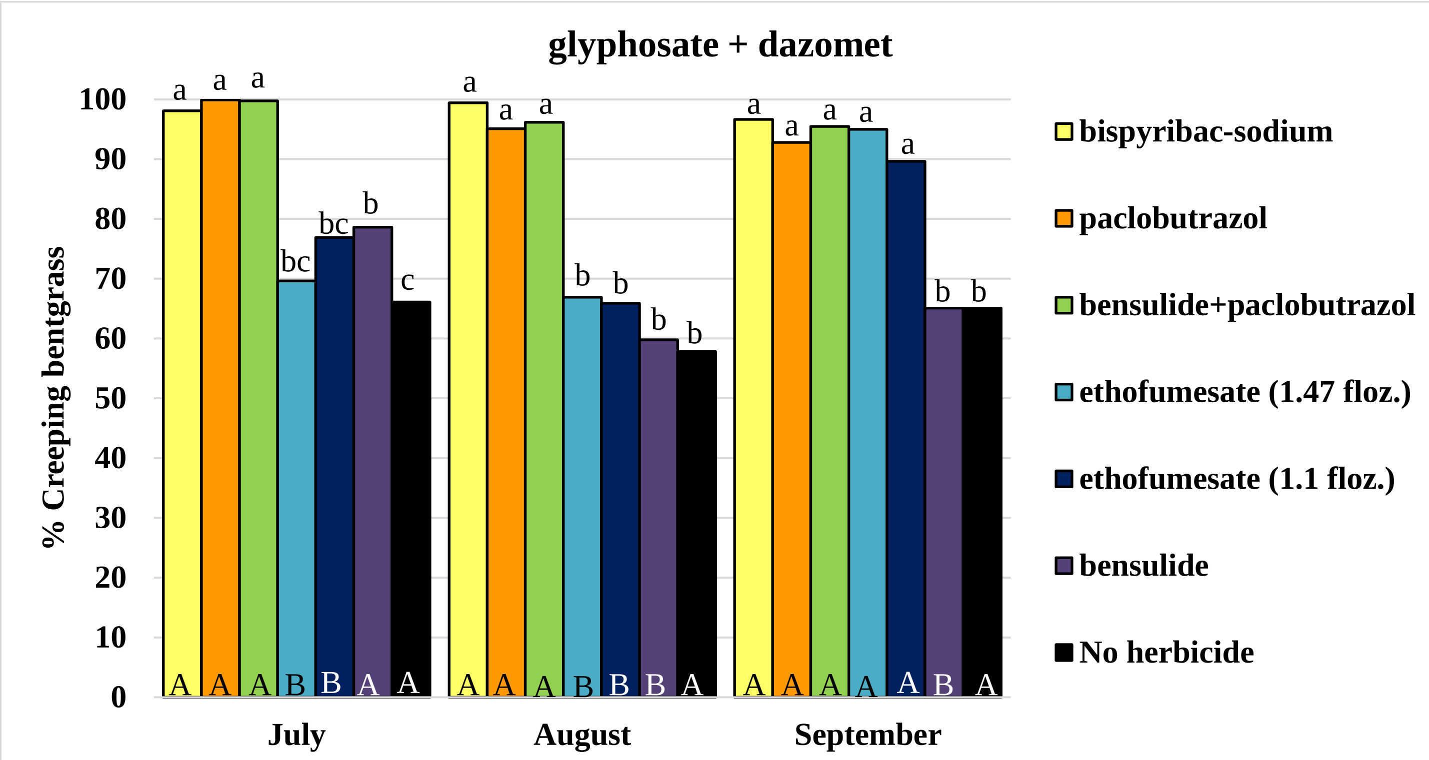


Figure 2: Population of creeping bentgrass influenced by pre-plant eradicant, post-plant herbicide and renovation month, sliced by pre-plant eradicant on 19 May 2018 for the 2017 trial at the Plant Science Research and Education Facility in Storrs, CT. (*P*=0.0444). Means followed by the same lowercase letter within each renovation month are not statistically different. Means followed by the same uppercase letter within each post-seeding herbicide are not statistically different.



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NITROGEN AND PHOSPHORUS LEACHING FROM COMPOST-AMENDED LAWNS FALL 2017 THROUGH FALL 2018

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INTRODUCTION

The use of compost as a substitute for synthetic fertilizers is a growing trend in turfgrass lawn maintenance practices. There is a perception that compost poses less of an environmental threat to water quality than synthetic fertilizers when applied to lawns. However, there are insufficient data to determine the nitrogen (N) and phosphorus (P) leaching potential of compost amendments to lawns and their effects on water quality. Therefore, the objective of this study is to determine if relationships exists between soil tests (labile N and extractable P) and leaching concentrations and losses of N and P from lawn turf receiving varying rates of compost. If relationships are determined, then a secondary objective is to propose environmental critical levels of soil labile N and extractable P for compost-amended lawns to guide compost application rates.

MATERIALS & METHODS

This study is being conducted with zero-tension, soil-monolith lysimeters on a site that was constructed for previous turfgrass leaching studies (Mangiafico and Guillard, 2006; Barry et al., 2009). There are 14 soil-monolith lysimeters installed at the site, and each are connected to separate collection wells. The experiment was initiated in June 2017, and set out as a completely random design with 7 establishment compost rates at 0 (the control), ¼-inch, ½-inch, ¾-inch, 1-inch, 1.5-inch, and 2-inch thick applications (or approximate to 0, 0.75, 1.5, 2.25, 3, 3.75, and 4.5 yd^3 per $1000ft^2$) with two replicates. These rates fall within the NOFA CT guidelines for turf establishment (NOFA CT, 2017). The compost was obtained from the University of Connecticut's Composting Facility with average total N and P_2O_5 concentrations of 0.86 and 0.67%, respectively, and C:N ratio of 9:1. Each plot is 4.6ft by 7.9ft, for a total of $36.3ft^2$, with the lysimeters located near the middle of the plots.

Compost was applied to the bare soil over the plots, then incorporated to a depth of 4 to 6 inches. Following compost incorporation and seedbed preparation, Kentucky bluegrass ('Brooklawn') was seeded into the plots and managed as a home lawn.

Beginning in spring 2018, compost was applied twice yearly (split applications in spring and fall per NOFA CT guidelines up to ¼-inch maximum rate) as a surface treatment at the following rates: 0, 0.02, 0.05, 0.1, 0.2, 0.4, and 0.75 yd^3 per $1000ft^2$. Plots are mowed weekly at a 3-in height of cut with a push mower. Each month before mowing, NDVI of each plot was measured with a Spectrum TCM500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Aurora, IL).

Leachate from the lysimeters was collected and analyzed for concentrations of ammonia (NH_3–N), nitrite + nitrate (NO_2+NO_3)–N, total Kjeldahl N (TKN), ortho-phosphate (PO_4–P), and total Kjeldahl P (TP).

Prior to compost applications in 2018, soil samples were collected from each plot to a depth of 4-inches past the thatch layer. Samples were analyzed for concentrations of extractable modified-Morgan P concentrations using the stannous-chloride method on a discrete analyzer, and soil labile N concentrations were measured by using the Solvita Labile Amino N test (Brinton, 2016).

RESULTS & DISCUSSION

Soil test P concentrations increased with increasing compost additions (Fig. 1). At the three highest application rates, modified-Morgan soil test extractable P approach or exceed the agronomic and environmental critical levels (40 and 80 lbs P_2O_5 per acre, respectively) that have been set for agricultural production fields.

Leachate concentrations of NH_3–N, (NO_2+NO_3)–N, TKN, PO_4–P, and TP are shown in Figs. 2 to 6. Across compost rates, there was no consistent trend of concentrations for NH_3–N, (NO_2+NO_3)–N, TKN, or PO_4–P. Approximately 30% of the NH_3-N concentrations were > 0.5 mg L^{-1}. Concentrations of (NO_2+NO_3)–N at times exceeded the drinking water standard of 10 mg L^{-1}, whereas concentrations of PO_4–P were generally less than 0.05 mg L^{-1}, but several samples were between 0.1 to 0.5 mg L^{-1}. Approximately 70% of the TP concentrations were > 0.1 mg L^{-1}. Concentrations of TP tended to be higher with increasing rates of compost. Percolate concentrations of N and P suggest some concern for water quality associated with a cool-season turfgrass lawn amended with compost.

This study will continue through 2019.

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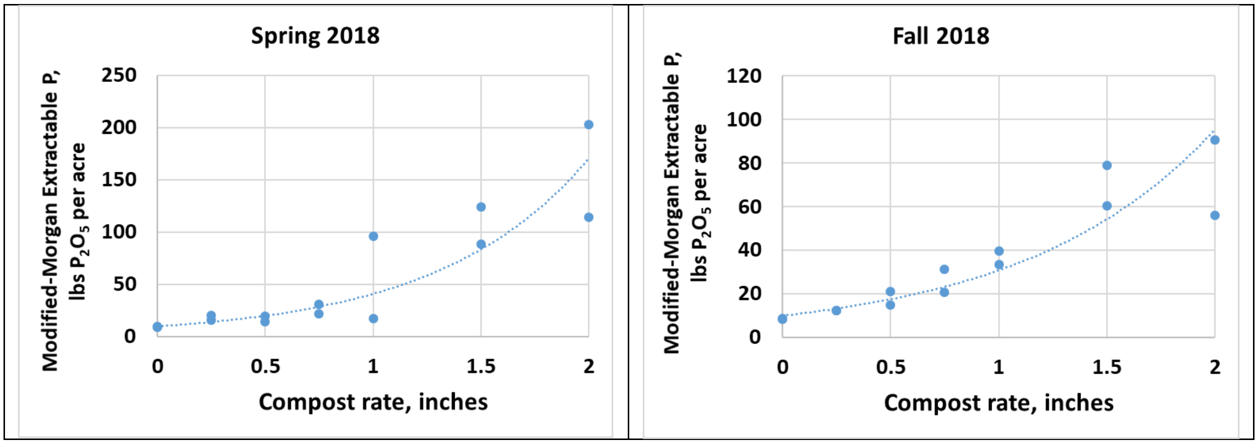

Figure 1. Modified-Morgan extractable soil phosphorus from compost-amended Kentucky bluegrass managed as a lawn in 2018.

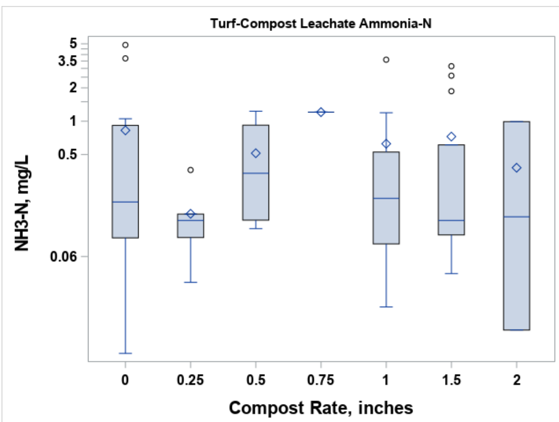

Figure 2. Concentrations of percolate ammonia (NH_3–N), Fall 2017–Fall 2018.

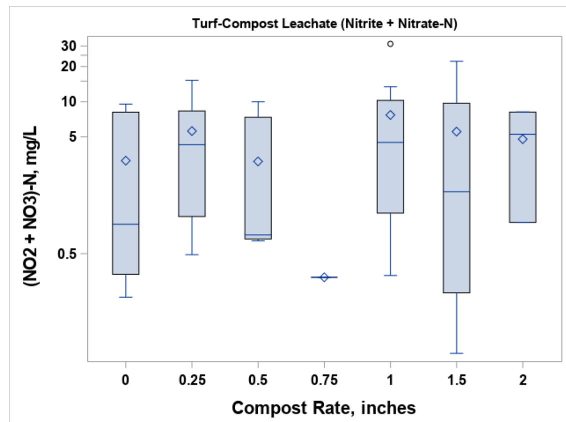

Figure 3. Concentrations of percoate nitrite+nitrate (NO_2+NO_3)–N, Fall 2017–Fall 2018.

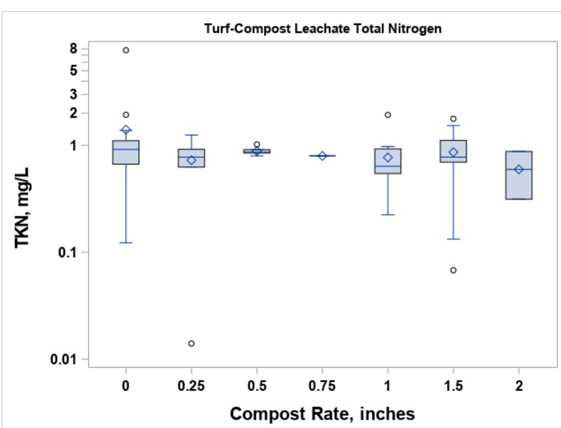

Figure 4. Concentrations of percolate total Kjeldhal nitrogen (TKN), Fall 2017–Fall 2018.

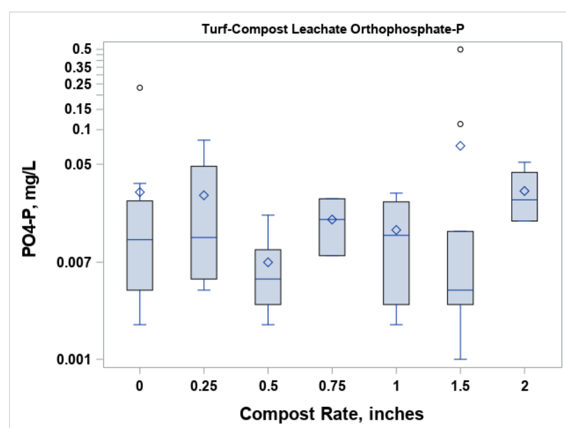

Figure 5. Concentrations of percolate ortho-phosphate (PO_4–P), Fall 2017–Fall 2018.

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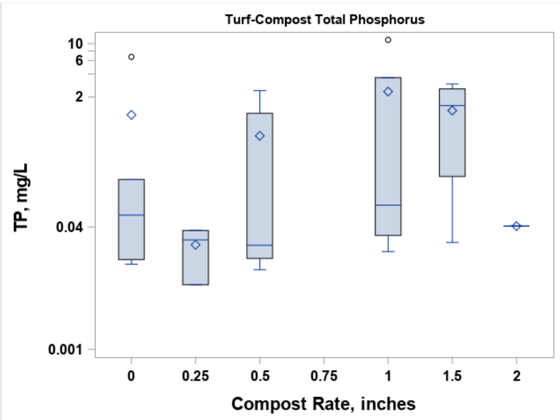

Figure 6. Concentrations of percolate total phosphorus (TP), Fall 2017–Fall 2018.

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SOLVITA® SOIL TEST KITS TO CATEGORIZE GOLF COURSE FAIRWAY RESPONSIVENESS TO NITROGEN FERTILIZATION - 2018

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INTRODUCTION

The ability to predict the N mineralization potential of any turfgrass site and its expected response to N fertilization would be a valuable tool in nutrient management. Turfgrass soils often accumulate organic matter over time, and this increases their mineralization potential. However, assessing this mineralization potential is not routine due to the lack of mineralization tests offered with many labs, cost of the tests, and the long-term requirements (a week to months) of these tests for reliable results. Solvita® & Woods End Laboratories offers two test kits that have been developed to rapidly measure the biologically-active C and N fractions in soil organic matter: the Soil CO_2-Burst (SCB) and Soil Labile Amino Nitrogen (SLAN) test kits. These tests measure labile C and N fractions are correlated to soil microbial activity, and therefore, the Solvita® soil tests should be able to estimate the mineralization potential of turfgrass soils. An estimate of the mineralization potential should help guide N fertilization.

MATERIALS & METHODS

The study site is located in Storrs, CT, and was initiated in August, 2017. The experiment was set out as a split-block design with traffic (with/without) as the horizontal factor and compost (10 rates, in 0.25-lb increments from 0 to 2.25 lbs available N per $1000ft^2$) as the vertical factor with three replicates. Compost was incorporated into the 0 to 4-inch soil profile by rototilling prior to seeding. After compost incorporation, creeping bentgrass (‘13M’) was seeded into the study site and managed as a fairway. During the bentgrass grow-in period during the late fall of 2017, an organic fertilizer (Suståne all natural 5-2-4) was applied to the plots at the same rates as the initial incorporated compost rates. In addition to the organic treatments, a standard fertilizer regime treatment with 0.2 to 0.25 lbs N $1000ft^2$ was applied approximately every 21 days as liquid urea. The fall of 2017 was used as the establishment period. Full implementation of the treatments and data collection commenced in 2018.

Beginning in the spring 2018, traffic was applied with a cart-traffic simulator three times a week during the growing season. Bentgrass response measurements (NDVI, percentage green cover, Dark Green Color Index [DGCI], visual quality, visual color, visual density, and clippings yield) and soil samples were collected monthly from May through October from each plot. Data were not collected in November due to frequent heavy rains and occasional snow cover. Soil samples were analyzed using the Solvita® SCB and SLAN tests.

Data were statistically analyzed using analysis of variance to determine treatment effects (fertilizer rates, traffic, and the fertilizer rate × traffic interaction) on the mean bentgrass quality and growth responses, and soil SCB and SLAN concentrations. Bentgrass responses were correlated to the Solvita® soil test concentrations to determine if any relationship exists between the variables using regression analyses. For those variables that suggested a positive correlation, binary logistic regression was applied to determine the probability of response to N fertilization in relation to a given soil test value, using the responses from the standard N fertilization practice as the comparison benchmark values.

RESULTS & DISCUSSION

Traffic effects were significant for visual quality, visual color, visual density, percentage green cover, DGCI, and clipping yields; fertilizer treatment effects were significant for NDVI, visual quality, color, and density, percentage green cover and clipping yields (Table 1). Generally, responses from the low organic rates were significantly lower than the standard treatment for the visual measurements, whereas, NDVI from three of the four highest organic rates were significantly greater than the standard treatment.

When pooled across the entire growing season for the first year of treatment imposition, relative NDVI, relative visual quality, relative visual color, and relative visual density showed significant, but weak, logistic regression models to SLAN concentrations for the No-Traffic plots, but not for the Trafficked plots. When SLAN concentrations were ≥ 169, 216, 180, and 201 mg kg^{-1}, there was a ≥ 67% chance that the bentgrass responses for NDVI, visual quality, visual color, and visual density would equal or exceed the response of the Standard fertilizer treatment (approximately 0.2 lbs N per $1000ft^2$ every 21 days) in the No-Traffic plots (Fig. 1). To date, there is no significant correlation between the Trafficked plot variables for either soil test.

If our hypothesis that the Solvita® soil test kits results are correlated to bentgrass fairway turf responses is valid, then golf course superintendents would be able to easily and quickly assess the mineralization potential of any fairway on their course. These tests will be site specific, and will give the superintendent an objective guidance for N fertilization. Using a more site-specific, objective means to guide N fertilization will maintain optimum turf quality and function, while reducing fertilizer costs, reducing turf loss due to certain N-related diseases, reducing the risk of water pollution caused by N losses, and reducing the greenhouse gas emission footprint (especially with N_2O) of the golf course by not applying N when it has a low probability of response due to high mineralization potential, or not applying the full rate of N when mineralization potential is moderate. The value of using the Solvita® soil test kits also would be seen on fairway areas where mineralization potential is low, and where they could benefit from N fertilizer applications. An additional advantage of the Solvita® soil test kits is that these could be conducted on-site by the superintendent, if desired, without the need to send samples to a laboratory.

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Table 1. Mean Solvita soil test concentrations and bentgrass quality and growth responses, with analysis of variance *P* values.

	SLAN	CO_2-Burst	NDVI	Visual Quality	Visual Color	Visual Density	Cover	DGCI	Sum Clippings yield
Traffic	mg kg^{-1}	mg kg^{-1}					% green		g m^{-2}
No	178.6	132.6	0.720	5.8	5.8	6.0	96.2	0.443	56.5
Yes	177.7	131.9	0.719	5.1	5.5	5.6	97.5	0.435	23.2
Treatment†									
0	173.0	130.1	0.703	5.0*	5.1*	5.3*	94.4*	0.427	30.0
0.25	179.4	132.6	0.710	5.3*	5.4*	5.6*	95.3	0.433	32.2
0.50	174.5	131.2	0.717	5.4*	5.6	5.7	96.6	0.436	38.1
0.75	176.8	130.7	0.720	5.4*	5.5	5.8	96.9	0.438	39.5
1.00	177.0	132.8	0.720	5.5	5.8	5.8	96.9	0.440	35.5
1.25	177.6	135.6	0.723	5.6	5.8	5.9	97.4	0.440	46.8
1.50	179.7	133.9	0.727*	5.6	5.8	5.9	97.9	0.444	43.9
1.75	180.4	132.0	0.724	5.5	5.8	6.0	97.5	0.440	43.5
2.00	180.8	135.1	0.727*	5.7	5.9	5.9	98.0	0.446	45.5
2.25	185.2	132.6	0.729*	5.6	5.8	6.0	97.9	0.444	45.8
Standard	174.9	128.2	0.714	5.8	5.8	6.0	96.6	0.440	37.9
				AOV *P*-values					
Traffic	0.7893	0.4354	0.2135	0.0060	0.0101	<0.0001	<0.0001	<0.0001	<0.0001
Treatment	0.4040	0.2837	<0.0001	0.0005	<0.0001	<0.0001	0.0009	0.3669	0.0048
Traffic × Treat.	0.5366	0.5485	0.1130	0.2272	0.2711	0.8699	0.4911	0.8318	0.5049

* Significantly different from the Standard treatment ($P < 0.05$)

†Compost and organic fertilizer rates of available N (lbs per 1000ft^2); Standard treatment is liquid urea at approximately 0.2 lbs N per 10000ft^2 every 21 days.

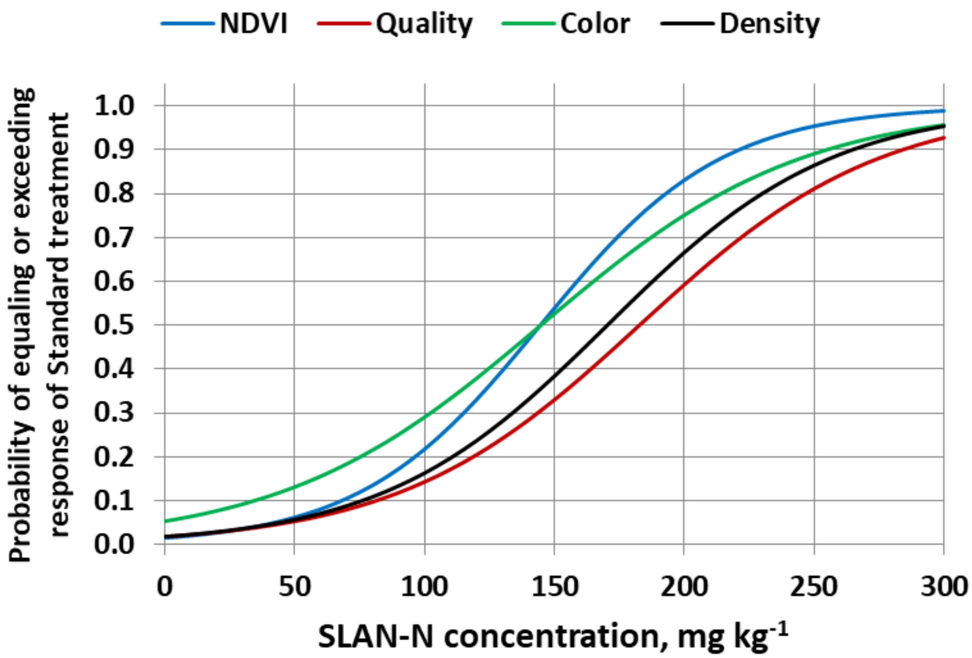

Figure 1. Probability curves of equaling or exceeding the NDVI, visual color, visual color, and visual density response of the Standard Fertilizer treatment (approximately 0.2 lbs N per 1000ft^2 every 21 days) in relation to the Solvita® SLAN-N concentrations for the No-Traffic plots.

SUMMARY

There were no significant fertilizer treatment or traffic differences in mean Solvita® SLAN or SCB concentrations for the first year of treatment imposition, but it is expected that differences should become apparent in the 2nd and 3rd year of the study with more mineralization.

It is anticipated that with time, mineralization of the compost and yearly organic fertilizer applications will further widen the range of Solvita® soil test concentrations, which should give a better model fit for the bentgrass fairway quality and growth responses.

NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2014 NATIONAL FINELEAF FESCUE ANCILLARY TEST – 2018 RESULTS

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INTRODUCTION

Fineleaf fescues are fine leaf grasses that are medium to dark green in color. The leaves are narrow and "needle like". Fineleaf fescues are often utilized for turf that is grown under low input (fertility, water, etc.) conditions. A few areas/locations where they are often planted would be home lawns, parks, commercial properties, golf course roughs, and roadsides. Desirable characteristics of fineleaf fescues are that they have fine leaf texture, high leaf density, good to excellent drought resistance, low fertility needs, and they exhibit good to excellent shade tolerance. Some of the disadvantages of fineleaf fescues are that they exhibit moderate to poor wear tolerance, become thatchy, and they are slow to recuperate from injury. Fineleaf fescues are typically maintained at mowing heights between 1 to 3 inches. Fineleaf fescues include hard fescue, sheep fescue, creeping red fescue and chewings fescue. Hard, sheep, and chewings fescues are considered bunch type grasses (without rhizomes) while the creeping red fescues (both strong and slender) are both rhizomatous.

Golf course managers continue to face government restrictions and regulations regarding water and pesticide use on their golf course properties. An average eighteen hole golf course may have anywhere from 25 to 40 acres of fairways. Fairways are often irrigated and treated with pesticides. Most golf course fairways are maintained at mowing heights of one half inch or less. Typical grasses grown on fairways in northern climates are creeping bentgrass, perennial ryegrasses, and compact bluegrasses. The purpose of this study is to investigate the quality of fineleaf fescues maintained at lower mowing heights, and subjected to simulated golf cart traffic. Cultivars or species of fineleaf fescues that can be successfully grown at fairway mowing heights, and that can survive under traffic conditions may be a good alternative to the conventional grasses that have higher water and fertilizer requirements.

The National Turfgrass Evaluation Program (NTEP) is sponsored by the Beltsville Agriculture Research Center and the National Turfgrass Federation Inc. NTEP works with breeders and testing sites throughout the United States in evaluating turfgrass species and cultivars. Results from turfgrass evaluations can aid professionals in their selection of turfgrass species/cultivars that best meet their needs. Results also aid breeders in selecting new cultivars that they may put into production, as well as helping in marketing their varieties. In 2014 NTEP selected ten standard testing sites and eleven ancillary test locations for their 2014 National Fineleaf Fescue Test. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected as an ancillary test site investigating simulated golf cart traffic tolerance of fineleaf fescue entries maintained at 0.5"mowing height. Evaluations will be made to both trafficked and non-trafficked test plots that are maintained with minimal inputs including supplemental water and fertility.

MATERIALS AND METHODS

Forty two fineleaf fescue plots were seeded on September 4, 2014 in Storrs Connecticut. Of the forty two fine fescue entries: 12 were hard fescues, 10 were strong creeping red fescues, 10 were chewings fescues, 6 were creeping red fescues, 3 were slender creeping red fescues, and 1 was a sheep fescue. A complete randomized block design with 3 replicates of each cultivar was utilized for this study. Plot size is 5' X 5'. Sponsors and entries are listed in Table 1.

For the entire 2015 growing season, simulated golf cart traffic was withheld to allow for turf to mature. Beginning in April 2016 simulated golf cart traffic treatments began on one half of each plot. As agreed upon by the cooperators of the ancillary traffic study, each plot was divided in half. One-half of each plot received simulated golf cart traffic and the other half of the plot was not subjected to traffic. The trafficked half of each plot received to two passes of simulated golf cart traffic three times per week for a total of 6 passes per week (figures 1 and 2). In 2018, traffic was initiated on plots beginning on 5/2/18 and continued throughout the season and concluded at the end of September 2018. Traffic will resume in the spring of 2019.

MANAGEMENT PRACTICES

Since establishment, all plots and cultivars received the same management protocol throughout the study.

Fertilizer and pesticide applications
5/4/18 - Pre-emergent 0.54 oz. /1,000 ft^2 Prodiamine®.
5/14/18 - 25-0-12 60% SCU at rate of 1.25 #N/1,000 sq.'
6/13/18 - Acelepryn®, .367 fl. Oz. /1,000 ft^2
8/24/18 - T-Zone®, 1.5 Oz. /1,000 ft^2
8/31/18 - Secure® fungicide 0.5 oz. /1,000 ft^2 and 26019 Flo. 4 oz. / 1,000 (dollar spot control)

Mowing - Plots were maintained at a mowing height of 0.5 inches and mowed three times per week. Clippings were returned.

Irrigation – Irrigation was applied only to prevent severe drought stress. Supplemental irrigation was applied two times throughout the 2018 growing season (one time in July and one time in August).

DATA COLLECTION

Spring green-up ratings were taken and recorded (Table 2 non-trafficked and Table 3 trafficked) on April 19, 2018. Green-up measures the transition from winter dormancy to active spring growth. Ratings were based on a scale of 1-9, with 1 equaling brown turf and 9 equaling dark green turf.

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2018 growing season. Overall turfgrass quality was determined using a visual rating system of 1-9. A score of 1 illustrates the poorest quality turf and 9 the highest quality. Monthly quality and mean quality ratings are provided in Table 2 for non-trafficked plots and Table 3 for trafficked plots.

Percent Living Cover Ratings for percent living cover were taken on three separate dates; May 7th, July 26th and September 9th. Percent living cover ratings are provided in Table 2 for non-trafficked plots and Table 3 for trafficked plots.

RESULTS & DISCUSSION

In 2014 the University of Connecticut was chosen as a site for the Fineleaf Fescue Ancillary trial. Results (2018) of this ongoing study for both, simulated golf cart traffic and non-trafficked fineleaf fescue species and cultivars can be found in tables 2 and 3.

2018 marked the fourth year of this fine fescue trial. The overall turfgrass quality for 2018 was much lower than the previous three years. Possible reasons for reduced quality could be related to the continual 0.5” mowing height, the simulated golf cart traffic (for the ancillary study) or the fact that 2018 was a very wet year. While all three factors combined may have led to a decrease in turfgrass quality, I believe that high soil moisture had the greatest impact on overall turfgrass quality.

In 2017, dollar spot infestations were so heavy that it was difficult to determine if poor turf quality was the result of simulated golf cart traffic or disease. For this reason, in 2018 a fungicide application was made in the fall to help control dollarspot.

Percent living cover ratings were taken on three separate occasions during the season. The first ratings were taken before traffic was initiated, the second rating was taken mid-season, and the third rating was when traffic concluded at the end of September. While percent cover ratings were taken for both trafficked and non-trafficked studies, the traffic effect is best noted and is discussed below. However, results for both non-trafficked and trafficked plots can be found in tables 2 and 3. Over all, for the trafficked plots, the Chewings fescues appeared to have the best overall performance (Table 3). The top three species/cultivars for percent living cover were Radar (chewings), Bar VV-VP3-CT (chewings), and DLFPS-FRC-3057 (chewings) In general, the hard fescues exhibited the least traffic tolerance. Nine of the bottom ten entries for percent living ground cover (trafficked) were hard fescues.

Overall visual turfgrass quality ratings for both trafficked and non-trafficked plots were similar to 2017 results. Chewings, slender, and creeping red fescues exhibited higher quality ratings when compared to the hard and sheep fescues. One exception was hard fescue DLFPS-FRC/3060 which scored in the top ten for both quality and percent density.

Results from 2018 simulated golf cart traffic trial indicate, from the mean values, that eight of the top 10 species for quality were chewings fescues. Radar a chewings fescue and Bolster (C14-OS3) a strong creeping red fescue illustrated the highest ratings under simulated golf cart traffic conditions.

Lower turf quality ratings for hard fescue and sheep fescue were likely impacted by the lower mowing heights and traffic treatments. Quality for both species (hard and sheep) would most likely be higher if plots were maintained at mowing heights greater than 0.5 inches and traffic is minimal.

The results of the first three years of this study were promising. There are cultivars and species that exhibit quality turf even when subjected to traffic, reduced irrigation and reduced fertilizer. However in 2018 (fourth year of study) overall turfgrass quality began to decline for all entries. While a few entries were acceptable under traffic conditions (Table 3) the overall number of acceptable entries declined compared to the previous three years. The wet weather of 2018 appeared to have a negative impact on quality and percent living cover.

Perhaps the biggest key for success of these species in fairway turf would be to significantly reduce irrigation. This would require the manager to be diligent in scouting and monitoring the turf for drought symptoms as well as monitoring soil moisture levels.

Table 1 – Sponsors, Entries, and Species		
SPONSOR	**ENTRY**	**SPECIES**
Landmark Turf and Native Seed	Minimus	Hard Fescue
Landmark Turf and Native Seed	Marvel	Strong Creeping Red
Brett Young Seeds Ltd	7C34	Strong Creeping Red
DLF Pickseed USA	DLFPS-FL/3066	Hard Fescue
DLF Pickseed USA	DLFPS-FRC/3060	Hard Fescue
DLF Pickseed USA	DLFPS-FL/3060	Hard Fescue
DLF Pickseed USA	DLFPS-FRR/3069	Strong Creeping Red
University of Minnesota	MNHD-14	Hard Fescue
DLF Pickseed USA	DLFPS-FRR/3068	Strong Creeping Red
Standard Entry	Quatro	Sheep
Standard Entry	Boreal	Strong Creeping Red
Columbia River Seed	Gladiator (TH456)	Hard Fescue
SiteOne Landscape Supply	Resolute (7H7)	Hard Fescue
Columbia River Seed	Sword	Hard Fescue
Standard Entry	Seabreeze GT	Slender Creeping Red
Standard Entry	Radar	Chewings
Standard Entry	Beacon	Hard Fescue
Standard Entry	Navigator II	Strong Creeping Red
Mountain View Seeds	Jetty (PPG-FL 106)	Hard Fescue
The Scotts Company	Momentum (PPG-FRC 114)	Chewings
Mountain View Seeds	SeaMist (PPG-FRT 101)	Slender Creeping Red
Mountain View Seeds	Cardinal II (PPG-FRR 111)	Strong Creeping Red
Mountain View Seeds	Compass II (PPG-FRC 113)	Chewings
Columbia Seeds	Kent	Strong Creeping Red
Columbia Seeds	Castle (RAD-FC32)	Chewings
Barenbrug USA	BAR FRT 5002	Slender Creeping Red
Barenbrug USA	BAR VV-VP3-CT	Chewings
Barenbrug USA	BAR 6FR126	Chewings
The Scotts Company	Bolster (C14-OS3)	Strong Creeping Red
Brett-Young Seed LTD	RAD-FR33R	Strong Creeping Red
Bailey Seed Company	RAD-FC44	Chewings
Bailey Seed Company	RAD-FR47	Creeping Red Fescue
Pure Seed Testing Inc.	PST-4DR4	Creeping Red Fescue
Pure Seed Testing Inc.	PST-4RUE	Creeping Red Fescue
Pure Seed Testing Inc.	PST-4BEN	Creeping Red Fescue
Pure Seed Testing Inc.	PST-4BND	Hard Fescue
Pure Seed Testing Inc.	PST-4ED4	Creeping Red Fescue
DLF Pickseed USA	DLFPS-FRC/3057	Chewings
Standard Entry	Cascade	Chewings
DLF Pickseed USA	DLF-FRC 33388	Chewings
DLF Pickseed USA	DLF-FRR 6162	Creeping Red Fescue
DLF Pickseed USA	Beudin	Hard Fescue

Figure 1 – 2014 NTEP Fineleaf fescue ancillary Low cut/traffic Trials, University of Connecticut (Photo- July 2018)

Figure 2 – Golf cart traffic simulator

Figure 3- Fine Fescue turf plots traffic and non-traffic treatments July 2018

Table 2 2018 results for non-trafficked fine fescue turfgrass plots. Ratings are for: spring green-up (ratings 1-9, where 9 equals darker green –up), percent living ground cover on three separate dates, monthly turfgrass quality (rating 1-9, where 9 equals the highest turf quality), Table is listed with highest mean quality cultivars listed first.

	Spring green up	Percent Living cover				Quality						
Entry	04/19/18	05/07/18	07/26/18	09/10/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
Radar	7.3	99.0	89.7	94.7	94.4	8.3	8.0	6.7	7.0	7.0	7.0	7.3
DLFPS-FRC/3060	6.3	96.0	88.3	93.3	92.6	6.7	7.7	7.0	6.7	7.7	7.3	7.2
Momentum	6.3	97.7	86.7	86.7	90.3	6.7	7.3	7.0	6.0	7.0	7.0	6.8
Bolster	6.7	98.7	85.0	91.0	91.6	7.0	7.7	6.7	5.7	6.7	6.7	6.7
Compass II	6.7	97.7	76.0	86.7	86.8	7.3	7.3	6.3	5.3	6.7	7.0	6.7
DLF-FRC 3338	6.3	96.0	81.7	83.3	87.0	6.7	7.3	6.7	5.7	7.0	6.3	6.6
DLFPS-FRC/3057	6.3	97.3	85.0	85.0	89.1	6.7	7.7	7.0	5.7	6.0	6.0	6.5
SeaMist	6.3	99.0	75.0	86.7	86.9	7.0	7.3	6.7	5.3	6.0	6.0	6.4
BAR VV-VP3-CT	6.7	96.3	83.3	81.7	87.1	7.0	7.3	6.7	5.0	6.7	5.7	6.4
7C34	5.7	96.3	94.0	86.7	92.3	6.3	6.7	6.3	6.7	6.3	5.7	6.3
RAD-FC44	7.3	97.7	73.3	75.0	82.0	6.7	7.3	6.7	4.7	6.0	6.0	6.2
Marvel	5.7	91.7	87.7	83.3	87.6	5.7	6.0	6.3	5.7	5.7	5.3	5.8
Jetty	6.0	86.3	85.0	70.0	80.4	5.7	6.7	5.7	5.7	6.0	4.3	5.7
Castle	7.7	99.0	73.3	80.0	84.1	6.7	6.7	6.0	4.0	5.0	5.3	5.6
DLF-FRR-6162	6.0	91.7	86.7	83.3	87.2	5.7	6.7	5.3	5.7	5.3	5.0	5.6
RAD-FR33R	7.3	90.0	86.7	85.0	87.2	5.0	6.0	5.0	6.0	6.0	5.3	5.6
DLFPS-FRR/3068	4.7	89.3	78.3	71.7	79.8	5.0	6.7	5.3	4.7	5.0	6.3	5.5
Cascade	6.3	92.7	81.7	78.3	84.2	5.7	5.7	5.7	5.3	5.3	5.3	5.5
MNHD-14	5.0	89.7	85.7	78.3	84.6	5.3	5.7	5.7	5.7	5.7	4.7	5.4
DLFPS-FL/3060	6.0	90.7	74.3	66.7	77.2	5.3	6.3	6.0	4.7	5.0	4.7	5.3
Cardinal II	5.7	85.0	78.3	76.7	80.0	5.0	6.0	5.7	5.3	5.0	5.0	5.3
DLFPS-FL/3066	5.7	83.3	76.7	60.0	73.3	5.7	7.0	5.3	5.0	4.7	4.0	5.3
PST-4RUE	5.7	88.3	75.0	68.3	77.2	5.0	5.7	5.3	5.0	5.0	5.3	5.2
PST-4BEN	5.7	86.7	80.0	71.7	79.4	4.3	5.3	5.0	5.0	6.0	5.7	5.2
Gladiator	5.3	78.0	73.3	58.3	69.9	5.0	6.0	5.0	5.0	5.0	4.7	5.1
RAD-FR47	6.3	85.7	60.0	73.3	73.0	4.7	4.7	5.0	4.7	5.3	6.3	5.1
Quatro	6.0	95.3	83.3	68.3	82.3	5.0	6.0	5.7	4.7	5.0	4.0	5.1
BAR 6FR 126	6.7	91.3	56.7	38.3	62.1	7.0	6.7	5.3	3.7	3.7	4.0	5.1

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Table 2 *(cont)* 2018 results for non-trafficked fine fescue turfgrass plots. Ratings are for: spring green-up (ratings 1-9, where 9 equals darker green –up), percent living ground cover on three separate dates, monthly turfgrass quality (rating 1-9, where 9 equals the highest turf quality), Table is listed with highest mean quality cultivars listed first.

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Entry	04/19/18	05/07/18	07/26/18	09/10/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
PST-4DR4	4.7	90.0	76.7	66.7	77.8	5.0	5.7	5.3	4.7	4.7	5.0	5.1
BAR FRT 5002	4.7	96.0	65.0	28.3	63.1	6.3	7.0	6.3	3.3	3.7	3.0	4.9
Navigator II	5.7	87.7	65.0	53.3	68.7	4.7	5.3	4.3	4.7	5.3	5.0	4.9
7H7	6.0	76.3	75.0	53.3	68.2	5.7	5.3	5.0	4.3	4.3	4.3	4.8
Beudin	4.7	94.0	73.3	38.3	68.6	5.3	6.3	6.3	2.7	4.0	4.0	4.8
Sword	5.3	79.3	76.7	56.7	70.9	4.7	5.7	4.7	4.7	4.7	4.0	4.7
Seabreeze GT	5.3	89.3	68.3	46.7	68.1	5.7	6.0	5.0	3.7	4.0	4.0	4.7
PST-4ED4	6.3	86.0	75.0	61.7	74.2	5.0	5.7	5.0	4.0	4.7	4.0	4.7
DLFPS-FRR/3069	5.0	88.3	76.7	63.3	76.1	5.0	4.7	5.0	4.3	5.0	4.0	4.7
Kent	5.0	85.3	70.0	51.7	69.0	4.7	5.0	4.7	4.0	4.7	5.0	4.7
Boreal	5.0	85.0	65.0	46.7	65.6	5.0	5.0	4.3	3.3	4.3	4.0	4.3
Beacon	4.7	79.3	68.3	45.0	64.2	4.7	4.7	4.7	3.7	4.7	3.7	4.3
Minimus	5.3	79.0	66.7	46.7	64.1	5.3	4.7	4.7	4.0	3.3	3.7	4.3
PST-4BND	4.7	69.3	27.7	23.3	40.1	3.3	3.7	3.7	2.7	3.0	2.7	3.2
$LSD_{0.05}$	1.34	14.30	19.91	23.74	15.69	1.35	1.77	1.34	1.64	1.27	1.28	1.06
CV%	14.1	9.8	16.1	21.6	12.4	14.7	17.7	14.7	20.8	14.8	15.6	12.0

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Table 3. 2018 results for trafficked fine fescue turfgrass plots. Ratings are for: spring green-up (ratings 1-9, where 9 equals darker green –up), percent living ground cover on three separate dates, monthly turfgrass quality (rating 1-9, where 9 equals the highest turf quality), Table is listed with highest mean quality cultivars listed first.

	Spring green up	Percent Living cover				Quality						
Entry	04/19/18	05/07/18	07/26/18	09/10/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
Radar	7.3	98.0	88.3	65.0	83.8	6.3	7.0	6.0	6.0	5.7	5.7	6.1
Bolster	6.7	97.3	75.0	38.3	70.2	6.7	7.7	7.0	4.7	4.0	4.3	5.7
Momentum	6.3	97.7	75.0	41.7	71.4	6.0	7.3	5.7	4.7	5.0	5.0	5.6
BAR VV-VP3-CT	6.7	98.7	80.0	46.7	75.1	6.3	6.7	6.3	5.0	5.0	4.0	5.6
Compass II	6.7	69.3	61.7	40.0	57.0	6.7	7.0	6.3	4.0	4.0	4.3	5.4
DLF-FRC 3338	6.3	95.7	63.3	30.0	63.0	6.3	7.0	5.7	4.3	3.3	4.0	5.1
7C34	5.7	93.0	85.0	33.3	70.4	5.3	6.7	5.7	4.7	4.0	4.0	5.1
DLFPS-FRC/3057	6.3	98.3	73.3	55.0	75.6	6.3	6.0	5.7	4.0	3.7	4.7	5.1
DLFPS-FRC/3060	6.3	91.3	73.3	35.0	66.6	5.0	6.0	5.3	4.7	3.7	4.0	4.8
SeaMist	6.3	94.0	68.3	31.7	64.7	6.0	6.3	5.3	3.3	3.7	3.0	4.6
Castle	7.7	95.7	55.0	16.7	55.8	6.7	6.3	5.3	3.3	3.0	2.7	4.6
Quatro	6.0	94.7	76.7	30.0	67.1	5.0	5.3	5.0	4.7	3.7	2.7	4.4
Cascade	6.3	95.0	63.3	38.3	65.6	5.3	4.7	4.7	4.0	4.0	3.3	4.3
Marvel	5.7	89.3	66.7	20.0	58.7	5.3	5.7	4.7	3.3	4.0	2.7	4.3
RAD-FC44	7.3	92.7	41.7	25.0	53.1	6.3	6.3	5.0	1.7	2.7	2.3	4.1
DLF-FRR-6162	6.0	93.3	53.3	16.7	54.4	5.0	5.3	4.7	2.7	3.3	2.3	3.9
RAD-FR33R	7.3	89.3	58.3	21.7	56.4	5.3	4.7	4.0	3.0	3.0	3.0	3.8
Navigator II	5.7	88.0	50.0	21.7	53.2	5.0	4.7	4.0	3.7	3.0	2.3	3.8
Kent	5.0	91.3	46.7	13.3	50.4	4.3	4.7	4.0	3.0	3.0	3.0	3.7
Seabreeze GT	5.3	91.3	40.0	6.7	46.0	5.0	5.0	4.3	2.3	2.3	2.7	3.6
RAD-FR47	6.3	88.0	48.3	41.0	59.1	4.7	4.3	4.3	2.7	3.0	2.7	3.6
PST-4DR4	4.7	86.7	40.0	15.0	47.2	4.7	4.7	4.0	2.7	3.3	2.3	3.6
PST-4BEN	5.7	89.7	63.3	23.3	58.8	4.3	4.3	4.0	3.7	2.7	2.7	3.6

Table 3 *(cont).* 2018 results for trafficked fine fescue turfgrass plots. Ratings are for: spring green-up (ratings 1-9, where 9 equals darker green –up), percent living ground cover on three separate dates, monthly turfgrass quality (rating 1-9, where 9 equals the highest turf quality), Table is listed with highest mean quality cultivars listed first.

	Spring green up	Percent Living cover				Quality						
Entry	04/19/18	05/07/18	07/26/18	09/10/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
PST-4ED4	6.3	89.3	26.7	21.7	45.9	4.3	4.7	4.0	2.3	3.3	3.0	3.6
Cardinal II	5.7	90.0	58.3	11.0	53.1	4.7	4.7	4.3	2.7	2.7	2.3	3.6
DLFPS-FRR/3068	4.7	87.3	43.3	7.0	45.9	4.3	5.0	3.7	2.3	2.3	2.3	3.3
Boreal	5.0	88.7	45.0	20.0	51.2	4.0	5.0	4.0	2.3	2.7	2.0	3.3
Jetty	6.0	74.7	45.0	10.0	43.2	4.0	4.3	3.7	2.3	3.3	2.3	3.3
BAR FRT 5002	4.7	87.3	41.7	3.7	44.2	5.0	5.0	5.0	1.7	1.3	1.7	3.3
PST-4RUE	5.7	72.7	43.3	14.3	43.4	4.3	4.0	3.7	2.7	3.0	2.0	3.3
Resolute	6.0	68.0	37.7	17.0	40.9	4.0	4.0	4.0	2.0	3.3	2.0	3.2
DLFPS-FRR/3069	5.0	88.3	28.3	6.0	40.9	4.0	4.3	3.7	2.0	2.0	2.3	3.1
Beudin	4.7	81.3	46.7	4.3	44.1	4.0	4.7	5.3	1.3	1.0	1.7	3.0
MNHD-14	5.0	63.3	37.7	16.0	39.0	4.0	3.7	3.7	2.0	2.7	1.7	2.9
Sword	5.3	75.0	36.7	11.7	41.1	3.3	3.7	3.3	2.3	2.7	2.3	2.9
DLFPS-FL/3060	6.0	83.7	30.0	6.7	40.1	4.0	3.3	3.3	2.3	2.3	2.0	2.9
DLFPS-FL/3066	5.7	80.3	28.3	7.0	38.6	3.3	4.0	3.7	2.0	2.0	2.0	2.8
Beacon	4.7	64.0	31.7	9.7	35.1	3.0	3.3	3.3	2.7	2.0	2.3	2.8
BAR 6FR 126	6.7	69.3	17.3	7.7	31.4	4.0	4.3	3.3	1.3	1.7	2.0	2.8
Gladiator	5.3	60.3	40.3	8.7	36.4	3.0	3.0	3.0	2.3	2.3	1.7	2.6
Minimus	5.3	63.7	11.7	9.3	28.2	3.0	2.7	3.0	1.7	2.7	2.0	2.5
PST-4BND	4.7	57.0	12.3	7.0	25.4	2.7	2.3	2.7	1.0	1.7	2.0	2.1
$LSD_{0.05}$	1.34	30.43	25.26	22.71	19.67	1.57	1.76	1.20	1.54	1.47	1.26	0.98
CV%	14.1	22.1	31.0	64.9	23.2	20.2	21.7	16.5	31.7	29.6	27.8	15.8

ACKNOWLEDGEMENTS

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NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP) 2016 PERENNIAL RYEGRASS TEST – 2018 RESULTS

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INTRODUCTION

Perennial ryegrass is one of the more popular cool season turfgrass species. Perennial ryegrasses are often mixed as blends with other perennial ryegrass cultivars or added to mixtures that contain other turfgrass species. Perennial ryegrass is utilized for many turfgrass areas including: golf courses, athletic fields, home lawns, parks, and corporate lawns. Characteristics that make perennial ryegrass desirable are: its rapid germination and establishment rate, it maintains a dense, dark green color, it can be maintained at mowing heights as low as one half inch, it has good wear tolerance, and it is compatible with mixtures that also contain Kentucky bluegrass and fine leaf fescue. Limitations of perennial ryegrass are: it exhibits poor tolerance to cold temperatures, it does not tolerate prolonged drought, and it is susceptible to gray leafspot disease. Perennial ryegrass is best adapted to moist, moderately fertile soils.

The National Turfgrass Evaluation Program (NTEP) is sponsored by the Beltsville Agriculture Research Center and the National Turfgrass Federation Inc. NTEP works with breeders and testing sites throughout the United States in evaluating turfgrass species and cultivars. Results from turfgrass evaluations can aid professionals in their selection of turfgrass species/cultivars that best meet their needs. Results also aid breeders in selecting new cultivars that they may put into production, as well as helping in marketing their varieties. In 2016 NTEP selected thirteen standard testing sites and ten ancillary test locations for the 2016 National Perennial Ryegrass Test. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected as a standard site for the 2016 Perennial Ryegrass Test. NTEP trials typically run for five years, The 2016 Perennial Ryegrass trial will run through the 2021 growing season.

MATERIALS AND METHODS

One hundred and fourteen Perennial ryegrass cultivars were seeded on September 9, 2016 in Storrs Connecticut. A complete randomized block design with 3 replicates of each cultivar was utilized for this study. Plot size is 3' X 5'. Sponsors and entries are listed in Table 1.

MANAGEMENT PRACTICES

Since establishment, all plots and cultivars received the same management protocol throughout the study. Management practices for 2018 were as follows:

Mowing - Plots were maintained at a mowing height of 2.25 inches and mowed two times per week. Clippings are returned.

Irrigation – Supplemental irrigation is applied only at times of severe drought.

Fertilizer and pesticide applications for 2018
5/4/18 -0.54 oz. /1,000 ft^2 Prodiamine®. 65 WDG,
5/14/18 - 1.25# N /1,000 ft^2, 25-0-12 (60% SCU).
5/21/21 - Prograss® herbicide, applied 3.5 fl. 1,000 ft^{2}oz.
6/13/18 Aceleprynⓡ, .367 fl. Oz. /1,000 ft^2
6/21/18 Tenacity®, 3 fl oz. /A
6/27/18- 1#N/m using 25-0-12 (60% SCU).
7/12/18- Tenacity® applied at a rate of 3 fl oz. /A:
8/24/18 – T-Zone® 1.5 oz. /
10/5/18 - Prograss® rate was 3.0 fl oz. /1,000 sq. ft.
10/10/18 1#N/1,000 sq.ft - 30-0-6
10/30/18 - Prograss® rate was 3.0 fl oz. /1,000 sq. ft.

DATA COLLECTION

Spring Green-up Ratings - Spring green-up ratings were taken and recorded (Table 2) on April 19, 2018. Green-up measures the transition from winter dormancy to active spring growth. Ratings were based on a scale of 1-9, with 1 equaling brown turf and 9 equaling dark green turf.

Genetic Color Ratings - Genetic color ratings (Table 2) were taken in the late spring (June 6, 2018) while the grass was actively growing and not under stress conditions. Ratings were based on visual color with 1 being light green and 9 being dark green. Areas of plots that contained browning tissue (chlorosis or necrotic) from outside factors such as disease were not considered for genetic color (Table 2).

Quality Ratings - Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2018 growing season. Overall turfgrass quality was determined using a visual rating system of 1-9. A score of 1 illustrates the poorest quality turf and 9 the highest quality. Monthly quality and mean quality ratings are provided in table 2.

RESULTS & DISCUSSION

Results for spring green up, genetic color, and monthly quality ratings, are provided in Table 2.

General observations noted during the 2018 growing season were: mean quality values for overall quality continue to illustrate that there is little diversity between cultivars. PPG-PR 360 and PPG-PR 442 had the highest mean quality ratings. However, there was no significant difference noted when comparing these top two entries with the next thirty-two cultivars. Linn exhibited the poorest overall turf quality.

Since establishment, all plots had contained small amounts of Poa annua. In order to reduce poa annua encroachment and to remove existing poa from the study, plots have been treated with both Tenacity® and Prograss® (see management practices)

Table 1- Sponsors and Entries

ENTRY	SPONSOR	ENTRY	SPONSOR
021	Scotts Miracle-GRO	GO-143	Grassland Oregon
BSP-17	Bailey Seed and Grain	APR2612	ProSeeds Marketing
BWH	Bailey Seed and Grain	APR3060	Pennington
BSP-17	Bailey Seed and Grain	AMP-R1	AMPAC Seed
Savant	Ledeboer Seed	DLFPS-236/3546	DLF Pickseed USA
LPB-SD-105	Ledeboer Seed	DLFPS-236/3547	DLF Pickseed USA
Saguaro	Ledeboer Seed	DLFPS-236/3548	DLF Pickseed USA
LPD-SD-104	Ledeboer Seed	PR-6-15	Columbia Seed
Mensa	Ledeboer Seed	DLFPS-236/3550	DLF Pickseed USA
LPD-SD-101	Ledeboer Seed	DLFPS-236/3552	DLF Pickseed USA
LPD-SD-102	Ledeboer Seed	023	Brett Young Seeds
LPD-SD-103	Ledeboer Seed	FP2	Turf Merchants
DLFPS-236/3540	DLF Pickseed USA	02BS2	Brett Young Seeds
DLFPS-236/3542	DLF Pickseed USA	RRT	Scotts Miracle-GRO
DLFPS-236/3544	DLF Pickseed USA	Slider LS (PPG-PR 241)	Mountain View Seeds
Intense	Landmark Turf and Native Seed	Fastball 3GL (PPG-PR 329	Mountain View Seeds
Xcelerator	Landmark Turf and Native Seed	PPG-PR 331	Turf Merchants
UF3	Landmark Turf and Native Seed	Derby Extreme	Standard
JR123	Jacklin Seed by Simplot	Apple 3GL (PPG-PR 339)	Mountain View Seeds
JR747	Jacklin Seed by Simplot	Slugger 3GL (PPG-PR 343)	Mountain View Seeds
JR 888	Jacklin Seed by Simplot	PPG-PR 360	Integra Turf
DLFPS-236/3541	DLF Pickseed USA	PPG-PR 367	Mountain View Seeds
DLFPS-236/3543	DLF Pickseed USA	PPG-PR 370	Lewis Seed
DLFPS-236/3545	DLF Pickseed USA	PPG-PR 371	Turf Merchants
Evolve	SiteOne Landscape	PPG-PR 372	Columbia Seeds
MRSL-PR16	SiteOne Landscape	PPG-PR 385	Mountain View Seeds
PL2	SiteOne Landscape	Homerun LS (PPG-PR 419)	Mountain View Seeds
MRSL-PR15	SiteOne Landscape	PPG-PR 420	Peak Plant Genetics
SNX	Smith Seed Services	PPG-PR 421	Proseeds Marketing
Signet	Smith Seed Services	PPG-PR 422	Columbia Seeds
Shield (02BS4)	Smith Seed Services	PPG-PR 423	Peak Plant Genetics
CS-6	Columbia Seed	PPG-PR 424	Peak Plant Genetics
DLFPS-236/3556	DLF Pickseed USA	Karma	Standard
ASP0116EXT	Allied Seed	SR 4650	Standard
ASP0117(A-PR15)	Allied Seed	DLFPS-236/3538	DLF Pickseed USA
ASP0118GL(A-4G)	Allied Seed	Grand Slam GLD	Standard
ASP0218	Allied Seed	Furlong (LTP-FCB)	Lebanon Seaboard
NP-3	Pennington Seed	BAR LP 6117	Barenbrug USA
NP-2	Pennington Seed	BAR LP 6131	Barenbrug USA
APR2616	Pennington Seed	BAR LP 6159	Barenbrug USA
GO-141	Grassland Oregon	BAR LP 6233	Barenbrug USA

Table 1 (continued) - Sponsors and Entries			
ENTRY	**SPONSOR**	**ENTRY**	**SPONSOR**
GO-142	Grassland Oregon	PST-2Foxy	Pure Seed Testing
Silver Sport (PST-2CRP)	Rose Agri-Seed	BAR LP 6165	Barenbrug USA
PST-2EGAD	Pure Seed Testing	Overdrive 5G	Burlingham Seeds
Gray Hawk (PST-2Find)	Pure Seed Testing	02BS1	ProSeeds
PST-2EGAD	Pure Seed Testing	CPN	Columbia seeds
PST-2BDT	Grassland Oregon	JR-197	Jacklin Simplot
PST-2MAY	Pure Seed Testing	DLFPS-238/3014	DLF Pickseed USA
Gray Wolf (PST-2 GAL	Rose Agri-Seed	Pepper II (RAD-PR 103)	Lewis Seed Company
PST-2PDA	Pure Seed Testing	RAD-PR 112	Baily Seed
PST-2A2	Pure Seed Testing	UMPQUA	Vista Seed Partners
DLFPS-236/3553	DLF Pickseed USA	Seabiscuit	Lebanon Seaboard
DLFPS-236/3554	DLF Pickseed USA	Man O'War	Lebanon Seaboard
PR-5-16	Columbia Seeds	Pharaoh	Lebanon Seaboard
BAR LP 6158	Barenbrug USA	Allstar III	Standard
BAR LP 6162	Barenbrug USA	Brightstar SLT	Standard
BAR LP 6164	Barenbrug USA	Linn	Standard

Figure 1 – 2016 NTEP National Perennial Ryegrass Test, University of Connecticut (photo- July 2018)

Table 2. Perennial Ryegrass NTEP results 2018 for spring green-up, genetic color (ratings 1-9, where 9 equals darker green), turfgrass quality (rating 1-9, where 9 equals the highest turf quality). Table is listed with highest mean quality cultivars listed first.

	Spring Green Up	Genetic color	Quality						
Entry	04/19/18	06/06/18	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	mean
PPG-PR 360	6.0	7.7	6.3	7.7	7.0	7.0	7.7	7.0	7.1
PPG-PR 422	7.0	7.7	6.7	8.0	6.7	7.0	7.0	7.3	7.1
DLFPS-236/3542	6.0	7.7	6.7	7.7	6.7	6.3	7.3	7.0	6.9
NP-3	7.0	6.7	7.3	7.7	6.3	6.7	7.3	6.3	6.9
PPG-PR 421	7.0	7.3	7.3	7.3	6.7	7.3	5.7	7.3	6.9
PPG-PR 372	6.7	8.0	7.0	7.7	6.7	7.0	5.7	7.3	6.9
DLFPS-236-3546	7.0	7.7	7.0	7.3	6.3	7.0	6.3	7.0	6.8
PL2	6.7	8.0	7.7	8.0	7.0	6.3	5.3	6.3	6.8
DLFPS-236-3552	7.0	7.7	7.0	7.3	6.7	6.3	7.0	6.3	6.8
PPG-PR 331	6.7	7.3	7.7	7.0	6.3	7.3	6.3	6.0	6.8
PPG-PR 424	8.0	7.3	7.7	6.7	5.7	7.7	6.3	6.7	6.8
DLFPS-236/3554	6.3	7.3	7.0	7.0	6.3	7.0	7.3	5.7	6.7
DLFPS-236/3545	6.0	7.0	6.7	6.0	6.0	7.7	7.0	6.7	6.7
DLFPS-236-3548	5.7	7.7	6.3	7.3	6.7	7.3	6.7	5.7	6.7
PR-6-15	6.0	7.7	5.7	6.7	6.7	7.3	6.7	7.0	6.7
PPG-PR 371	6.0	7.7	6.3	6.7	6.3	6.7	7.0	7.0	6.7
Pharaoh	7.7	7.7	7.0	6.7	6.7	6.7	6.0	7.0	6.7
Xcelerator	6.7	7.3	7.7	7.0	6.7	6.3	5.7	6.3	6.6
NP-2	6.3	7.3	7.7	7.7	7.0	6.3	4.3	6.7	6.6
PPG-PR 423	6.3	7.0	6.7	7.7	5.7	6.7	6.3	6.7	6.6
21	6.3	6.0	6.7	6.3	6.0	6.3	7.3	6.7	6.6
02BS4	6.0	7.3	7.0	7.7	6.0	6.3	6.0	6.3	6.6
02BS2	6.3	7.0	7.0	6.7	5.3	7.0	6.0	7.3	6.6
PST-2GAL	6.7	7.7	7.0	7.7	7.0	5.7	6.0	6.0	6.6
DLFPS-236-3547	7.0	7.0	6.3	7.7	5.7	7.0	5.7	6.7	6.5
RRT	7.3	7.0	6.7	7.0	6.3	6.0	6.7	6.3	6.5
PST-2BDT	5.3	7.3	6.7	7.0	5.7	6.3	7.3	6.0	6.5
DLFPS-236/3553	6.0	7.0	7.0	7.0	6.3	7.0	6.0	5.7	6.5
UMPQUA	6.7	6.0	7.0	7.0	6.3	6.7	6.0	6.0	6.5
DLFPS-236-3550	6.0	6.7	6.7	6.7	6.3	6.7	6.7	5.7	6.4
PPG-PR 339	6.7	7.0	6.3	7.0	6.0	6.0	7.0	6.3	6.4
23	7.3	7.7	7.3	7.0	6.7	7.0	5.0	5.3	6.4
PPG-PR 420	7.0	7.7	7.3	7.0	6.7	6.7	5.0	5.7	6.4
BAR LP 6158	5.0	6.7	5.7	6.7	6.3	6.0	7.3	6.3	6.4
Overdrive 5G	6.3	7.0	7.3	7.0	6.3	6.7	5.3	5.7	6.4
DLFPS-236/3540	5.7	6.7	6.3	5.7	6.0	7.3	7.0	5.7	6.3
Intense	7.3	7.0	6.0	7.0	6.3	6.3	6.3	6.0	6.3
A-PR15	5.7	7.3	5.7	8.0	6.3	6.0	6.0	6.0	6.3
PPG-PR 241	6.3	7.0	7.3	7.0	6.7	6.0	5.0	6.0	6.3

Table 2 *(cont)*. Perennial Ryegrass NTEP results 2018 for spring green-up, genetic color (ratings 1-9, where 9 equals darker green), turfgrass quality (rating 1-9, where 9 equals the highest turf quality). Table is listed with highest mean quality cultivars listed first.

	Spring Green Up	Genetic color	Quality						
Entry	04/19/18	06/06/18	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	mean
PPG-PR 367	7.3	7.7	6.3	6.7	6.0	5.7	6.7	6.7	6.3
DLFPS-236/3538	6.7	7.3	6.3	7.7	6.3	6.0	6.3	5.3	6.3
BAR LP 6233	5.0	6.7	6.3	6.0	7.7	6.0	6.3	5.7	6.3
PST-2GTD	6.0	6.7	5.7	7.0	6.3	6.7	7.3	5.0	6.3
PST-2A2	6.7	8.0	7.7	7.0	6.7	6.3	4.7	5.7	6.3
Man O"War	6.3	7.3	6.7	7.3	6.3	5.7	6.3	5.7	6.3
Savant	5.7	7.3	7.7	6.7	7.0	6.3	4.3	5.7	6.3
JR-123	6.3	7.0	6.7	6.7	6.0	6.3	6.0	6.0	6.3
JR-888	6.7	6.0	7.3	6.3	6.7	6.3	5.0	6.0	6.3
DLFPS-236/3543	6.7	7.3	6.3	6.3	6.3	7.0	6.3	5.3	6.3
PPG-PR 370	6.7	8.0	7.3	6.3	6.7	7.0	4.7	5.7	6.3
PST-2FOXY	5.7	7.0	5.7	6.7	6.0	6.3	7.0	6.0	6.3
LPB-SD-102	4.7	7.7	6.7	7.0	7.3	5.3	5.3	5.7	6.2
Signet	7.0	7.7	6.7	6.3	6.3	7.0	5.7	5.3	6.2
DLFPS-236/3544	7.3	6.7	6.0	6.0	6.0	6.0	6.7	6.3	6.2
UF3	5.7	7.3	6.7	7.3	6.0	6.3	5.0	5.7	6.2
LTP-FCB	7.0	8.0	7.0	8.0	6.3	5.7	4.7	5.3	6.2
LPB-SD-101	4.7	6.0	5.7	6.7	7.0	6.0	6.0	5.3	6.1
Evolve	6.0	6.7	5.7	7.0	6.0	5.7	7.0	5.3	6.1
A-4G	5.3	7.3	4.7	6.3	6.3	6.7	6.7	6.0	6.1
PPG-PR 343	6.0	6.7	6.3	7.0	6.0	5.7	5.3	6.3	6.1
PPG-PR 419	6.7	7.3	6.3	7.0	5.7	5.3	6.3	6.0	6.1
A-6D	6.3	8.3	5.7	8.0	6.0	4.7	6.0	6.0	6.1
PST-2EGAD	5.7	7.3	6.3	6.7	5.7	5.3	6.3	6.0	6.1
JR-197	6.7	7.3	6.3	5.7	6.3	6.0	5.7	6.3	6.1
Seabisquit	7.7	7.0	7.0	6.3	6.3	5.3	5.0	6.3	6.1
Saguaro	5.7	6.0	6.3	6.3	6.3	5.7	5.0	6.3	6.0
Derby Xtreme	6.7	6.7	6.3	7.0	5.3	6.7	5.0	5.7	6.0
DLFPS-236/3541	6.3	6.7	5.7	6.7	5.7	5.3	6.0	6.3	5.9
SR4650	6.3	7.0	6.7	6.7	6.3	5.3	5.0	5.7	5.9
PST-2FIND	6.3	6.7	5.7	7.0	5.7	6.0	5.7	5.7	5.9
BAR LP 6164	6.0	6.0	6.0	6.0	5.7	5.7	6.0	6.3	5.9
CPN	6.7	6.7	6.7	6.0	5.7	6.3	5.7	5.3	5.9
LPB-SD-104	4.7	8.3	5.7	7.3	7.0	5.7	4.3	5.3	5.9
MRSL-PR15	6.0	8.0	5.7	7.7	6.0	6.0	5.0	5.0	5.9
Apr-16	5.7	7.3	6.0	6.3	5.3	5.7	6.7	5.3	5.9
PST-2MAY	6.7	7.3	6.0	6.3	6.0	4.7	6.0	6.3	5.9
BAR LP 6165	5.0	5.0	6.3	5.7	6.3	6.0	5.7	5.3	5.9
02BS1	6.3	6.3	5.7	7.0	5.7	5.7	5.3	6.0	5.9

Table 2 *(cont)*. Perennial Ryegrass NTEP results 2018 for spring green-up, genetic color (ratings 1-9, where 9 equals darker green), turfgrass quality (rating 1-9, where 9 equals the highest turf quality). Table is listed with highest mean quality cultivars listed first.

	Spring Green Up	Genetic color	Quality						
Entry	04/19/18	06/06/18	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	mean
Allstar III	6.0	7.0	5.3	6.7	5.7	5.7	6.3	5.7	5.9
Mensa	5.3	6.7	6.7	7.3	6.3	5.7	3.3	5.7	5.8
GO-142	5.3	7.0	5.0	7.0	5.7	5.0	6.7	5.7	5.8
FP2	7.0	7.0	6.3	6.0	6.0	6.3	5.3	5.0	5.8
PPG-PR 329	6.3	6.3	5.3	6.7	6.0	6.7	5.0	5.3	5.8
Grand Slam GLD	6.7	7.0	6.3	6.3	6.0	5.3	5.3	5.7	5.8
PST-2PDA	6.7	7.0	6.0	6.3	5.0	5.7	6.7	5.3	5.8
PR-5-16	5.7	7.0	6.7	6.3	6.0	5.7	4.7	5.7	5.8
BSP-17	6.0	8.7	5.0	6.0	5.0	6.3	6.3	6.0	5.8
PPG-PR 385	5.7	6.7	6.7	6.7	6.0	5.7	4.3	5.3	5.8
DLFPS-236-3556	6.7	7.7	6.3	6.3	6.3	4.7	5.0	5.7	5.7
Apr-12	5.3	6.0	5.0	5.7	6.7	5.7	6.0	5.3	5.7
Apr-60	5.3	7.0	5.7	6.7	6.0	6.0	4.7	5.0	5.7
PST-2CRP	5.7	7.3	6.0	7.3	5.7	5.0	4.3	5.3	5.6
RAD-PR-103	6.0	7.7	5.0	7.7	5.0	4.7	5.7	5.7	5.6
AMP-R1	5.3	7.3	5.3	7.3	5.0	4.7	6.0	5.0	5.6
Karma	5.3	6.7	6.0	6.0	5.3	6.0	5.0	5.0	5.6
LPB-SD-105	5.0	7.7	6.0	7.7	6.7	5.3	3.3	4.0	5.5
LPB-SD-103	5.7	7.0	6.0	6.3	6.3	4.3	4.3	5.7	5.5
CS-6	5.0	7.3	5.7	6.0	5.7	5.0	4.7	6.0	5.5
GO-141	5.7	6.7	5.3	6.7	5.7	5.0	5.3	5.0	5.5
ASP0116EXT	5.3	8.3	5.0	5.0	5.0	6.0	6.3	5.3	5.4
BWH	6.3	8.7	5.0	6.3	5.7	4.7	4.7	6.0	5.4
Brightstar SLT	5.0	6.0	5.3	6.0	5.0	6.0	5.0	5.0	5.4
SNX	5.7	8.3	5.3	5.7	6.0	4.7	5.0	5.3	5.3
BAR LP 6117	5.3	6.7	5.3	6.0	5.7	5.0	5.3	4.7	5.3
BAR LP 6131	4.7	6.3	5.0	6.3	5.3	4.7	5.7	5.0	5.3
BAR LP 6159	5.0	6.0	5.0	6.3	6.0	4.3	5.0	5.0	5.3
DLFPS-238/3014	5.0	6.7	5.3	6.3	5.3	4.7	5.3	4.7	5.3
GO-143	5.0	6.0	4.7	5.7	5.0	5.3	5.0	5.7	5.2
RAD-PR-112	5.0	7.7	4.3	5.7	5.7	5.0	5.0	5.3	5.2
JR-747	4.3	7.3	4.7	6.7	6.0	4.7	3.7	5.0	5.1
MRSL-PR16	5.0	6.7	5.3	6.7	4.7	4.0	5.0	4.7	5.1
BAR LP 6162	4.7	5.3	4.7	6.0	4.7	4.7	5.7	4.3	5.0
BSP-25	4.7	8.3	4.0	6.7	4.7	4.3	5.0	5.0	4.9
Linn	4.7	4.0	5.0	4.0	4.0	3.0	2.7	3.3	3.7
$LSD_{0.05}$	1.17	1.20	1.18	1.50	1.40	1.53	1.66	1.13	0.68
CV%	12.0	10.5	11.8	13.8	14.4	16.0	18.0	12.1	7.0

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NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2015 STANDARD AND ANCILLARY LOW INPUT COOL SEASON TEST – 2018 RESULTS

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INTRODUCTION

There has been increased interest to develop new plant management strategies, or to investigate new plant systems that require less input such as water, fertilizer, and pesticides. Overall quality and functionality are still desired. This trial is unique because after the establishment period, maintenance has been minimal. No supplemental water, fertilizer or pesticides have been applied. The only exception is with the ancillary trial, where one preemergent application was made in the first year of the study. Also unique about this trial is that it not only includes single turfgrass cultivars, it includes, blends, mixtures and mixtures with grass and non-grass species.

In 2015, the National Turfgrass Evaluation Program (NTEP) selected thirteen standard testing locations and thirteen ancillary test locations for their 2015 Low Input Cool-Season Trials. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected for both a Standard and Ancillary site. The duration of this study is five years and will conclude in the fall of 2020.

The National Turfgrass Evaluation Program (NTEP) is sponsored by the Beltsville Agriculture Research Center and the National Turfgrass Federation Inc. NTEP works with breeders and testing sites throughout the United States in evaluating turfgrass species and cultivars. This low input study differs from conventional NTEP trials in two ways. One is that many of the entries are not single cultivars or varieties being evaluated, they contain mixtures. The second difference is that many of the entries contain non-turfgrass species. Results from this trail may aid homeowners and professionals in their selection of low input species and mixtures that provide a suitable ground cover that will require less water, fertility and mowing.

MATERIALS AND METHODS

Two low-input trials were seeded on September 14, 2015 in Storrs Connecticut. One trial was a "standard" test while the second trial was an "ancillary" test. Each test consisted of thirty-two entries (Table 1) containing different species, different mixtures, and different compositions. Both, the ancillary and standard trial contained the same entries and received the same maintenance regimes. The only difference between the two trials was that the ancillary trial received a preemergent application for weeds in the spring of 2016. Sponsors and entries are listed in Table 1. A complete randomized block design with three replicates of each cultivar was utilized for each study. Plot size is 5' X 5'.

ESTABLISHMENT MANAGEMENT PRACTICES

After seeding, plots were covered to aid in germination and to reduce any chances of seed migration. All plots for each study received the same management protocol since establishment.

Mowing (Standard and Ancillary trials) - Plots are maintained at a mowing height of 3.25" inches and mowed when no more than 1/3 of the leaf is removed.

Irrigation Regime (Standard and Ancillary trials) - No irrigation

Fertilizer and pesticide applications (2015/2016)

- Standard and Ancillary trials - Plots received a total of 1 pound of nitrogen. 4/22/16
- Standard trial – No Preemergent applied
- Ancillary Trial – Preemergent applied on 4/29/16 (Prodiamine® 4L at .5oz./1000 ft^2)

DATA COLLECTION

Quality Ratings- Quality ratings are taken on a monthly basis throughout the growing season for overall quality (color/density). Overall quality is determined using a visual rating system of 1-9. A score of 1 illustrates the poorest quality and 9 the highest quality. (Table 2 standard test and Table 3 ancillary test).

Percent Living Ground Cover- Percent living cover ratings were taken after the growing season on November 19, 2018. (Table 2 standard test and Table 3 ancillary test).

Percent grassy and broadleaf weed encroachment Ratings – Weed encroachment ratings are taken twice per year, once in the spring and once in the fall. In 2018, ratings were done on July 7th and September 11th. (Table 2 standard test and Table 3 ancillary test).

RESULTS & DISCUSSION

Evaluating the different species and grasses for visual quality was/is challenging. This is especially true when comparing broadleaf entries such as clover with straight grass entries or grass and clover mixes. Visual ratings were most influenced by plant density of the original planted species. Many of the plots had a high level of weed encroachment from non-seeded species which negatively impacted their quality ratings. The mean quality ratings for the top four entries for both the standard and ancillary studies were CRS Mix #3, DLFPS-TFAM, DLFPS TFAStC, and "Vitality Low Maintenance Mix". The CRS Mix 3, consists of hard fescue and ten percent Dutch white clover. Both DLPS –TFAM and DLFPS TFAStC contained 97 percent tall fescue and 3 percent clover. Vitality Low Maintenance Mix consisted of 80 percent hard fescue and 20 percent chewings fescue (Table 1). While Yaak (100% a western yarrow) performed well in previous years, over all quality wasn't as good in 2018. For the second year in a row (2017 and 2018) Kenblue Kentucky bluegrass and 100% Dutch White Clover had the poorest rating in both trials. Visual differences between ancillary trial plots (receiving preemergent applications) and non- ancillary plots (not receiving preemergent applications) were minimal for the 2018 season.

Density ratings indicated that many of the original species planted had died off. The percentages of Kenblue that remained in the plots at the conclusion of the 2018 growing season were estimated to be about 10% for the standard trail and 7% for the ancillary trial.

In 2018 there was an extremely high level of weed encroachment in many of the plots. Clover was the predominate weed. Interestingly, plots that were seeded with 100% white clover were almost clover free, while plots seeded with mixtures that did not contain clover in the original seed mix were almost completely overtaken by clover. An example was the Kenblue plots. The predominant plant species in the planted Kenblue plots at the end of the 2018 season was clover. A complete population shift. One possible explanation for clover encroachment in many of the plots may be because plots have not received any supplemental nitrogen fertilization since establishment. Encroachment may also be occurring from neighboring plots that had clover in the original seed mix.

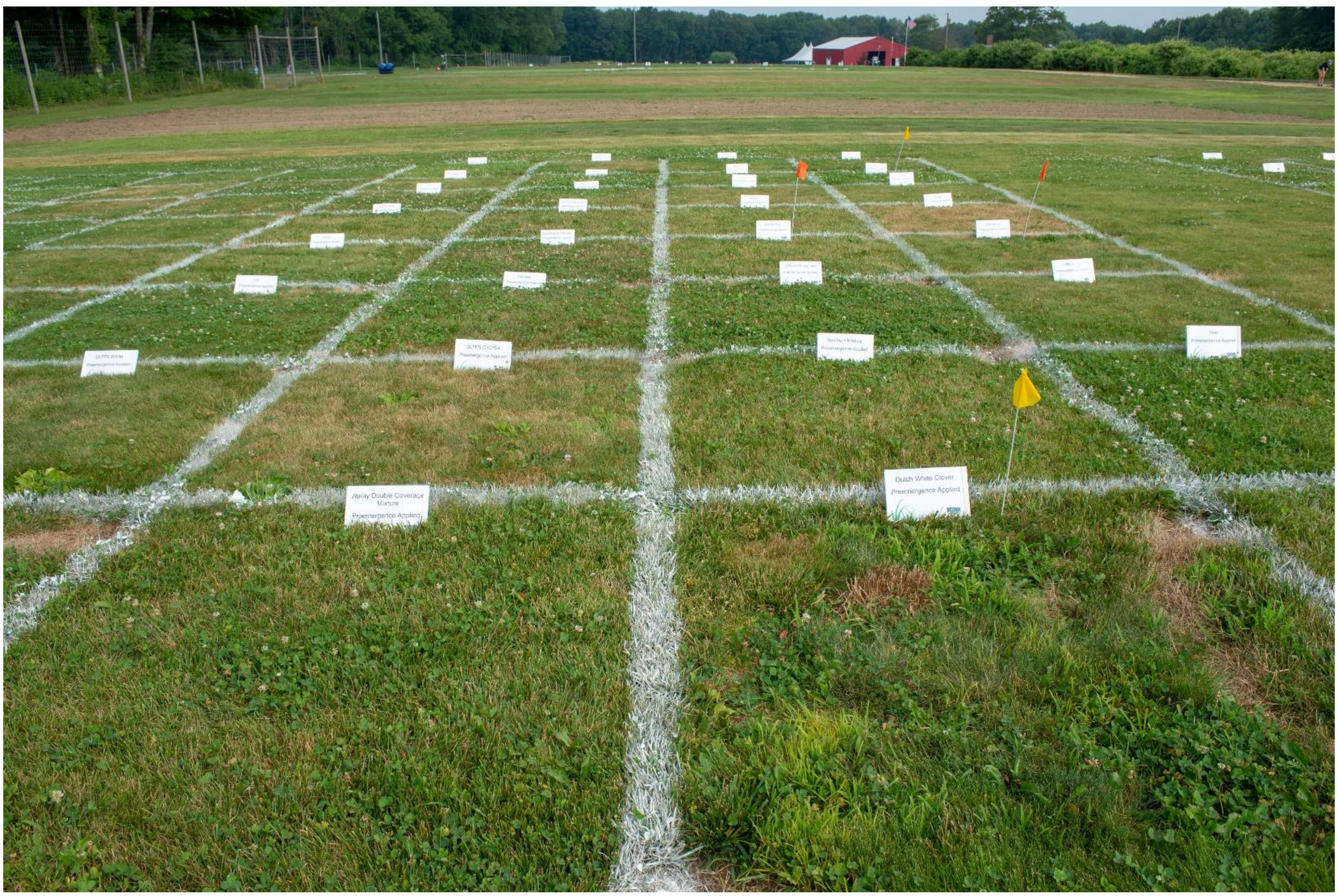

Figure 1- 2015 NTEP Low Input Cool Season Trials University of Connecticut Photo taken July 2018

Table 1 Entries, Species, and Composition of the 2015 Standard and Ancillary Low Input Cool-Season Tests

PLOT	ENTRY	SPECIES/COMPOSITION	SPONSOR
1	Natural Knit® PRG Mix	50% Mensa perennial ryegrass 50% Savant perennial ryegrass	Ledeboer Seed LLC
2	Bullseye	100% Bullseye tall fescue	Standard entry
3	Bewitched	100% Bewitched Ky. Bluegrass	Standard entry
4	BGR-TF3	100% BGR-TF3 tall fescue	Berger International LLC
5	MNHD-15	100% MNHD-15 hard fescue	University of Minnesota
6	DLFPS TF-A	33% Mustang tall fescue 33% Grande 3 tall fescue 34% Fayette tall fescue	DLF/Pickseed/Seed Research of Oregon
7	DLFPS ChCrM	24% Longfellow 3 chewings fescue 24% Windward chewings fescue 24% Chantilly strong creeping red fescue 25% Ruddy strong creeping red fescue (CRF) 3% Microclover™	DLF/Pickseed/Seed Research of Oregon
8	DLFPS ShHM	32% Quatro sheep fescue 32% Spartan II hard fescue 33% Eureka II hard fescue 3% Microclover™	DLF/Pickseed/Seed Research of Oregon
9	DLFPS TFAM	33% Mustang tall fescue 33% Grande 3 tall fescue 34% Fayette tall fescue 3% Microclover™	DLF/Pickseed/Seed Research of Oregon
10	Vitality Low Maintenance Mixture	80% VNS hard fescue 20% VNS chewings fescue	Landmark Turf & Native Seed
11	Vitality Double Coverage Mixture	90% VNS tall fescue 10% VNS Kentucky bluegrass	Landmark Turf & Native Seed
12	Chantilly	100% Chantilly strong creeping red fescue (CRF)	Standard entry
13	Dutch White Clover	100% Dutch White Clover	Standard entry
14	DLFPS TFAStC	32% Mustang tall fescue 32% Grande 3 tall fescue 33% Fayette tall fescue 3% Strawberry clover	DLF/Pickseed/Seed Research of Oregon
15	DLFPS ChCrSH	14% Longfellow 3 chewings fescue 14% Windward chewings fescue 14% Chantilly strong CRF 14% Ruddy strong CRF	DLF/Pickseed/Seed Research of Oregon
16	Spartan II	100% Spartan II hard fescue	Standard entry
17	Quatro	100% Quatro sheep fescue	Standard entry
18	Ky-31E+	100% Ky-31 tall fescue w/endophyte	Standard entry
19	CRS Mix #1	55% Gladiator hard fescue 45% 4GUD hard fescue	Columbia River Seed
20	CRS Mix #2	67% Gladiator hard fescue 33% NA13-14 Kentucky bluegrass	Columbia River Seed
21	CRS Mix #3	45% Gladiator hard fescue 45% Sword hard fescue 10% Dutch White Clover	Columbia River Seed
22	DTT Tall Fescue Mix	50% DTT20 tall fescue 50% DTT43 tall fescue	Allied Seed

PLOT	ENTRY	SPECIES/COMPOSITION	SPONSOR
23	DTTHO TF/KBG Mix	45% DTT20 tall fescue 45% DTT43 tall fescue 10% Holiday lawn Ky. Bluegrass	Allied Seed
24	A-SFT	100% A-SFT tall fescue	Allied Seed
25	Kingdom	100% Kingdom tall fescue	SiteOne Landscape Supply
26	7H7	100% 7H7 hard fescue	SiteOne Landscape Supply
27	Northern Mixture	40% VNS perennial ryegrass 20% VNS Kentucky bluegrass 20% VNS chewings fescue 20% VNS creeping red fescue	Proseeds Marketing
28	Southern Mixture	70% VNS tall fescue 10% VNS perennial ryegrass 10% VNS Kentucky bluegrass 10% VNS chewings fescue	Proseeds Marketing
29	CS Mix	40% Castle chewings fescue 40% Sword hard fescue 10% Kent creeping red fescue 10% B-15.2415 sheep fescue	Columbia Seeds LLC
30	Yaak	100% Yaak western yarrow	Pacific NW Natives
31	Radar	100% Radar chewings fescue	Standard entry
32	Kenblue	100% Kenblue Kentucky bluegrass	Standard entry

Table 2. NTEP Low Input Standard Test results 2018 spring green-up, percent Living cover for fall, percent weed coverage for spring and fall, and monthly visual quality (rating 1-9, where 9 equals the highest turf quality)

	Spring green up	Percent Living cover planted species	Percent weed coverage			Quality						
Entry	04/19/18	11/19/18	07/02/18	09/11/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
CRS Mix #3	6.7	94.7	2.0	8.3	5.2	6.7	7.3	7.3	6.7	7.0	6.7	6.9
DLFPS-TFAM	5.3	91.7	2.7	8.3	5.5	8.0	7.0	6.7	5.0	6.3	6.7	6.6
DLFPS TFAStC	3.7	88.3	2.0	13.3	7.7	7.7	7.3	6.0	4.0	5.7	5.7	6.1
CRS Mix #1	6.0	91.7	6.7	40.0	23.3	6.7	6.7	6.3	5.0	5.3	5.0	5.8
Vitality Low Maintenance Mix	5.3	88.3	6.3	50.0	28.2	6.7	6.3	6.7	4.3	4.7	5.3	5.7
Bullseye	4.7	93.0	38.3	41.7	40.0	5.7	5.7	5.3	4.0	5.3	5.7	5.3
DLFPS TF-A	2.7	91.7	20.7	40.0	30.3	5.7	6.3	5.7	3.0	4.7	6.3	5.3
MNHD-15	5.0	76.7	18.3	65.0	41.7	5.7	5.7	6.0	4.7	4.3	5.3	5.3
Southern Mixture	5.0	83.3	23.3	46.7	35.0	7.0	6.3	5.7	2.3	5.0	4.7	5.2
7H7	5.7	71.7	20.7	65.0	42.8	5.7	6.0	5.7	4.7	4.0	4.7	5.1
BGR-TF3	3.7	93.3	19.0	53.3	36.2	6.0	6.0	6.0	3.3	4.0	5.3	5.1
CS Mix	5.3	83.3	11.0	75.0	43.0	6.0	5.3	6.0	4.3	3.7	5.0	5.1
DLFPS-ShHM	6.0	80.0	3.0	50.0	26.5	5.7	6.7	6.0	3.3	3.7	5.0	5.1
CRS Mix #2	5.7	86.7	25.0	63.3	44.2	5.3	5.3	5.7	4.3	4.0	4.7	4.9
Vitality Double Coverage Mix	3.3	86.7	37.0	68.3	52.7	5.3	5.0	5.3	4.3	4.0	5.3	4.9
DLFPS-ChCrM	7.3	88.3	4.7	53.3	29.0	5.7	5.7	4.3	4.0	3.7	5.7	4.8
Kingdom	3.7	90.0	35.3	75.0	55.2	5.0	5.7	5.3	4.3	3.3	5.3	4.8
Yaak	3.3	43.3	25.0	73.3	49.2	7.0	6.3	5.3	4.0	3.0	3.3	4.8
Spartan II	6.7	65.0	13.7	78.3	46.0	6.3	6.0	6.0	3.7	2.7	3.3	4.7
DTT Tall Fescue Mix	4.3	90.0	31.0	73.3	52.2	6.0	5.0	5.3	3.0	3.3	4.7	4.6
Ky-31 E+	3.0	73.3	26.0	38.3	32.2	5.7	5.3	4.3	3.3	4.7	4.0	4.6
Quatro	5.7	56.7	14.7	68.3	41.5	6.3	5.7	5.7	3.3	3.3	3.0	4.6
A-SFT	4.7	85.0	28.3	56.7	42.5	5.0	5.0	5.0	2.7	4.0	5.3	4.5
Radar	7.3	80.0	20.3	76.7	48.5	5.7	5.7	4.7	3.3	3.3	4.3	4.5
DLFPS ChCrSH	5.3	76.7	17.0	80.0	48.5	4.7	5.3	5.3	2.7	3.0	5.0	4.3

<u>Table 2</u> *(cont)*. NTEP Low Input Standard Test results 2018 spring green-up, percent Living cover for fall, percent weed coverage for spring and fall, and monthly visual quality (rating 1-9, where 9 equals the highest turf quality)

	Spring green up	Percent Living cover planted species	Percent weed coverage			Quality						
Entry	04/19/18	11/19/18	07/02/18	09/11/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
DTTHO TF/KBG Mix	3.0	78.3	48.3	75.0	61.7	5.0	4.3	4.0	4.0	3.0	4.0	4.1
Chantilly	7.3	63.3	48.3	90.0	69.2	4.3	4.7	4.7	2.7	2.7	3.7	3.8
Northern Mixture	5.3	41.7	36.7	91.0	63.8	4.0	4.3	4.7	1.7	1.7	3.0	3.2
Natural Knit®PRG Mix	6.3	66.7	58.3	90.0	74.2	3.7	4.0	4.3	1.7	2.0	3.3	3.2
Bewitched	5.0	63.3	86.7	93.0	89.8	3.0	2.0	3.7	2.7	2.3	4.0	2.9
Kenblue	4.7	2.3	60.0	96.0	78.0	2.3	3.0	3.0	1.0	1.3	1.0	1.9
Dutch White Clover	2.3	1.3	90.0	90.0	90.0	1.0	1.3	2.3	1.0	1.7	1.0	1.4
$LSD_{0.05}$	1.62	26.37	30.91	33.55	28.68	1.32	1.63	1.33	1.73	1.75	1.63	1.00
CV%	20.0	21.8	68.8	33.1	39.2	14.9	18.5	15.4	30.2	28.5	22.0	13.2

Table 3. **NTEP Low Input Ancillary Test results 2018 Ratings for spring green-up, percent living cover for fall, percent weed coverage for spring and fall, and monthly visual quality (rating 1-9, where 9 equals the highest turf quality)**

	Spring green up	Percent Living cover planted species	Percent weed coverage			Quality						
Entry	04/19/18	11/19/18	07/02/18	09/11/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
CRS Mix #3	5.0	92.7	1.0	10.0	5.5	6.0	7.3	7.7	6.3	7.0	7.0	6.9
DLFPS-TFAM	3.3	96.0	3.0	20.0	11.5	6.7	7.7	6.7	5.7	6.3	6.3	6.6
DLFPS TFAStC	4.3	96.0	20.7	33.3	27.0	6.7	6.0	5.7	6.0	6.3	6.3	6.2
Vitality Low Maintenance Mix	5.0	91.7	5.7	40.0	22.8	5.3	6.7	6.0	5.7	5.7	6.0	5.9
CS Mix	6.0	84.3	23.7	43.3	33.5	5.7	6.3	5.7	5.3	5.3	6.3	5.8
Bullseye	4.0	94.3	26.7	28.3	27.5	5.7	6.0	4.7	6.0	5.7	6.0	5.7
DLFPS-ShHM	5.3	58.3	4.0	36.7	20.3	5.3	6.3	6.3	5.7	5.3	5.0	5.7
DLFPS-ChCrM	7.3	88.3	2.7	46.7	24.7	6.3	6.0	5.3	5.7	5.0	5.3	5.6
Radar	7.0	85.0	13.3	46.7	30.0	5.7	6.0	5.3	4.7	5.3	5.7	5.4
MNHD-15	5.7	75.0	23.3	58.3	40.8	4.3	6.3	5.7	5.3	4.7	5.7	5.3
Spartan II	6.0	78.3	9.3	53.3	31.3	5.7	6.0	5.7	5.3	4.3	5.0	5.3
Vitality Double Coverage Mix	3.7	93.3	33.3	50.0	41.7	5.7	4.7	6.0	4.3	4.3	6.0	5.2
CRS Mix #1	6.0	81.3	20.7	58.3	39.5	5.3	5.0	5.7	5.7	3.7	5.7	5.2
DLFPS TF-A	4.0	94.3	23.3	50.0	36.7	4.7	5.0	5.0	5.0	4.3	6.0	5.0
CRS Mix #2	5.0	89.3	39.0	61.7	50.3	5.3	5.0	5.7	5.3	3.3	5.0	4.9
Kingdom	4.0	90.0	43.3	66.7	55.0	5.0	4.3	4.7	4.7	4.7	5.7	4.8
DLFPS ChCrSH	6.0	66.7	20.7	85.0	52.8	5.7	5.0	5.3	3.7	2.7	5.7	4.7
Southern Mixture	4.3	85.0	48.3	83.3	65.8	6.0	5.3	4.7	3.3	4.0	4.3	4.6
DTT Tall Fescue Mix	4.3	88.3	41.7	80.0	60.8	4.0	4.7	4.3	4.3	4.0	5.3	4.4
BGR-TF3	4.3	93.0	50.0	61.7	55.8	4.0	4.7	3.3	3.7	4.0	6.0	4.3
A-SFT	4.3	86.7	40.0	81.7	60.8	4.0	4.7	4.7	4.0	2.7	5.3	4.2
7H7	6.3	56.7	48.3	85.0	66.7	4.7	4.3	4.3	5.0	3.0	4.0	4.2
DTTHO TF/KBG Mix	4.0	80.0	56.7	83.3	70.0	4.0	4.0	4.3	3.7	3.7	5.3	4.2
Chantilly	7.3	51.7	30.0	81.7	55.8	4.3	4.3	4.3	3.7	4.0	4.0	4.1

<u>Table 3 *(cont)*.</u> NTEP Low Input Ancillary Test results 2018 Ratings for spring green-up, percent living cover for fall, percent weed coverage for spring and fall, and monthly visual quality (rating 1-9, where 9 equals the highest turf quality)

	Spring green up	Percent Living cover planted species	Percent weed coverage			Quality						
Entry	04/19/18	11/19/18	07/02/18	09/11/18	Mean	05/07/18	06/06/18	07/02/18	08/14/18	09/11/18	10/26/18	Mean
Yaak	3.0	43.3	30.0	73.3	51.7	5.7	5.3	3.0	4.0	3.0	3.7	4.1
Ky-31 E+	3.0	66.7	55.0	66.7	60.8	5.3	4.0	3.7	4.3	3.0	3.7	4.0
Northern Mixture	7.0	66.7	53.3	80.0	66.7	5.3	4.0	3.3	3.3	2.3	2.3	3.4
Quatro	5.0	33.3	51.7	70.0	60.8	4.0	3.7	4.7	2.7	2.3	2.3	3.3
Bewitched	7.3	76.7	86.7	81.7	84.2	3.0	2.7	2.7	3.3	3.0	3.0	2.9
Natural Knit®PRG Mix	5.7	56.7	48.3	83.3	65.8	2.7	4.3	2.3	2.0	2.7	2.7	2.8
Kenblue	6.7	11.7	91.7	95.7	93.7	2.7	2.0	2.0	1.7	1.3	1.3	1.8
Dutch White Clover	2.0	0.7	91.7	95.7	93.7	1.0	1.7	1.0	1.0	1.0	1.0	1.1
$LSD_{0.05}$	1.36	20.58	29.25	33.28	25.83	1.66	1.46	1.71	1.54	2.06	1.46	1.04
CV%	16.4	17.2	50.4	32.8	32.4	20.8	17.9	22.3	21.5	31.7	18.8	13.7

Acknowledgements: The National Turfgrass Evaluation Program funds this project.

2018 ALLIANCE FOR LOW INPUT SUSTAINABLE TURFGRASSES (ALIST) – PERENNIAL RYEGRASS

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INTRODUCTION

The Alliance for Low Input Sustainable Turf (ALIST) is a non-profit organization that seeks to develop guidelines for sustainable turfgrass growth. The variety evaluation trial program was initiated by turfgrass breeders of independent commercial seed companies to support evaluation of both experimental and commercial cultivars, both of high turf quality and low-input performance. The following companies contributed germplasm for evaluation: Mountain View Seeds, Seed Research of Oregon, Lebanon Turf, Landmark Turf and Native Seed, and DLF Pickseed. The University of Connecticut is one of eight universities that serves as an ALIST Cooperator. The 2016 Perennial Ryegrass Trial has eight locations. Site cooperators collect data on visual turf quality and digital image analysis. Cultivars are evaluated for two years from the date of establishment.

MATERIALS AND METHODS

Twenty-four cultivars of perennial ryegrass were established on September 26, 2016 at the Plant Science Research and Education Facility in Storrs, CT. A complete randomized block design with four replicates of each cultivar was utilized for this study. Plot size was 3' X 5'. Cultivars, species, and sponsors are listed in Table 1.

All cultivars received the same management protocol during establishment and during the first year of evaluation. Plots were seeded on 9/26/2016 and were fertilized at the time of seeding at the rate of 1 #N/1,000 ft^2. Once seeding was completed, the plots were protected with a Remay turf cover until germination was evident. Plots were seeded at a rate of 7 lb. seed per 1,000 ft^2. 'Karma' perennial ryegrass was seeded around the perimeter of the trial.

Plots were managed under a low maintenance regime that consisted of a mowing height of 2.5 in., mown once a week with clippings returned. The plots were fertilized on May 11, 2018 and received 1#N/1,000 ft^2 of a 50% slow 30-0-6, applied in 2 directions. Prodiamine was applied on 5/3/2018 at a rate of .48 fl. oz./A. As a revision to standard ALIST maintenance protocol, a broadleaf herbicide application was requested. An application of T-Zone at the rate of 1.5 fl. oz/m was applied on 8/24/2018. No supplemental irrigation was applied in 2018.

All tests were visually rated each month throughout the growing season (May-November) on a scale of 1-9, where a score of 1 represented the poorest quality and 9 represented the most desirable turf quality. A subjective visual rating for turf quality included observations on overall turf performance, turf density, texture, color, as well as any impacts of weed, disease and insect pressure. The monthly and mean quality ratings are provided in Tables 2 and 3.

Additionally, digital image analysis (DIA) was captured 7 times during the growing season (5/11/18, 6/8/18, 7/9/18, 8/09/2018, 9/17/2018, 10/17/2018, 11/05/18) and was used to quantify dark green color and percent green cover (Karcher and Richardson, 2005). The digital images were scanned by Sigma Scan software (Cranes Software International Ltd. Chicago, IL. 1991).

RESULTS & DISCUSSION

Overall data for turfgrass quality ratings and percent green color are presented in Tables 2 and 3. Turfgrass quality ratings were impacted by drought stress, disease, and broadleaf weed pressure that increased as the summer season progressed. Turf quality means for 2016 perennial ryegrass ALIST test ranged from 6.0 – 4.1 with LSD of .40.

Little diversity in turf quality was evident between the cultivars of the top statistical group, which included DLFPS 3538, DLFPS 3548, PPG-PR-329, DLFPS 3543, DLFPS 3556, PPG-PR-367, DLFPS-3541, PPG-PR-385, DLFPS 3542, Stellar 3GL and Grand Slam GLD. Linn PRG exhibited the poorest turf quality.

The top statistical group of cultivars with the highest mean of percent green cover included LTP-FCB, DLFPS-3556, Pharoah, Man O'War, PPG-PR-329, PPG-PR-343, DLFPS-3541, PPG-PR-339, Stellar 3GL, DLFPS-3548 and DLFPS-3538. Linn PRG exhibited the poorest mean for percent green cover.

Table 1. Perennial Ryegrass, Cultivars and Sponsors

PLOT	CULTIVAR	SPONSOR
1	DLFPS-3538	DLF Pickseed USA
2	DLFPS-3540	DLF Pickseed USA
3	DLFPS-3541	DLF Pickseed USA
4	DLFPS-3542	DLF Pickseed USA
5	DLFPS-3543	DLF Pickseed USA
6	DLFPS-3548	DLF Pickseed USA
7	DLFPS-3556	DLF Pickseed USA
8	SR-4650	DLF Pickseed USA
9	Tetradark	DLF Pickseed USA
10	Karma	DLF Pickseed USA
11	Seabiscuit	Lebanon Turf Products
12	Man O' War	Lebanon Turf Products
13	Pharoah	Lebanon Turf Products
14	LTP-FCB	Lebanon Turf Products
15	LTP-DF	Lebanon Turf Products
16	PPG-PR 329	Mountain View Seeds
17	PPG-PR 339	Mountain View Seeds
18	PPG-PR 343	Mountain View Seeds
19	PPG-PR 367	Mountain View Seeds
20	PPG-PR 385	Mountain View Seeds
21	PPG-PR 419	Mountain View Seeds
22	Stellar 3GL	Mountain View Seeds
23	Grand Slam GLD	Mountain View Seeds
24	Linn	Mountain View Seeds

Table 2. ALIST Results 2018: Sorted by Highest Mean Quality

		Quality								Green Cover, %							
Entry no.	**Entry**	**05/11/18**	**06/08/18**	**07/09/18**	**08/09/18**	**09/17/18**	**10/17/18**	**11/05/18**	**Mean**	**05/11/18**	**06/08/18**	**07/09/18**	**08/09/18**	**09/17/18**	**10/17/18**	**11/05/18**	**Mean**
1	DLFPS-3538	5.5	6.5	6.8	7.0	7.8	7.5	7.5	**6.9**	86.5	96.3	89.2	94.3	91.1	95.8	93.1	**87.2**
6	DLFPS-3548	5.3	6.3	6.5	6.5	7.8	8.0	8.0	**6.9**	86.6	97.3	85.8	92.6	94.8	98.2	96.9	**87.4**
16	PPG-PR-329	5.3	6.5	6.3	6.5	7.8	7.5	7.5	**6.8**	86.9	96.7	86.4	94.2	91.2	97.1	96.4	**88.0**
5	DLFPS-3543	5.3	5.8	6.3	6.3	7.5	7.8	7.8	**6.6**	88.1	97.0	87.9	94.6	94.9	97.7	96.5	**88.7**
7	DLFPS-3556	5.0	6.0	5.8	6.3	7.5	7.8	7.5	**6.5**	87.5	96.1	86.2	95.7	94.6	97.4	97.8	**89.2**
19	PPG-PR-367	5.8	6.0	6.0	6.3	6.5	7.8	7.5	**6.5**	91.7	95.9	84.0	92.4	88.7	96.9	97.6	**86.4**
3	DLFPS-3541	5.0	5.3	6.3	6.5	7.3	7.5	7.5	**6.5**	88.2	96.5	88.4	93.4	90.5	97.8	97.8	**87.8**
20	PPG-PR-385	5.3	6.0	6.3	6.3	6.8	7.5	7.3	**6.5**	81.2	95.6	85.0	93.2	90.9	94.9	93.0	**85.4**
4	DLFPS-3542	5.0	5.8	5.8	6.3	7.3	7.5	7.5	**6.4**	93.0	96.9	85.0	93.2	90.1	97.5	96.6	**87.0**
22	Stellar 3GL	5.3	6.0	6.0	6.0	7.3	7.5	7.0	**6.4**	89.8	95.3	86.2	94.2	91.6	97.4	95.2	**87.5**
23	Grand Slam	5.0	5.5	6.3	6.3	6.8	7.8	7.5	**6.4**	91.5	95.6	89.1	92.9	91.5	96.7	97.0	**86.8**
14	LTP-FCB	5.5	5.3	6.0	6.3	7.0	7.5	7.3	**6.4**	94.0	96.3	92.3	94.5	94.7	97.6	97.9	**89.8**
17	PPG-PR-339	5.3	5.8	6.0	6.5	6.5	7.5	7.3	**6.4**	83.2	95.4	87.4	94.3	91.3	97.0	96.7	**87.8**
18	PPG-PR-343	5.3	5.8	5.8	5.8	6.8	7.5	7.0	**6.3**	89.3	96.6	91.0	92.6	93.0	96.2	94.7	**87.8**
21	PPG-PR-419	5.3	5.8	5.8	6.0	6.3	7.5	7.3	**6.3**	83.4	96.2	87.5	93.1	90.8	96.5	94.8	**86.7**
12	Man O'War	5.0	5.5	5.5	5.8	6.8	7.5	7.3	**6.2**	89.5	96.0	91.1	93.0	94.1	97.8	97.7	**88.7**
2	DLFPS-3540	5.0	5.8	6.0	6.0	6.3	7.0	7.0	**6.1**	85.8	95.6	86.0	93.7	90.4	96.5	95.2	**85.4**
13	Pharoah	5.0	5.0	5.3	5.8	6.5	7.8	7.3	**6.1**	90.5	96.0	91.1	93.5	93.7	98.4	97.8	**89.2**
8	SR-4650	4.8	5.0	5.5	6.0	6.5	7.5	7.0	**6.0**	87.6	96.4	87.3	93.4	89.5	95.7	94.7	**86.5**
10	Karma	5.0	5.0	5.3	5.8	6.5	7.0	7.0	**5.9**	87.4	95.9	83.6	93.1	89.0	94.4	91.5	**85.1**
15	LTP-DF	5.0	5.3	5.3	6.0	5.8	7.0	7.0	**5.9**	86.4	95.9	86.7	92.2	87.9	96.6	96.5	**85.4**
11	Seabiscuit	4.8	5.3	4.8	5.5	6.3	7.5	7.0	**5.9**	85.8	94.1	88.9	91.0	92.5	94.8	94.1	**86.8**
9	Tetradark	4.8	4.8	4.8	5.3	5.3	6.5	6.3	**5.4**	95.9	93.2	90.0	90.0	79.8	90.8	85.6	**83.7**
24	Linn	4.0	3.8	4.0	4.5	4.0	4.3	4.0	**4.1**	90.7	90.3	86.5	85.6	70.6	83.5	82.7	**77.8**
	$LSD_{0.05}$	0.59	0.76	1.07	0.89	1.12	0.87	0.68	**0.56**	5.88	1.73	5.56	3.10	6.58	1.96	2.24	**2.64**
	CV%	8.2	9.7	13.2	10.4	11.9	8.4	6.7	**6.4**	4.7	1.3	4.5	2.4	5.2	1.4	1.7	**2.2**

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Table 3. ALIST Results 2018: Sorted by Highest Mean Cover

		Quality								Green Cover, %							
Entry no.	**Entry**	**05/11/18**	**06/08/18**	**07/09/18**	**08/09/18**	**09/17/18**	**10/17/18**	**11/05/18**	**Mean**	**05/11/18**	**06/08/18**	**07/09/18**	**08/09/18**	**09/17/18**	**10/17/18**	**11/05/18**	**Mean**
14	LTP-FCB	5.5	5.3	6.0	6.3	7.0	7.5	7.3	**6.4**	94.0	96.3	92.3	94.5	94.7	97.6	97.9	**89.8**
7	DLFPS-3556	5.0	6.0	5.8	6.3	7.5	7.8	7.5	**6.5**	87.5	96.1	86.2	95.7	94.6	97.4	97.8	**89.2**
13	Pharoah	5.0	5.0	5.3	5.8	6.5	7.8	7.3	**6.1**	90.5	96.0	91.1	93.5	93.7	98.4	97.8	**89.2**
5	DLFPS-3543	5.3	5.8	6.3	6.3	7.5	7.8	7.8	**6.6**	88.1	97.0	87.9	94.6	94.9	97.7	96.5	**88.7**
12	Man O'War	5.0	5.5	5.5	5.8	6.8	7.5	7.3	**6.2**	89.5	96.0	91.1	93.0	94.1	97.8	97.7	**88.7**
16	PPG-PR-329	5.3	6.5	6.3	6.5	7.8	7.5	7.5	**6.8**	86.9	96.7	86.4	94.2	91.2	97.1	96.4	**88.0**
18	PPG-PR-343	5.3	5.8	5.8	5.8	6.8	7.5	7.0	**6.3**	89.3	96.6	91.0	92.6	93.0	96.2	94.7	**87.8**
3	DLFPS-3541	5.0	5.3	6.3	6.5	7.3	7.5	7.5	**6.5**	88.2	96.5	88.4	93.4	90.5	97.8	97.8	**87.8**
17	PPG-PR-339	5.3	5.8	6.0	6.5	6.5	7.5	7.3	**6.4**	83.2	95.4	87.4	94.3	91.3	97.0	96.7	**87.8**
22	Stellar 3GL	5.3	6.0	6.0	6.0	7.3	7.5	7.0	**6.4**	89.8	95.3	86.2	94.2	91.6	97.4	95.2	**87.5**
6	DLFPS-3548	5.3	6.3	6.5	6.5	7.8	8.0	8.0	**6.9**	86.6	97.3	85.8	92.6	94.8	98.2	96.9	**87.4**
1	DLFPS-3538	5.5	6.5	6.8	7.0	7.8	7.5	7.5	**6.9**	86.5	96.3	89.2	94.3	91.1	95.8	93.1	**87.2**
4	DLFPS-3542	5.0	5.8	5.8	6.3	7.3	7.5	7.5	**6.4**	93.0	96.9	85.0	93.2	90.1	97.5	96.6	**87.0**
23	Grand Slam	5.0	5.5	6.3	6.3	6.8	7.8	7.5	**6.4**	91.5	95.6	89.1	92.9	91.5	96.7	97.0	**86.8**
11	Seabiscuit	4.8	5.3	4.8	5.5	6.3	7.5	7.0	**5.9**	85.8	94.1	88.9	91.0	92.5	94.8	94.1	**86.8**
21	PPG-PR-419	5.3	5.8	5.8	6.0	6.3	7.5	7.3	**6.3**	83.4	96.2	87.5	93.1	90.8	96.5	94.8	**86.7**
8	SR-4650	4.8	5.0	5.5	6.0	6.5	7.5	7.0	**6.0**	87.6	96.4	87.3	93.4	89.5	95.7	94.7	**86.5**
19	PPG-PR-367	5.8	6.0	6.0	6.3	6.5	7.8	7.5	**6.5**	91.7	95.9	84.0	92.4	88.7	96.9	97.6	**86.4**
15	LTP-DF	5.0	5.3	5.3	6.0	5.8	7.0	7.0	**5.9**	86.4	95.9	86.7	92.2	87.9	96.6	96.5	**85.4**
2	DLFPS-3540	5.0	5.8	6.0	6.0	6.3	7.0	7.0	**6.1**	85.8	95.6	86.0	93.7	90.4	96.5	95.2	**85.4**
20	PPG-PR-385	5.3	6.0	6.3	6.3	6.8	7.5	7.3	**6.5**	81.2	95.6	85.0	93.2	90.9	94.9	93.0	**85.4**
10	Karma	5.0	5.0	5.3	5.8	6.5	7.0	7.0	**5.9**	87.4	95.9	83.6	93.1	89.0	94.4	91.5	**85.1**
9	Tetradark	4.8	4.8	4.8	5.3	5.3	6.5	6.3	**5.4**	95.9	93.2	90.0	90.0	79.8	90.8	85.6	**83.7**
24	Linn	4.0	3.8	4.0	4.5	4.0	4.3	4.0	**4.1**	90.7	90.3	86.5	85.6	70.6	83.5	82.7	**77.8**
	$LSD_{0.05}$	0.59	0.76	1.07	0.89	1.12	0.87	0.68	**0.56**	5.88	1.73	5.56	3.10	6.58	1.96	2.24	**2.64**
	CV%	8.2	9.7	13.2	10.4	11.9	8.4	6.7	**6.4**	4.7	1.3	4.5	2.4	5.2	1.4	1.7	**2.2**

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2018 ALLIANCE FOR LOW INPUT SUSTAINABLE TURFGRASSES (ALIST) – KENTUCKY BLUEGRASS

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INTRODUCTION

The Alliance for Low Input Sustainable Turf (ALIST) is a non-profit organization that seeks to develop guidelines for sustainable turfgrass growth. The variety evaluation trial program was initiated by turfgrass breeders of independent commercial seed companies to support evaluation of both experimental and commercial cultivars, both of high turf quality and low-input performance. The following companies contributed germplasm for evaluation: Mountain View Seeds, Seed Research of Oregon, Lebanon Turf, Landmark Turf and Native Seed, and DLF Pickseed. The University of Connecticut is one of the universities that serves as an ALIST Cooperator. The 2018 Kentucky Bluegrass Trial has 8 locations. Site cooperators collected data on visual turf quality and digital image analysis. Cultivars are evaluated for two years from the date of establishment.

MATERIALS AND METHODS

Twenty-four cultivars of Kentucky bluegrass were established on September 21, 2017 at the Plant Science Research and Education Facility in Storrs, CT. A complete randomized block design with four replicates of each cultivar was utilized for this study. Plot size was 3’ X 5’. Cultivars, species, and sponsors are listed in Table 1.

All cultivars received the same management protocol during establishment and during the first year of evaluation. Plots were seeded on 9/21/2017 and were fertilized at the time of seeding at the rate of 1 pound of nitrogen per 1,000 ft^2. Once seeding was completed, the plots were protected with a Remay turf cover until germination was evident. Plots were seeded at a rate of 2.2 lb. seed per 1,000 ft^2. ‘Benchmark’ perennial ryegrass was seeded around the perimeter of the trial.

Plots were managed under a low maintenance regime that consisted of a mowing height of 2.5 in., mown twice per week with clippings returned. The plots were fertilized on May 10, 2018 and received 1#N/1,000 ft^2 of a 50% slow 30-0-6, applied in 2 directions. Mesotrione was applied in three applications (5/13/2018, 5/24/2018, and 6/21/18) at a rate of .5, .2, .3 fl. oz./A, respectively. .5#N/1,000 ft^2 of a 60% slow 25-0-12, was applied in two directions on 7/9/2018. A broadleaf herbicide application was included as a revision to standard maintenance protocol. Therefore, an application of T-Zone at the rate of 1.5 fl.oz/m was applied on 8/24/2018. Supplemental irrigation was applied if needed during establishment in 2017 and in the spring of 2018.

All tests were visually rated each month throughout the growing season (May-November) on a scale of 1-9, where a score of 1 represented the poorest quality and 9 represented the most desirable turf quality. A subjective visual rating for turf quality included observations on overall turf performance, turf density, texture, color, as well as any impacts of weed, disease and insect pressure. The monthly and mean quality ratings are provided in Tables 2 and 3.

Additionally, digital image analysis (DIA) was captured 3 times during the growing season (9/17/2018, 10/17/2018, 11/07/2018) and was used to quantify dark green color and percent green cover (Karcher and Richardson, 2005). The digital images were scanned by Sigma Scan software (Cranes Software International Ltd. Chicago, IL. 1991).

RESULTS & DISCUSSION

Overall data for turfgrass quality ratings and percent green color are presented in Tables 2 and 3. Turfgrass quality ratings were impacted by drought stress, disease, and broadleaf weed pressure that increased as the growing season progressed. Turf quality means for 2018 Kentucky bluegrass ALIST test ranged from 6.9 – 4.9 with LSD of .61.

Little diversity in turf quality was evident between the cultivars of the top statistical group, which included Martha (A06-46), Jackrabbit, LTP-11-41, SRX-466, A12-7, SRX-2758, A11-38, PPG-KB 1320, Fullback and 5321. Bordeaux exhibited the poorest turf quality.

The top statistical group of cultivars with the highest mean percent green cover included SRX-466, 5321, LTP-11-41, A11-40, SRX-2758, Keeneland, A12-34, PPG-KB 1320, Martha, Zinfandel, Fullback, and Merlot. MVS-130 exhibited the poorest mean for percent green cover.

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PLOT	CULTIVAR	SPONSOR
1	Champagne	Lebanon Turf Products
2	Hampton	Landmark Turf & Native Seed
3	PPG-KB 1131	Mountain View Seeds
4	Keeneland	DLF Pickseed USA
5	Bordeaux	Lebanon Turf Products
6	Bluebank	Landmark Turf & Native Seed
7	A12-34	Mountain View Seeds
8	SRX-2758	DLF Pickseed USA
9	Zinfandel	Lebanon Turf Products
10	Fullback	Landmark Turf & Native Seed
11	A11-38	Mountain View Seeds
12	5321	DLF Pickseed USA
13	Merlot	Lebanon Turf Products
14	NAI-13-14	Landmark Turf & Native Seed
15	MVS-130	Mountain View Seeds
16	Jackrabbit	DLF Pickseed USA
17	LTP-11-41	Lebanon Turf Products
18	A12-7	Landmark Turf & Native Seed
19	PPG-KB 1320	Mountain View Seeds
20	SRX-466	DLF Pickseed USA
21	A11-40	Landmark Turf & Native Seed
22	Legend	Mountain View Seeds
23	Martha	DLF Pickseed USA
24	Control	DLF Pickseed USA

Table 1. Kentucky Bluegrass, Cultivars and Sponsors

Table 2. ALIST Results 2018: KBG Sorted by Highest Mean Quality

		Quality								Green Cover, %			
Entry no.	Entry	05/04/18	06/08/18	07/06/18	08/02/18	09/17/18	10/17/18	11/07/18	**Mean**	09/17/18	10/17/18	11/07/18	Mean
23	Martha (A06-46)	6.3	7.0	6.8	6.8	7.5	7.0	7.0	**6.9**	88.3	84.7	79.5	84.2
16	Jackrabbit	6.3	7.0	6.0	6.0	7.3	7.5	7.5	**6.8**	82.7	83.0	81.9	82.5
17	LTP-11-41	6.0	6.3	6.3	6.8	7.3	7.0	7.0	**6.6**	85.0	90.3	88.2	87.8
20	SRX-466	5.8	6.5	6.0	6.0	7.8	7.0	7.0	**6.6**	88.7	89.9	85.7	88.1
18	A12-7	5.5	6.3	6.3	6.5	7.0	7.3	7.0	**6.5**	85.9	85.4	76.9	82.7
8	SRX-2758	5.5	6.0	6.3	6.0	6.8	7.3	6.8	**6.4**	86.1	88.6	85.4	86.7
11	A11-38	5.3	5.8	6.3	6.5	7.0	7.3	6.5	**6.4**	83.8	83.2	80.7	82.6
19	PPG-KB 1320	5.3	5.5	5.8	6.3	7.0	7.3	7.3	**6.3**	89.0	87.4	79.4	85.3
10	Fullback	5.8	6.8	5.8	6.3	6.5	6.5	6.5	**6.3**	83.5	87.3	79.8	83.5
12	5321	5.0	6.0	6.3	6.5	6.5	6.8	6.8	**6.3**	91.0	89.7	83.5	88.1
2	Hampton	5.5	6.3	5.8	6.0	7.0	7.0	6.0	**6.2**	87.0	85.1	73.4	81.8
4	Keeneland	5.5	6.0	6.0	6.3	6.5	6.8	6.5	**6.2**	85.8	88.7	83.8	86.1
21	A11-40	5.5	5.5	5.5	6.3	6.8	6.8	6.8	**6.1**	89.9	89.8	82.9	87.5
6	Bluebank	5.5	5.5	5.3	6.0	7.3	6.8	6.5	**6.1**	86.8	71.4	72.1	76.8
14	NAI-13-14	5.5	5.0	5.8	6.0	7.3	6.8	6.3	**6.1**	88.0	72.7	76.1	78.9
13	Merlot	5.0	5.5	5.5	5.8	7.0	6.5	6.5	**6.0**	92.7	87.0	70.0	83.2
22	Legend	5.3	5.5	5.8	6.0	6.3	6.3	6.3	**5.9**	88.8	81.7	71.4	80.6
3	PPG-KB 1131	5.3	5.0	5.0	5.8	6.8	6.3	6.0	**5.7**	90.2	74.1	73.2	79.2
9	Zinfandel	4.8	5.3	5.8	5.8	6.5	6.0	6.0	**5.7**	89.5	87.3	75.5	84.1
15	MVS-130	5.0	5.0	5.8	5.5	6.3	6.0	6.0	**5.6**	70.5	80.3	77.9	76.2
7	A12-34	4.8	5.0	5.5	5.3	6.3	5.8	5.8	**5.5**	85.1	90.0	81.5	85.5
1	Champagne	4.3	4.3	5.3	5.5	6.0	6.0	5.5	**5.3**	81.0	83.1	77.5	80.5
5	Bordeaux	4.3	4.3	4.8	5.3	5.5	5.3	5.3	**4.9**	79.9	85.3	74.6	79.9
	$LSD_{0.05}$	0.72	0.86	0.79	1.04	1.01	0.81	0.80	**0.61**	6.71	5.61	7.56	**4.83**
	CV%	9.6	10.7	9.7	12.2	10.5	8.6	8.8	**7.0**	5.5	4.7	6.8	**4.1**

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Table 3. ALIST Results 2018: KBG Sorted by Highest Mean Cover

		Quality								Green Cover, %			
Entry no.	Entry	05/04/18	06/08/18	07/06/18	08/02/18	09/17/18	10/17/18	11/07/18	Mean	09/17/18	10/17/18	11/07/18	**Mean**
20	SRX-466	5.8	6.5	6.0	6.0	7.8	7.0	7.0	6.6	88.7	89.9	85.7	**88.1**
12	5321	5.0	6.0	6.3	6.5	6.5	6.8	6.8	6.3	91.0	89.7	83.5	**88.1**
17	LTP-11-41	6.0	6.3	6.3	6.8	7.3	7.0	7.0	6.6	85.0	90.3	88.2	**87.8**
21	A11-40	5.5	5.5	5.5	6.3	6.8	6.8	6.8	6.1	89.9	89.8	82.9	**87.5**
8	SRX-2758	5.5	6.0	6.3	6.0	6.8	7.3	6.8	6.4	86.1	88.6	85.4	**86.7**
4	Keeneland	5.5	6.0	6.0	6.3	6.5	6.8	6.5	6.2	85.8	88.7	83.8	**86.1**
7	A12-34	4.8	5.0	5.5	5.3	6.3	5.8	5.8	5.5	85.1	90.0	81.5	**85.5**
19	PPG-KB 1320	5.3	5.5	5.8	6.3	7.0	7.3	7.3	6.3	89.0	87.4	79.4	**85.3**
23	Martha (A06-46)	6.3	7.0	6.8	6.8	7.5	7.0	7.0	6.9	88.3	84.7	79.5	**84.2**
9	Zinfandel	4.8	5.3	5.8	5.8	6.5	6.0	6.0	5.7	89.5	87.3	75.5	**84.1**
10	Fullback	5.8	6.8	5.8	6.3	6.5	6.5	6.5	6.3	83.5	87.3	79.8	**83.5**
13	Merlot	5.0	5.5	5.5	5.8	7.0	6.5	6.5	6.0	92.7	87.0	70.0	**83.2**
18	A12-7	5.5	6.3	6.3	6.5	7.0	7.3	7.0	6.5	85.9	85.4	76.9	**82.7**
11	A11-38	5.3	5.8	6.3	6.5	7.0	7.3	6.5	6.4	83.8	83.2	80.7	**82.6**
16	Jackrabbit	6.3	7.0	6.0	6.0	7.3	7.5	7.5	6.8	82.7	83.0	81.9	**82.5**
2	Hampton	5.5	6.3	5.8	6.0	7.0	7.0	6.0	6.2	87.0	85.1	73.4	**81.8**
22	Legend	5.3	5.5	5.8	6.0	6.3	6.3	6.3	5.9	88.8	81.7	71.4	**80.6**
1	Champagne	4.3	4.3	5.3	5.5	6.0	6.0	5.5	5.3	81.0	83.1	77.5	**80.5**
5	Bordeaux	4.3	4.3	4.8	5.3	5.5	5.3	5.3	4.9	79.9	85.3	74.6	**79.9**
3	PPG-KB 1131	5.3	5.0	5.0	5.8	6.8	6.3	6.0	5.7	90.2	74.1	73.2	**79.2**
14	NAI-13-14	5.5	5.0	5.8	6.0	7.3	6.8	6.3	6.1	88.0	72.7	76.1	**78.9**
6	Bluebank	5.5	5.5	5.3	6.0	7.3	6.8	6.5	6.1	86.8	71.4	72.1	**76.8**
15	MVS-130	5.0	5.0	5.8	5.5	6.3	6.0	6.0	5.6	70.5	80.3	77.9	**76.2**
	$LSD_{0.05}$	0.72	0.86	0.79	1.04	1.01	0.81	0.80	**0.61**	6.71	5.61	7.56	**4.83**
	CV%	9.6	10.7	9.7	12.2	10.5	8.6	8.8	**7.0**	5.5	4.7	6.8	**4.1**

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MOLECULAR MECHANISM OF SHADE TOLERANCE IN PERENNIAL RYEGRASS

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ABSTRACT

Perennial ryegrass (*Lolium perenne* L.) is an important cool-season turfgrass species which is widely grown around the world. However, it is susceptible to shade stress, which can be improved by understanding of biochemical and molecular basis of shade tolerance. Shade tolerant mutants, *shadow-1* and *shadow-2*, isolated from gamma-ray treatment, used in this study to understand mechanism of shade tolerance in perennial ryegrass. *shadow-1* and *shadow-2* mutants had 7-fold increase in jasmonic acid compare to wild-type under shade condtions that reveal the role of JA in shade tolerance. We analyzed the gene expression level of Jasmonates (JAs) biosynthesis and responsive genes to understand their role in shade tolerance using transcriptome and qPCR gene expression analysis. We found elevated levels of *AOC*, *COI1* and *JAZ* genes in the *shadow-1* in the transcriptome analysis. To validate our results, these genes expression were analyzed in another shade tolerant mutant *shadow-2* under shade conditions using qPCR. These genes expression analysis confirmed elevated levels of expression in *shadow-2* similar to *shadow-1*. These all results suggest the important role of *AOC*, *COI1* and *JAZ* genes in shade tolerance of perennial ryegrass. These findings might be helpful for the turfgrass breeding to develop shade-tolerant cultivars by manipulating these genes.

INTRODUCTION

Perennial ryegrass (*Lolium perenne* L.) is an important cool-season turfgrass species that is used globally and is included in many commercial seed mixtures due to its fast germination and fast establishment (Pearson *et al*., 2011). However, perennial ryegrass is very susceptible to abiotic stresses, such as notable shade stress (Stier, 1999). Under shade stress perennial ryegrass undergoes the shade avoidance response (SAR), which includes rapid leaf elongation and chlorosis (Mc Millen & Mc Clendon, 2011). So far, molecular basis of shade tolerance have not been reported in perennial ryegrass.

Methyl-jasmonate (MeJA) is a methyl ester that is found in most plants species (Cheong & Choi, 2003). It was first extracted as a volatile compound present in Jasmin oil from *Jasmonium gradiflorum*. MeJA is synthesized via the lipoxygenase pathway and is known to regulate plant growth and response to environmental stress. The effect of MeJA on plant development has been intensively studied in dicots, including repression of leaf expansion, inhibition of root growth, increase leaf senescence and delayed flowering. MeJA belongs to a large group of hormones called ‘Jasmonate (JA)’. MeJA is a derivative of jasmonic acid, Jasmonic acid is believed to be confined within the cell as an intracellular signal compound. MeJA, on the other hand, is a volatile compound which can act as both an intra- and intercellular hormone in the plant and it has been shown to interact between plants as well (Cleland, 1999).

Plants can be subjected to different abiotic stresses, such as drought, heat, salt, and shade stress. Plants subjected to shade display various morphological changes called SAR. (Kazan & Manners, 2011; Mc Millen & Mc Clendon, 2011; Yan *et al.*, 2013) Many phytohormones have been found to be involved in manipulating SAR across plant taxa. In particular, JA levels are reduced under low-light conditions (Kazan & Manners, 2011). Additionally, *Arabidopsis* JA-deficient mutants showed an exaggerated shade response under low-light conditions (Robson *et al.*, 2010; Wierstra & Kloppstech, 2000). Thus, those evidence suggests that JA plays an important role in SAR.

JAZ proteins have also been reported to be involved in the regulation of abiotic stresses including cold, salinity, drought, wounding and ozone (Savchenko *et al.*, 2014; Hu *et al.*, 2013). CORONATINE INSENSITIVE 1 (COI1) is an essential element for all JA-mediated responses (Chen *et al.,* 2007). COI1 degrades a major negative regulator of JA response by physically binding to it, thereby activating MeJA responsive pathways. Devoto *et al.* (2005) showed that *COI1* was required for the expression of approximately 84% of 212 genes induced by MeJA. Similarly, *COI1* was also required for the repression of 53% of 104 genes whose expression was suppressed by MeJA. These results demonstrate the importance of *COI1* as a regulatory gene involved in the MeJA-induced responses. *COI1* itself is a MeJA-inducible gene (Li *et al.*, 2012). An essential step in the biosynthesis of MeJA is catalyzed by ALLENE OXIDE CYCLASE (AOC), which establishes the naturally occurring enantiomeric structure of JAs. So far, one copy of *AOC* has been cloned and identified in rice, an important crop plant which is often used as a model plant for studying monocots (Kumar *et al.*, 2003). *AOC* is a specific JA biosynthesis gene. MeJA treatment was found to enhance *AOC* expression (Sasaki *et al.*, 2001), suggesting that MeJA biosynthesis is a positive feedback loop. Thus, *AOC* expression can be used to track endogenous MeJA production. JAZ is a plant specific protein that acts as a negative regulator of JA-responses (Kemal & Manners, 2012).

Limited information exists regarding MeJA’s role in monocot plants and no studies have explored the role of MeJA in SAR for perennial ryegrass. In this report, we demonstrate role of some key JA-biosynthesis genes in SAR in perennial ryegrass, which could helpful to develop shade-tolerant turf plants.

MATERIALS & METHODS

Plant material and shade environment

‘Fiesta 4’ wild-type plants, *shadow-1* and *shadow-2* mutant plants were used in this study. All of these plants were vegetatively propagated in order to maintain genotype. *shadow-1* and *shadow-2* shade tolerant mutants were isolated from the gamma-ray treatment. Plant roots and shoots were first cut to a 2.5 cm length, and six groups of two tillers each were evenly spread within each pot. Plants were maintained at a 5 cm height in full light for 6 weeks. Plants that were selected for shade-stress treatment were placed in a 95% shade environment (~65 μmol/m^2/s PAR on a sunny day, verified with a MQ-100 Quantum Meter, Apogee Instrument, Logan, Utah, USA) in the greenhouse, which was created with black polyfiber cloth (Fig. 1). Shade experiment was conducted for two weeks after which photos were taken and followed by samples for JA quantification and RNA extraction.

Quantification of endogenous JA concentration

Leaf sampling for JA quantification were done in the same manner as describe by Li *et al*. (2016). Leaf samples were collected from wild type and *shadow-1* and *shadow-2* from shade condtions. Leaf samples from ten plants were pooled for each biological replicate. Two biological replicates were analyzed for each genotype and treatment. Approximately 200 mg of frozen leaf samples was ground to a fine powder in liquid nitrogen with a mortar and pestle. Before extraction, 100 nmol of deuterium-labeled JA was added as an internal standard. JA content analysis was carried out with an ultra-high-performance LC tandem mass spectrometer (UPLC/MS/MS) (Quattro Premier XE ACQUITY Tandem Quadrupole; Waters, Milford, MA, USA). The data are reported as means of two biological replicates. Analysis of variance was performed on JA concentration data collected from wild-type and *shadow-1* plants under both full light and 95% shade by using IBM SPSS 19.0 (IBM Corp., Somers, NY, USA).

Transcriptome analysis for JA biosynhsis gene

Expression analysis was done in the same manner as described by Li *et al.* (2016). Clean reads were obtained by removing adapter sequences, then filtering out reads with over 20% low-Q-value (£20) bases as well as reads with more than 5% ambiguous "N" bases. The clean reads were then aligned to the perennial ryegrass genome assembled by Byrne *et al.* (2015), by using default settings in Tophat2 software (Kim *et al.*, 2013). Gene expression levels were calculated as reads per kilobase of transcript per million mapped reads. To identify JA biosynthesis genes and the JA response gene in perennial ryegrass, BLASTP searching was performed against the translated perennial ryegrass reference genome for each gene of interest. The top hits with an E-value < 10-4 were aligned in ClustalX 2.0 (Larkin *et al.*, 2007). To verify the protein domain, SMART was used in the pfam database. Then, multiple alignment was conducted using T-COFFEE. Finally, a phylogenetic tree was constructed for all selected hits in PHYML version 3.0 by using the maximum likelihood method (Guindon *et al.*, 2010) under the JTT evolutionary model. The closest neighbor for each protein was designated as the putative homolog for that protein in perennial ryegrass.

Gene expression analysis

Tissue sampling and RNA extraction: Leaf tissues for qPCR analysis were collected from wild type, *shadow-1*, and *shadow-2*. A total of three replicates were collected for each genotype under each treatment. Tissue was collected by cutting young leaves directly into a beaker of liquid nitrogen to preserve mRNA. For shade-treated plants, this procedure was done in a darkroom environment to avoid light contamination. Total plant RNA was extracted with a RNeasy Plant Mini Kit, including an RNase-Free DNase set (Qiagen, Valencia, CA, United States), according to the manufacturer's protocol. RNA purity and concentration were measured with a NanoDrop 2000 spectrophotometer (Thermo Fisher Scientific, Waltham, MA, United States). An iScript™ cDNA Synthesis Kit (Bio-Rad, Richmond, CA, United States) was used to synthesize cDNA, and cDNA products were utilized in qRT-PCR assays with SsoFast™ EvaGreen® Supermix (Bio-Rad, Richmond, CA, United States) on a CFX96™ Real-Time PCR detection system (Bio-Rad, Richmond, CA, United States).

qRT-PCR analysis: Three genes (*AOC*, *COI1* and *JAZ*) were analyzed by qRT-PCR. Primer sequences for all three genes are mentioned in Table1. The native *LpGAPDH* gene was used as the internal control (Petersen *et al*., 2004; Kovi *et al.*, 2016). The data were analyzed in CFX Manager™ software, version 2.0. The expression level in each sample was normalized to the expression level of *LpGAPDH* in the same sample. Three biological replicates were analyzed for each type of sample.

Table-1 List of the primer sequences used for qRT-PCR analysis

Gene name	Forward primer sequences (5'→3')	Reverse primer sequences (5'→3')
AOC	AGCATCTACTTCG GCGACTA	AAGGGGAAGACGAT CTGGTT
COI1	CCGACGGTGGATT AATCAGT	TAGCCCTGCACCCAT ACATA
JAZ	CACAAAGAGCAAC GGCACTA	GAGCGTGAAGTTGTC CAGTT
LpGAPDH	CATCACCATTGTC TCCAACG	AACCTTCAACGATGC CAAAC

Statistical analysis

All data collected were analyzed using analysis of variance (ANOVA) followed by protected Fisher's least-significant difference test. The means were separated by the least-significant difference at the level of probability. All the experiments were performed twice, and replicates were averaged.

RESULTS

JA concentration in *shadow-1* and *shadow-2* mutants under shade conditions

Jasmonic Acid is the main bioactive JA in plants. Jasmonic acid is a useful marker for total bioactive JA concentration in plants as it is the first bioactive form produced in the biosynthesis pathway and a further step is required to lead to other bioactive forms (Yan *et al*., 2013). JA hormone content analysis of shade-treated *shadow-1* and *shadow-2* plants had 7.35 and 7.22-fold, respectively, increase in Jasmonic Acid compare to wild type after exposure to 95% shade stress (Fig. 2). This significant differential increase in the Jasmonic Acid in the both mutants compare to wild type indicate that Jasmonic Acid play important role in shade tolerance in boths mutants. These results leaded us to analyse the expression of JA biosynthesis and responsive genes to understand their role in shade tolerance.

Transcriptome analysis of JA biosynthesis, signaling and responsive genes in the *shadow-1* mutant

Transcriptome data analysis revealed that JA - biosynthetic and JA-responsive genes were up-regulated in *shadow-1* compare to wild-type under shade conditions. *AOC*, which encode key enzyme in the early step of JA biosynthesis, was up-regulated by 252.6% compare to wild-type under shade conditions (Fig. 3). The JA signaling pathway genes *JAZ* and *COI1*, which have been reported to be JA-inducible genes, were found to be up-regulated in *shadow-1* mutant to 126.6% and 466.95% compare to wild-type, respectively (Fig. 3). These results indicate that all three genes *AOC*, *COI1*, and *JAZ* play important role in shade tolerance.

JA biosynthesis and responsive genes upregulated in *shadow-2*

To validate our results, a qRT-PCR analysis of *AOC*, *COI1* and *JAZ* genes were conducted in another shade tolerant mutant *shadow-2* under shade conditions. The data showed that *AOC*, *COI1* and *JAZ* were significantly upregulated (233%, 198% and 111715% of wild-type expression, respectively) in *shadow-2* plants compared with wild-type plants (Fig. 4). These results confirmed that the JA- signaling pathway is highly activated in the *shadow-2* mutant and play key role in shade tolerance in this mutant.

DISCUSSION & CONCLUSION

In this report, we demonstrated role of *AOC*, *COI1* and *JAZ* genes in the shade tolerance in perennial ryegrass using two shade tolerant mutant *shadow-1* and *shadow-2*. Furthermore, differential significant increase in the *AOC*, *COI1* and *JAZ* genes and Jasmonic Acid in the both mutants together play important role in shade tolerance.

Transcriptome data analysis of the *shadow-1* mutant showed that JA biosynthesis, signaling, and responsive genes were increased in the *shadow-1* mutant compared with the wild-type under shade, thus indicating that high activity of JA-biosynthesis and JA-signaling pathways is an important element in this mutant. Our results are further supported by gene expression analysis in another shade tolerant mutant *shadow-2*. It showed that all three genes *AOC*, *COI1* and *JAZ* were upregulated in *shadow-2* which is similar to those genes in *shadow-1*. Our study suggests that *AOC*, *COI1* and *JAZ* genes might be important elements of JA that regulates shade tolerance in perennial ryegrass.

Taken together, our study suggests that *AOC*, *COI1* and *JAZ* genes might be important elements of JA that regulates shade tolerance in perennial ryegrass.We believe that these findings may help direct turf breeders to develop new shade-tolerant cultivars. However, more work needs to be done to establish the effects of JA-deficiency in turfgrass.

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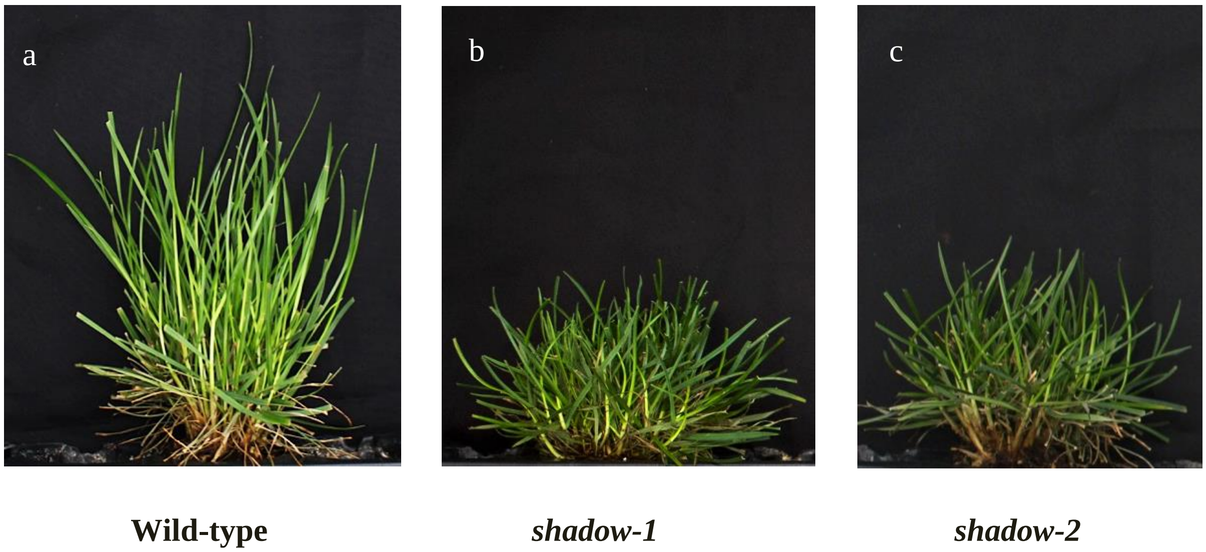

Figure 1: ***shadow-2* mutant displays similar shade response as *shadow-1* mutant in 95% shade. (a)** wild-type, **(b)** *shadow-1* and **(c)** *shadow-2*, after 2 weeks under 95% artificial shade in the greenhouse.

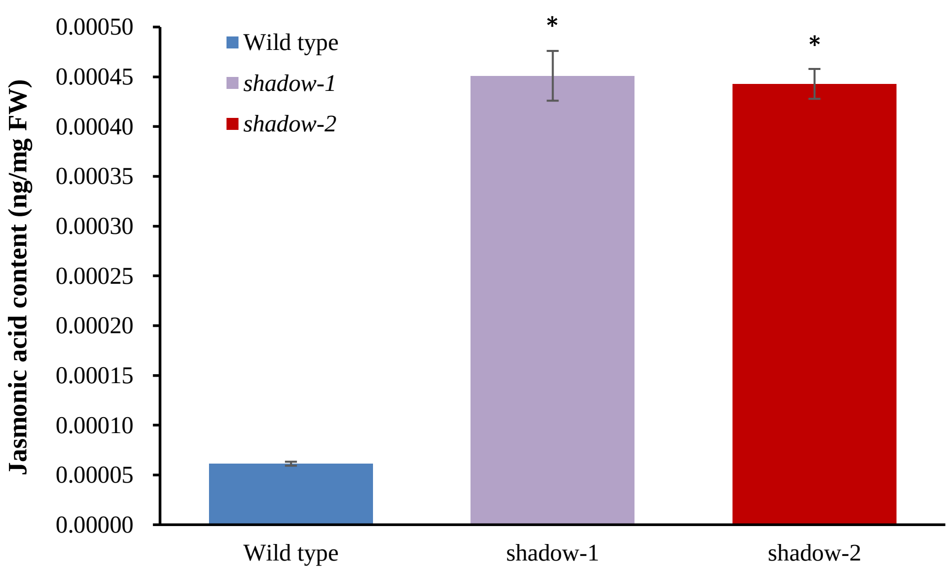

Figure 2: JA concentration in *shadow-1* plants grown under 95% shade conditions. Jasmonaic acid in *shadow-1* and *shadow-2* plants. Data represent the average of three replicates for each genotype. Each replicate consists of the pooled leaf samples from 10 plants. Bars show standard errors. Asterisks represent significant difference in response of *shadow-1* and *shadow-2* under 95% shade compared to wild-type using two-tailed Student's t-test ($p \leq 0.05$).

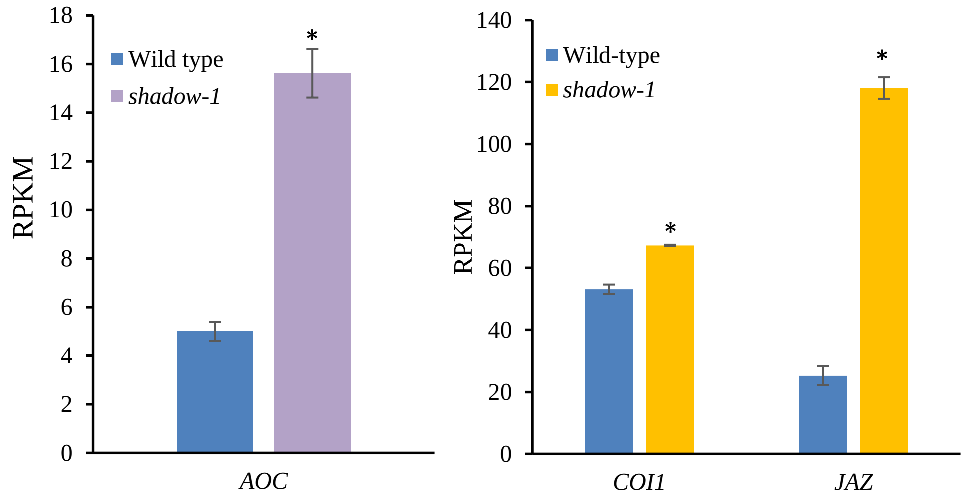

Figure 3: Transcriptome analysis of JA-biosynthesis and JA-responsive genes in *shadow-1* under shade conditions. (a) JA-biosynthesis gene *AOC was* significantly upregulated in shade-treated *shadow-1* plants, compared to wild-type under the same conditions. **(b)** Expression levels of JA-responsive genes, *COI1*and *JAZ*, were significantly increased in *shadow-1* under shade. Gene expression levels were calculated using reads per kilo base of transcript per million mapped reads (RPKM) values. Data represent means from three independent biological replicates. Asterisks represent significant differences compared to wild-type under 95% shade using two-tailed Student's t-test (p≤0.05).

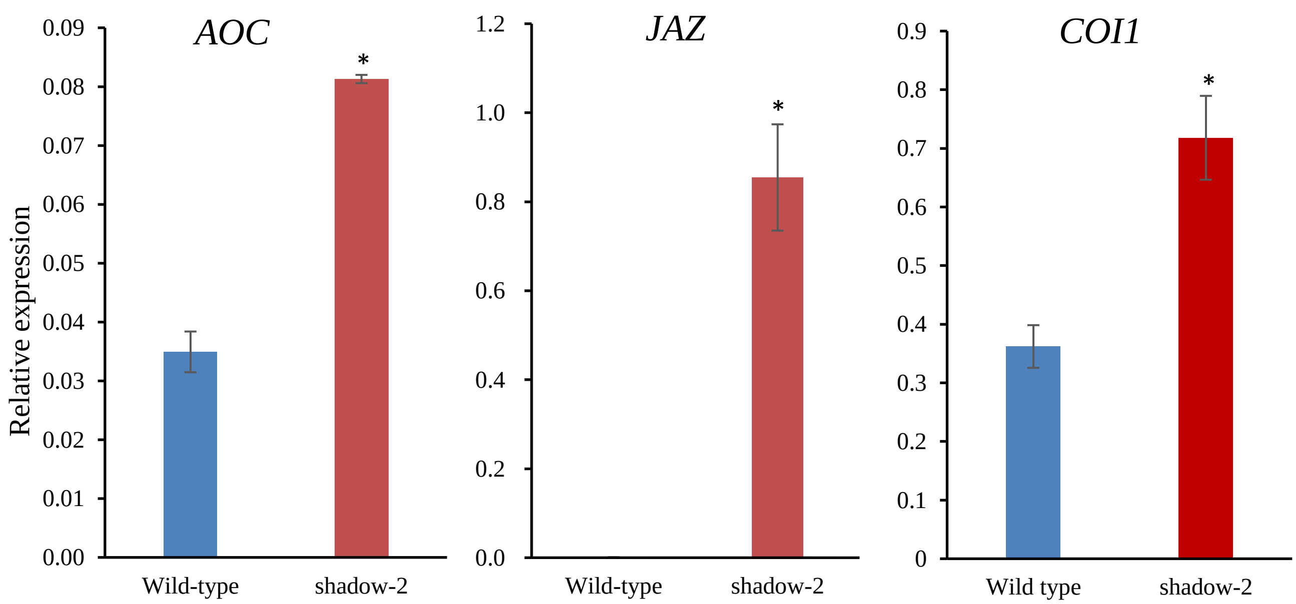

Figure 4: JA-biosynthesis and JA-responsive genes were upregulated in *shadow-2* mutant. Relatively high expression level of *AOC*, *COI1* and *JAZ* in *shadow-2* compared to wild-type plants under 95% shade conditions. Gene expression levels in each sample were normalized using the expression level of the internal control, *LpGAPDH*, in the same sample. The data presented are the averages of three independent biological replicates. Bars show standard errors. Asterisks represent significant difference in response of *shadow-2* under 95% shade compared to wild-type using two-tailed Student's t-test (p≤0.05).

POST-EMERGENT BROADLEAF WEED CONTROL WITH VARIOUS

POST-EMERGENT BROADLEAF WEED CONTROL WITH VARIOUS SELECTIVE HERBICIDES ON A MIXED COOL SEASON LAWN TURF, 2018

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INTRODUCTION

Broadleaf weeds are commonly found in turfgrass stands, especially in taller-cut turf such as home lawns and golf course roughs where the increased height-of-cut allows the weeds to seed and proliferate. These weeds can be problematic if they are competing with desired turf for moisture, sunlight, and nutrients, in addition to disrupting the aesthetic in lawn areas where a uniform appearance is desired. Selective chemical herbicides are often used to control broadleaf weeds, although challenges exist such as timing, injury to desired species, and lack of efficacy on difficult-to-control weeds.The objective of this study was to evaluate the efficacy of new and exisiting post-emergent broadleaf herbcides on control of various broadleaf weeds in a mixed cool-season turfgrass lawn.

MATERIALS & METHODS

A field study was conducted on a mixed species cool-season turfgrass lawn (primarily composed of Kentucky bluegrass (*Poa pratensis*) and perennial ryegrass (*Lolium multiflorum)*) grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed two days wk^{-1} at a setting of 2.5-inches. Nitrogen was applied at a total of 1 lb N 1000-ft^{-2} as water soluble sources from May through July. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new herbicide formulations and currently available products applied individually. Applications were made on 15 June using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. Existing broadleaf weeds within the trial area primarily consisted of broadleaf plaintain (*Plantago major*) and ground ivy (*Glechoma hederacea*).

Weed populations within each plot were visually assessed as a percentage of the plot area occupied by broadleaf weeds. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS AND DISCUSSION

Broadleaf Weed Control

Broadleaf weed populations in untreated control plots averaged 36% at the initiation of the trial (15 June, Table 1), and populations in treated plots on were comparable, with a maximum of 37% and a minimum of 28.5% on this date. Broadleaf weeds in untreated plots increased steadily over the trial's duration, reaching 54% as of 6 July and 62% on 27 July.

Plots treated with T-Zone, an herbicide consisting of a premix of Triclopyr, Sulfentrazone, 2,4-D, and Dicamba averaged 36% broadleaf weed cover at the initiation of the trial. This was reduced to 15% on 29 June (14 days after treatment, DAT) and reached a low of 1% on 13 July, 28 DAT. This represented a 97% reduction in broadleaf weed populations over the course of 28 days following a single treatment application. As of 27 July (42 DAT), regrowth led to a slight population increase (3% overall) but still represented a nearly 92% reduction in weed populations over the course of the trial.

Plots treated with Change-Up, an herbicide consisting of a premix of 2,4-D and Dicamba averaged 37% broadleaf weed cover at the initiation of the trial. This was reduced to 14.8% on 29 June (14 days after treatment, DAT) and reached a low of 2.1% on 13 July, 28 DAT. This represented a 94% reduction in broadleaf weed populations over the course of 28 days following a single treatment application. As of 27 July (42 DAT), regrowth led to a slight population increase (4% overall) but still represented an 89% reduction in weed populations over the course of the trial.

In addition to the above treatments, plots were also treated with SwitchBlade, a new herbicide premix consisting of Halauxifen-methyl, Dicamba, and Fluroxypyr. Notably, SwitchBlade does not contain 2,4-D, and therefore offers a potential alternative to older herbicide formulations. SwitchBlade was applied at both 3 and 4 pts/acre and initial broadleaf weed populations averaged 28.5 and 35.8% in these respective treatments. Plots treated at the 3 pint rate showed 13% weed cover and plots treated at the 4 pint rate showed 15.8% weed cover 14 DAT, and both treatments reached a low of 4.2% and 4.1% on 6 July (21 DAT), representing a 72% and 85% respective reduction in broadleaf weed populations over the course of 21 days following a single treatment application. Weed regrowth occurred sooner in these plots compared to T-Zone and Change Up, with 3 pint/A plots averaging 13.5% broadleaf weed cover and 4 pint/A plots averaging 11% weed cover as of 27 July, 42 DAT, representing a 52% and 69% reduction in broadleaf weed populations at the end of the trial relative to intial population counts.

Because regrowth of broadleaf weeds was observed by 42 DAT in all treated plots, it is likely that a single herbicide application may not be sufficient for long-term control of broadleaf weeds. In addition, cultural practices such as fertilization and regular mowing can help the desired turf species out-compete broadleaf weeds, especially if the weeds have been weakened by an herbicide.

Table 1. Broadleaf weed populations affected by various herbicides on a mixed cool-season lawn turf at the Plant Science Research and Education Facility in Storrs, CT during 2018.

Treatment[z]	Rate per 1000ft^2	Broadleaf Weed Population 15 Jun	29 Jun	6 Jul	13 Jul	27 Jul
		---------------------------- % Broadleaf Weeds ----------------------------				
Untreated Control		36.0 a[y]	48.0 a	54.3 a	53.7 a	62.3 a
SwitchBlade	3 pt/a	28.5 b	13.0 b	4.2 b	7.9 b	13.5 b
SwitchBlade	4 pt/a	35.8 a	15.8 b	4.1 b	5.4 b	11.0 bc
ChangeUp	3 pt/a	37.0 a	14.8 b	2.8 b	2.1 c	4.0 cd
T-Zone	4 pt/a	36.0 a	15.0 b	2.1 b	1.0 c	3.0 d
ANOVA: Treatment (P > F)		0.0141	0.0001	0.0001	0.0001	0.0001
Days after treatment		0	14	21	28	42

[z]Treatments were applied on 15 June using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000-ft-2 at 40 psi

[y]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)

DEVELOPMENT AND VALIDATION OF A WEATHER-BASED WARNING SYSTEM TO ADVISE FUNGICIDE APPLICATIONS TO CONTROL DOLLAR SPOT ON TURFGRASS

Smith D.L., J.P. Kerns, N.R. Walker, A.F. Payne, B. Horvath, J.C. Inguagiato, J.E. Kaminski, M. Tomaso-Peterson, P.L. Koch. 2018. Development and validation of a weather-based warning system to advise fungicide applications to control dollar spot on turfgrass. PLoSONE 13(3): e0194216.
https://doi.org/10.1371/journal.pone.0194216

ABSTRACT

Dollar spot is one of the most common diseases of golf course turfgrass and numerous fungicide applications are often required to provide adequate control. Weather-based disease warning systems have been developed to more accurately time fungicide applications; however, they tend to be ineffective and are not currently in widespread use. The primary objective of this research was to develop a new weather-based disease warning system to more accurately advise fungicide applications to control dollar spot activity across a broad geographic and climactic range. The new dollar spot warning system was developed from data collected at field sites in Madison, WI and Stillwater, OK in 2008 and warning system validation sites were established in Madison, WI, Stillwater, OK, Knoxville, TN, State College, PA, Starkville, MS, and Storrs, CT between 2011 and 2016. A meta-analysis of all site-years was conducted and the most effective warning system for dollar spot development consisted of a five-day moving average of relative humidity and average daily temperature. Using this model the highest effective probability that provided dollar spot control similar to that of a calendar-based program across the numerous sites and years was 20%. Additional analysis found that the 20% spray threshold provided comparable control to the calendar-based program while reducing fungicide usage by up to 30%, though further refinement may be needed as practitioners implement this warning system in a range of environments not tested here. The weather-based dollar spot warning system presented here will likely become an important tool for implementing precision disease management strategies for future turfgrass managers, especially as financial and regulatory pressures increase the need to reduce pesticide usage on golf course turfgrass.

COMPARISON OF PRESENTATION METHOD EFFECTIVENESS FOR DISSEMINATION OF PESTICIDE-FREE TURFGRASS MANAGEMENT INFORMATION

Campbell, J.H., J.J. Henderson, and V.H. Wallace. 2018. Comparison of presentation method effectiveness for dissemination of pesticide-free turfgrass management information. HortTech. 28(4):536-542. doi-org.ezproxy.lib.uconn.edu/10.21273/HORTTECH04019-18

ABSTRACT

This study examined how different presentation formats affected knowledge gain among school grounds managers. Results indicate large-group participants (presentation to ≈50 participants at a turfgrass field day) had greater knowledge retention than small-group participants (presentation to 6–10 participants at an interactive workshop). Small-group attendees had more flexibility to discuss issues that affected them directly and may have focused on those issues instead of the targeted information. Large-group meetings were more ridged in format and attendees were less able to deviate from the main subject matter being presented. However, the value of the small-group meeting should not be discounted, especially when athletic field grounds managers and staff require information specific to their situation. When disseminating more general information, the large-group meeting format is a better means of delivery.