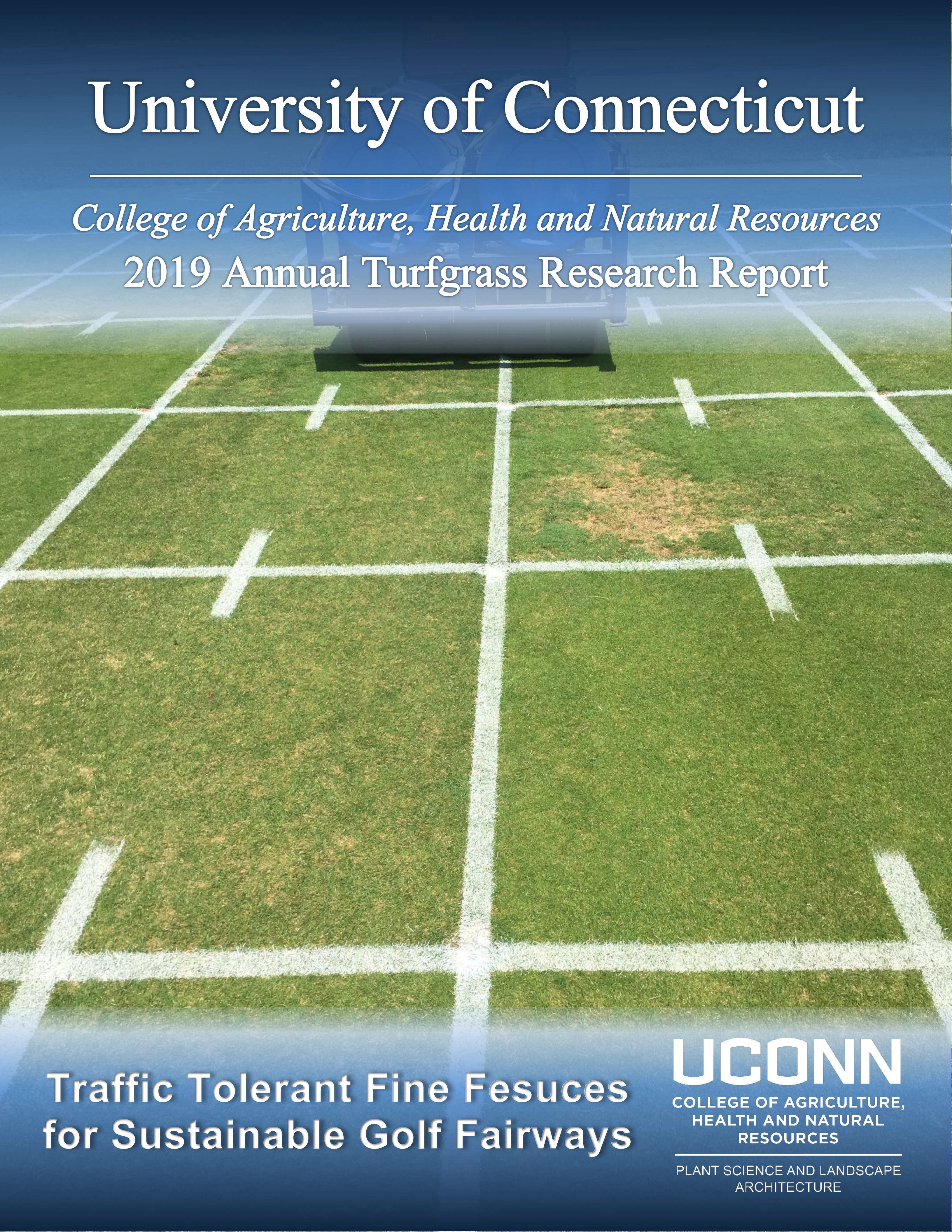
University of Connecticut

College of Agriculture, Health and Natural Resources

2019 Annual Turfgrass Research Report



Traffic Tolerant Fine Fesuces for Sustainable Golf Fairways

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PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

Cover photo: Fine fescue cultivars grown as fairway turf subjected to simulated golf cart traffic. Each cultivar main plot is split to receive simulated cart traffic or not. Fine fescues are generally recognized as low-input turfgrass species, however they are less tolerant of traffic stress than other grasses. Identifying traffic tolerant cultivars could expand their use on golf course fairways, reducing fertilizer and water requirements on these areas. (Photo credits: John C. Inguagiato, UCONN)

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PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

2019 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 2019 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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Kevin Miele, co-Editor
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The University of Connecticut Turfgrass Science Program appreciates the support of the turfgrass industry, state and federal agencies, private foundations, and university units and departments. Without your contributions, we would be unable to conduct many of the research projects included in this report. We extend our thanks to all of the individuals and companies who supported turfgrass research and education at the University of Connecticut.

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The University of Connecticut Turfgrass Science Program

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The University of Connecticut Turfgrass Science Program

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TURFGRASS CULTIVAR EVALUATION AND IMPROVEMENT

SCIENTIFIC PUBLICATIONS (ABSTRACTS & CITATIONS)

EARLY CURATIVE ANTHRACNOSE CONTROL WITH VARIOUS FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2019

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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 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 April through 1 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 Pinpoint (0.21 oz.) was applied every 14-d between 21 May and 24 July to prevent dollar spot development. Acelepryn and Tempo were applied on 23 May for control of annual bluegrass weevil and white grubs.

Treatments consisted of commercially available and developmental fungicides. Initial applications were made on 22 May immediately following the earlier than normal onset of symptoms in the trial area. Subsequent applications were made every 14- or 21-d through 30 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 severity was evaluated visually as the percent area blighted by *C. cereale* from 24 May through 26 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. 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 earlier than normal for our area on 20 May and increased slowly to approximately 8% plot area blighted in untreated control plots through mid-June. Disease increased rapidly during July as high day and nighttime temperatures and humidity contributed to favorable disease conditions. Anthracnose in untreated control plots increased from 20% plot area blighted on 4 July to 57% on 26 July (Table 1a + 1b). Through 14 June a majoriy of treatments provided good control with less than 5% plot area blighted. Treatment differences were more apparent beginning in mid-July through the end of the trial (Table 1b).

Premion, a PCNB + tebuconazole premix fungicide was applied at 4, 6, and 8 fl.oz. and tank mixed with Harrell's Par, a green pigment. The tank-mix provided excellent control of disease as of 19 July (< 1% plot area blighted) regardless of rate. Autilus, another fungicide containing only PCNB, also provided excellent control. Oximus, a pre-mix of azoxystrobin and tebuconazole, Mirage Stressgard (tebuconazole + green pigment), Tekken (tebuconazole + isofetamid), and Daconil Action + Appear II + Primo Maxx also provided excellent control as of this date and for the remainder of the trial.

Maxtima (mefentrifluconazole), a newly available DMI fungicide with enhanced phytosafety and Navicon, a premix containing the active ingredient in Maxtima and pyraclostrobin, provided good control (< 5% plot area blighted) for the duration of the trial.

Rotational Programs 2 and 3 provided near-complete control of disease for the entirety of the trial. Rotational program 1 also provided very good control (< 3%).

Developmental fungicide efficacy were also assessed. UC19-6 provided good control for the duration of the trial. UC19-2 applied at rates of 0.725 to 1.2 fl.oz. provided marginal anthracnose suppression regardless of rate during the trial, with 9 to 17% plot area blighted on 19 July and 7 to 20% on 26 July. UC19-22, UC19-14, and UC19-16 failed to provide acceptable control once disease pressure increased during July, regardless of rate.

Turf Quality, NDVI, and Phytotoxicity

Turf quality (Table 2a + 2b) was generally low during June as turf recovered from winter injury and early season anthracnose. As disease pressure increased in July, quality generally remained acceptable on plots with low disease, with Rotational program 3 and Daconil Action + Appear + Primo Maxx consistently standing out through the end of the trial This high quality was also reflected in these treatments NDVI readings (table 4).

As of 14 June and continuing until the end of the trial, phytotoxicity, albeit acceptable, was apparent on plots treated with Oximus at the 1.0 and 1.6 fl.oz. rates, as well as on plots treated with Mirage, UC19-22, and Tekken (Table 3a + 3b). Unlike other DMI or DMI-containing fungicides (such as Oximus, Mirage, and Tekken), Navicon and Maxtima displayed no phytotoxicity as of this date and for the duration of the trial.

Table 1a. Effect of various fungicides on early curative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	24 May	31 May	7 Jun	14 Jun	21 Jun
				Anthracnose Incidence				
				% plot area blighted				
UC19-2	0.725 fl.oz.	14-d	ACEGIK	0.0[x] -	0.5 -	1.2 b-j[w]	1.8 c-i	0.9 c-g
UC19-2	0.9 fl.oz.	14-d	ACEGIK	0.3 -	1.1 -	2.4 b-e	2.5 b-g	1.5 b-e
UC19-2	1.2 fl.oz.	14-d	ACEGIK	0.4 -	1.1 -	2.7 bcd	3.2 bcd	1.5 b-e
UC19-6	0.5 oz.	14-d	ACEGIK	0.1 -	1.1 -	1.6 b-i	2.0 c-h	0.3 d-h
UC19-4	0.0785 fl.oz.	14-d	ACEGIK	0.0 -	0.8 -	0.8 c-k	1.1 c-i	0.4 d-h
+UC19-3	0.118 fl.oz.							
+UC19-10	0.25 fl.oz.							
+UC19-11	0.00655 oz.							
UC19-4	0.157 fl.oz.	14-d	ACEGIK	0.6 -	0.5 -	2.0 b-g	3.1 b-e	1.4 b-f
+UC19-3	0.236 fl.oz.							
+UC19-10	0.5 fl.oz.							
+UC19-11	0.0131 fl.oz.							
Premion	4.0 fl.oz.	14-d	ACEGIK	0.0 -	0.3 -	0.1 h-k	0.8 d-i	0.1 gh
+Harrell's Par	0.37 fl.oz.							
Premion	6.0 fl.oz.	14-d	ACEGIK	0.1 -	0.5 -	0.0 jk	0.0 i	0.0 h
+Harrell's Par	0.37 fl.oz.							
Premion	8.0 fl.oz.	14-d	ACEGIK	0.0 -	0.9 -	0.3 f-k	0.4 ghi	0.1 gh
+Harrell's Par	0.37 fl.oz.							
Autilis	6.0 fl.oz.	14-d	ACEGIK	0.0 -	0.5 -	0.4 e-k	0.6 e-i	0.0 gh
+Harrell's Par	0.37 fl.oz.							
Oximus	0.8 fl.oz.	14-d	ACEGIK	0.5 -	0.9 -	0.4 e-k	0.2 hi	0.1 fgh
Oximus	1.0 fl.oz.	14-d	ACEGI	0.0 -	0.4 -	0.1 ijk	0.2 hi	0.0 h
Oximus	1.6 fl.oz.	14-d	ACEGIK	0.2 -	1.1 -	0.0 k	0.1 hi	0.0 h
Mirage	.1.0 fl.oz.	14-d	ACEGIK	0.2 -	0.9 -	0.2 g-k	0.5 f-i	0.1 gh
UC19-22	0.35 fl.oz.	14-d	ACEGIK	0.0 -	1.6 -	1.7 b-h	3.7 bc	1.5 b-f
UC19-22	0.7 fl.oz.	14-d	ACEGIK	0.4 -	0.7 -	0.5 d-k	1.0 c-i	1.7 b-e
UC19-14	0.41 fl.oz.	14-d	ACEGIK	0.3 -	2.0 -	2.2 b-f	2.9 b-f	1.9 bcd
UC19-16	0.092 fl.oz.	14-d	ACEGIK	0.0 -	0.6 -	1.0 c-k	2.1 c-h	1.5 b-e
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.138 fl.oz.	14-d	ACEGIK	0.2 -	1.7 -	3.2 bc	6.0 ab	3.5 ab
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.184 fl.oz.	14-d	ACEGIK	0.2 -	1.5 -	4.1 ab	5.6 ab	2.9 abc
+Non-Ionic Surfactant	0.25% v/v							
Tekken	3.0 fl.oz.	14/21-d	ACEHK	0.0 -	0.4 -	0.0 k	0.0 i	0.0 h
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.2 -	0.7 -	0.3 f-k	1.1 c-i	0.5 d-h
+Appear II	4.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.2 -	0.3 -	0.4 e-k	1.0 c-i	0.5 d-h
+Appear II	6.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.2 -	0.9 -	1.1 b-j	1.5 c-i	1.8 bcd
Daconil Weatherstik	3.5 fl.oz.	14-d	ACEGIK	0.0 -	1.0 -	1.8 b-g	3.3 bcd	2.9 abc
Navicon	0.85 fl.oz.	14-d	ACEGIK	0.0 -	1.2 -	0.7 c-k	1.5 c-i	0.2 e-h
Maxtima	0.6 fl.oz.	14-d	ACEGIK	0.5 -	1.7 -	0.6 d-k	0.9 c-i	0.0 h
Velista	0.5 oz.	14-d	ACEGIK	0.2 -	0.6 -	1.4 b-j	0.9 c-i	0.3 d-h
ANOVA: Treatment (P > F)				0.0745	0.1683	0.001	0.0001	0.0001
Days after treatment			14-d	2	9	3	10	2
			21-d	-	-	-	-	-

Continued…

Table 1a. Effect of various fungicides on early curative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019

Treatment	Rate per 1000ft²	Int	Application Dates	Anthracnose Incidence 24 May	14 Jun	7 Jun	14 Jun	21 Jun
				------------------------ % plot area blighted--------------------------				
Rotational Program 1		pgm		0.2 -	1.6 -	1.7 b-i	2.1 c-h	1.4 b-f
-Downforce ETQ	0.5 fl.oz.		ACEI					
-Nivales	1.5 fl.oz.		ACE					
-Echo Dyad ETQ	5.0 fl.oz.		GK					
-Sipcam Clearscape ETQ	0.6 fl.oz.		GK					
-Endow 2SC	0.77 fl.oz.		GK					
-E-Pro ETQ	6.0 fl.oz.		I					
-0-29-30 Phosphite	3.0 fl.oz.		ACEGIK					
Rotational Program 2		pgm		0.1 -	0.2 -	0.0 k	0.1 hi	0.5 d-h
-Premion	8.0 fl.oz.		A					
-Harrell's Par	0.37 fl.oz.		A					
-Signature Xtra	4.0 oz.		CI					
-Previa	3.6 fl.oz.		CI					
-Velista	0.3 oz.		EK					
-Affirm	4.0 oz.		EK					
-Oximus	1.0 fl.oz.		G					
-Medallion SC	1.5 fl.oz.		G					
Rotational Program 3		pgm		0.1 -	0.01 -	0.0 k	0.0 i	0.0 gh
-Daconil Action	3.5 fl.oz.		ACEGIK					
-Velista	0.5 oz.		AG					
-Appear II	6.0 fl.oz.		ACEGIK					
-Primo Maxx	0.125 fl.oz.		ACEGIK					
-Briskway	0.5 fl.oz.		CI					
-Medallion SC	1.0 fl.oz.		EK					
Untreated				0.6 -	3.8 -	8.2 a	8.6 a	6.3 a
ANOVA: Treatment (P > F)				0.0745	0.1683	0.0001	0.0001	0.0001
Days after treatment			14-d	2	9	3	10	2
			21-d	-	-	-	-	2

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.

[y]Treatments were initiated on 22 May. Application date codes were as follows: A=22 May; C= 4 June; E=19 June; G=2 July; H=9 July; I=16 July; K=30 July.

[x]Anthracnose means were arc-sine transformed from this date forward. Means are de-transformed 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 1b. Effect of various fungicides on early curative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Anthracnose Incidence 28 Jun	4 Jul	12 Jul	19 Jul	26 Jul
				% plot area blighted				
UC19-2	0.725 fl.oz.	14-d	ACEGIK	1.0[x] efg[w]	5.5 c-f	6.7 c-f	16.6 b-e	19.2 bcd
UC19-2	0.9 fl.oz.	14-d	ACEGIK	1.4 c-g	2.4 efg	2.5 f-j	9.1 def	7.2 d-g
UC19-2	1.2 fl.oz.	14-d	ACEGIK	0.6 efg	2.8 efg	2.9 f-i	12.7 c-f	9.3 def
UC19-6	0.5 oz.	14-d	ACEGIK	0.3 g	1.3 g	0.8 i-m	2.1 gh	3.4 f-i
UC19-4	0.0785 fl.oz.	14-d	ACEGIK	0.1 g	0.5 g	1.6 h-l	9.6 def	8.2 d-g
+UC19-3	0.118 fl.oz.							
+UC19-10	0.25 fl.oz.							
+UC19-11	0.00655 oz.							
UC19-4	0.157 fl.oz.	14-d	ACEGIK	1.1 d-g	1.3 g	2.4 g-k	5.0 fg	8.3 d-g
+UC19-3	0.236 fl.oz.							
+UC19-10	0.5 fl.oz.							
+UC19-11	0.0131 fl.oz.							
Premion	4.0 fl.oz.	14-d	ACEGIK	0.1 g	0.0 g	0.0 m	0.2 i	1.0 ijk
+Harrell's Par	0.37 fl.oz.							
Premion	6.0 fl.oz.	14-d	ACEGIK	0.0 g	0.0 g	0.0 m	0.3 hi	0.6 jk
+Harrell's Par	0.37 fl.oz.							
Premion	8.0 fl.oz.	14-d	ACEGIK	0.5 fg	0.5 g	0.5 klm	0.7 hi	0.9 ijk
+Harrell's Par	0.37 fl.oz.							
Autilis	6.0 fl.oz.	14-d	ACEGIK	0.1 g	0.1 g	0.2 lm	0.0 i	0.2 k
+Harrell's Par	0.37 fl.oz.							
Oximus	0.8 fl.oz.	14-d	ACEGIK	0.0 g	0.3 g	0.2 lm	1.9 gh	2.1 hij
Oximus	1.0 fl.oz.	14-d	ACEGIK	0.0 g	0.0 g	0.0 m	0.9 hi	1.0 h-k
Oximus	1.6 fl.oz.	14-d	ACEGIK	0.0 g	0.0 g	0.0 m	0.2 i	0.6 jk
Mirage	1.0 fl.oz.	14-d	ACEGIK	0.0 g	0.0 g	0.0 m	0.2 i	0.6 jk
UC19-22	0.35 fl.oz.	14-d	ACEGIK	1.9 b-f	6.3 cde	8.6 b-e	26.9 abc	25.4 abc
UC19-22	0.7 fl.oz.	14-d	ACEGIK	1.5 c-g	3.9 d-g	6.0 c-g	21.4 a-d	26.1 abc
UC19-14	0.41 fl.oz.	14-d	ACEGIK	2.1 b-e	7.0 cd	10.6 bcd	27.4 abc	28.1 abc
UC19-16	0.092 fl.oz.	14-d	ACEGIK	1.3 c-g	8.8 bc	14.4 abc	41.3 ab	45.9 ab
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.138 fl.oz.	14-d	ACEGIK	3.1 b	8.8 bc	14.7 abc	29.7 abc	40.5 ab
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.184 fl.oz.	14-d	ACEGIK	2.6 bcd	12.3 b	17.1 ab	39.2 ab	43.9 ab
+Non-Ionic Surfactant	0.25% v/v							
Tekken	3.0 fl.oz.	14/21-d	ACEHKN	0.0 g	0.0 g	0.0 m	0.0 i	0.2 k
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.4 fg	0.0 g	0.7 j-m	0.3 hi	0.2 k
+Appear II	4.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.0 g	0.0 g	0.1 m	0.0 i	0.6 jk
+Appear II	6.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.9 efg	0.8 g	3.5 e-h	9.0 def	13.2 cd
Daconil Weatherstik	3.5 fl.oz.	14-d	ACEGIK	2.8 bc	3.3 d-g	5.0 d-g	8.6 def	7.3 d-g
Navicon	0.85 fl.oz.	14-d	ACEGIK	0.0 g	0.0 g	0.2 lm	0.9 hi	4.0 e-h
Maxtima	0.6 fl.oz.	14-d	ACEGIK	0.0 g	0.0 g	0.0 m	2.2 gh	3.6 f-i
Velista	0.5 oz.	14-d	ACEGIK	0.3 g	0.3 g	1.2 h-m	7.4 ef	10.8 cde
ANOVA: Treatment (P > F)				0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment			14-d	9	2	10	3	10
			21-d	9	16	3	10	17

Continued…

Table 1b. Effect of various fungicides on early curative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft²	Int	Application Dates	Anthracnose Incidence 28 Jun	4 Jul	12 Jul	19 Jul	26 Jul
				---------------------------------- % plot area blighted				------------------------------
Rotational Program 1		pgm		0.8 efg	2.0 fg	2.6 f-j	2.2 gh	2.9 g-j
-Downforce ETQ	0.5 fl.oz.		ACEI					
-Nivales	1.5 fl.oz.		ACE					
-Echo Dyad ETQ	5.0 fl.oz.		GK					
-Sipcam Clearscape ETQ	0.6 fl.oz.		GK					
-Endow 2SC	0.77 fl.oz.		GK					
-E-Pro ETQ	6.0 fl.oz.		I					
-0-29-30 Phosphite	3.0 fl.oz.		ACEGIK					
Rotational Program 2		pgm		0.4 fg	0.0 g	0.2 lm	0.2 i	0.6 jk
-Premion	8.0 fl.oz.		A					
-Harrell's Par	0.37 fl.oz.		A					
-Signature Xtra	4.0 oz.		CI					
-Previa	3.6 fl.oz.		CI					
-Velista	0.3 oz.		EK					
-Affirm	4.0 oz.		EK					
-Oximus	1.0 fl.oz.		G					
-Medallion SC	1.5 fl.oz.		G					
Rotational Program 3		pgm		0.0 g	0.0 g	0.0 m	0.0 i	0.0 k
-Daconil Action	3.5 fl.oz.		ACEGIK					
-Velista	0.5 oz.		AG					
-Appear II	6.0 fl.oz.		ACEGIK					
-Primo Maxx	0.125 fl.oz.		ACEGIK					
-Briskway	0.5 fl.oz.		CI					
-Medallion SC	1.0 fl.oz.		EK					
Untreated				6.3 a	20.0 a	30.1 a	52.9 a	57.4 a
ANOVA: Treatment (P > F)				0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment			14-d	9	2	10	3	10
			21-d	9	16	3	10	17

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.

[y]Treatments were initiated on 22 May. Application date codes were as follows: A=22 May; C= 4 June; E=19 June; G=2 July; H=9 July; I=16 July; K=30 July.

[x]Anthracnose means were arc-sine transformed from this date forward. Means are de-transformed 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 2a. 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 2019.

Treatment[z]	Rate per 1000ft^2	Int	Application Dates[y]	Turf Quality 24 May	7 Jun	14 Jun	21 Jun	28 Jun
				---- 1-9; 6=min acceptable ----				
UC19-2	0.725 fl.oz.	14-d	ACEGIK	3.0 -	4.5 -	5.7 d-g[x]	5.0 hi	5.5 ghi
UC19-2	0.9 fl.oz.	14-d	ACEGIK	3.5 -	5.0 -	6.0 b-f	6.0 d-h	6.5 d-g
UC19-2	1.2 fl.oz.	14-d	ACEGIK	4.0 -	5.0 -	6.4 a-e	5.9 d-h	6.8 c-f
UC19-6	0.5 oz.	14-d	ACEGIK	4.0 -	5.3 -	6.5 a-d	6.5 def	7.5 bcd
UC19-4	0.0785 fl.oz.	14-d	ACEGIK	3.8 -	5.3 -	7.0 ab	6.7 cde	7.8 bc
+UC19-3	0.118 fl.oz.							
+UC19-10	0.25 fl.oz.							
+UC19-11	0.00655 oz.							
UC19-4	0.157 fl.oz.	14-d	ACEGIK	4.3 -	5.3 -	6.2 b-f	6.0 d-h	6.8 c-f
+UC19-3	0.236 fl.oz.							
+UC19-10	0.5 fl.oz.							
+UC19-11	0.0131 fl.oz.							
Premion	4.0 fl.oz.	14-d	ACEGIK	4.3 -	5.3 -	6.7 a-d	6.9 cd	7.5 bcd
+Harrell's Par	0.37 fl.oz.							
Premion	6.0 fl.oz.	14-d	ACEGIK	4.8 -	5.5 -	6.5 a-d	6.7 cde	6.8 c-f
+Harrell's Par	0.37 fl.oz.							
Premion	8.0 fl.oz.	14-d	ACEGIK	4.0 -	5.3 -	5.5 efg	6.2 d-g	6.3 e-h
+Harrell's Par	0.37 fl.oz.							
Autilis	6.0 fl.oz.	14-d	ACEGIK	4.5 -	5.5 -	6.5 a-e	7.0 bcd	7.0 cde
+Harrell's Par	0.37 fl.oz.							
Oximus	0.8 fl.oz.	14-d	ACEGIK	4.0 -	5.0 -	6.0 b-f	6.2 d-g	6.5 d-g
Oximus	1.0 fl.oz.	14-d	ACEGIK	3.5 -	6.0 -	5.7 d-g	5.5 f-i	6.8 c-f
Oximus	1.6 fl.oz.	14-d	ACEGIK	4.0 -	4.5 -	5.2 fgh	5.5 f-i	6.8 c-f
Mirage	.1.0 fl.oz.	14-d	ACEGIK	4.3 -	4.5 -	5.5 efg	5.5 f-i	7.3 cde
UC19-22	0.35 fl.oz.	14-d	ACEGIK	4.3 -	4.8 -	5.2 fgh	5.5 f-i	5.8 f-i
UC19-22	0.7 fl.oz.	14-d	ACEGIK	4.8 -	5.3 -	6.5 a-e	6.2 d-g	6.8 c-f
UC19-14	0.41 fl.oz.	14-d	ACEGIK	4.0 -	4.3 -	5.0 gh	5.0 hi	5.8 f-i
UC19-16	0.092 fl.oz.	14-d	ACEGIK	4.0 -	5.5 -	6.0 b-f	6.5 def	6.8 c-f
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.138 fl.oz.	14-d	ACEGIK	3.8 -	5.3 -	5.7 d-g	5.7 e-i	5.5 ghi
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.184 fl.oz.	14-d	ACEGIK	4.0 -	5.3 -	5.7 d-g	5.7 e-i	5.3 hi
+Non-Ionic Surfactant	0.25% v/v							
Tekken	3.0 fl.oz.	14/21-d	ACEHKN	4.0 -	4.5 -	5.5 efg	5.2 ghi	6.5 d-g
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	4.8 -	5.8 -	7.0 abc	8.0 abc	8.5 ab
+Appear II	4.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	4.8 -	5.8 -	7.2 a	8.2 ab	9.0 a
+Appear II	6.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	4.3 -	5.8 -	6.7 a-d	6.5 def	7.0 cde
Daconil Weatherstik	3.5 fl.oz.	14-d	ACEGIK	3.8 -	5.0 -	5.7 d-g	5.9 d-h	6.3 e-h
Navicon	0.85 fl.oz.	14-d	ACEGIK	4.0 -	4.8 -	6.0 b-f	6.2 d-g	7.8 bc
Maxtima	0.6 fl.oz.	14-d	ACEGIK	4.0 -	5.3 -	6.5 a-e	7.0 bcd	7.5 bcd
Velista	0.5 oz.	14-d	ACEGIK	4.5 -	5.5 -	6.0 c-f	6.5 def	7.0 cde
ANOVA: Treatment (P > F)				0.1581	0.2612	0.0001	0.0001	0.0001
Days after treatment			14-d	2	3	10	2	9
			21-d	-	-	-	2	9

Continued…

Table 2a. 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 2019.

Treatment	Rate per 1000ft^2	Int	Application Dates	Turf Quality 24 May	7 Jun	14 Jun	21 Jun	28 Jun
				1-9; 6=min acceptable				
Rotational Program 1		pgm		4.8 -	5.0 -	6.0 b-f	6.2 d-g	6.5 d-g
-Downforce ETQ	0.5 fl.oz.		ACEI					
-Nivales	1.5 fl.oz.		ACE					
-Echo Dyad ETQ	5.0 fl.oz.		GK					
-Sipcam Clearscape ETQ	0.6 fl.oz.		GK					
-Endow 2SC	0.77 fl.oz.		GK					
-E-Pro ETQ	6.0 fl.oz.		I					
-0-29-30 Phosphite	3.0 fl.oz.		ACEGIK					
Rotational Program 2		pgm		5.0 -	6.0 -	6.7 a-d	7.7 abc	7.8 bc
-Premion	8.0 fl.oz.		A					
-Harrell's Par	0.37 fl.oz.		A					
-Signature Xtra	4.0 oz.		CI					
-Previa	3.6 fl.oz.		CI					
-Velista	0.3 oz.		EK					
-Affirm	4.0 oz.		EK					
-Oximus	1.0 fl.oz.		G					
-Medallion SC	1.5 fl.oz.		G					
Rotational Program 3		pgm		3.8 -	5.5 -	7.5 a	8.7 a	9.0 a
-Daconil Action	3.5 fl.oz.		ACEGIK					
-Velista	0.5 oz.		AG					
-Appear II	6.0 fl.oz.		ACEGIK					
-Primo Maxx	0.125 fl.oz.		ACEGIK					
-Briskway	0.5 fl.oz.		CI					
-Medallion SC	1.0 fl.oz.		EK					
Untreated				3.5 -	4.3 -	4.5 h	4.7 i	4.8 i
ANOVA: Treatment (P > F)				0.1581	0.2612	0.0001	0.0001	0.0001
Days after treatment			14-d	2	3	10	2	9
			21-d	-	-	-	2	9

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.

[y]Treatments were initiated on 22 May. Application date codes were as follows: A=22 May; C= 4 June; E=19 June; G=2 July; H=9 July; I=16 July; K=30 July.

[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)

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Table 2b. 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 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Turf Quality 4 Jul	Turf Quality 19 Jul	Turf Quality 26 Jul
				------------- 1-9; 6=min acceptable	-------------	-------------
UC19-2	0.725 fl.oz.	14-d	ACEGIK	4.8 jk[x]	4.5 g-j	4.5 ijk
UC19-2	0.9 fl.oz.	14-d	ACEGIK	6.0 e-i	5.3 d-h	5.0 g-j
UC19-2	1.2 fl.oz.	14-d	ACEGIK	5.8 f-j	4.8 f-i	4.8 hij
UC19-6	0.5 oz.	14-d	ACEGIK	7.3 bcd	6.3 bcd	6.0 d-g
UC19-4	0.0785 fl.oz.	14-d	ACEGIK	6.0 e-i	5.0 e-i	4.8 hij
+UC19-3	0.118 fl.oz.					
+UC19-10	0.25 fl.oz.					
+UC19-11	0.00655 oz.					
UC19-4	0.157 fl.oz.	14-d	ACEGIK	6.0 e-i	5.3 d-h	5.5 e-i
+UC19-3	0.236 fl.oz.					
+UC19-10	0.5 fl.oz.					
+UC19-11	0.0131 fl.oz.					
Premion	4.0 fl.oz.	14-d	ACEGIK	7.3 bcd	7.0 b	6.8 cd
+Harrell's Par	0.37 fl.oz.					
Premion	6.0 fl.oz.	14-d	ACEGIK	7.0 b-e	6.5 bc	6.5 cde
+Harrell's Par	0.37 fl.oz.					
Premion	8.0 fl.oz.	14-d	ACEGIK	6.0 e-i	6.3 bcd	5.5 e-i
+Harrell's Par	0.37 fl.oz.					
Autilis	6.0 fl.oz.	14-d	ACEGIK	7.5 abc	7.0 b	6.5 cde
+Harrell's Par	0.37 fl.oz.					
Oximus	0.8 fl.oz.	14-d	ACEGIK	6.3 d-h	5.8 c-f	5.3 f-i
Oximus	1.0 fl.oz.	14-d	ACEGIK	5.8 f-j	6.0 b-e	5.5 e-i
Oximus	1.6 fl.oz.	14-d	ACEGIK	5.8 f-j	6.3 bcd	5.8 d-h
Mirage	.1.0 fl.oz.	14-d	ACEGIK	6.8 c-f	6.5 bc	6.3 def
UC19-22	0.35 fl.oz.	14-d	ACEGIK	5.3 h-k	4.0 i-l	3.5 klm
UC19-22	0.7 fl.oz.	14-d	ACEGIK	5.5 g-k	4.3 h-k	4.0 jkl
UC19-14	0.41 fl.oz.	14-d	ACEGIK	4.5 kl	4.0 i-l	3.5 klm
UC19-16	0.092 fl.oz.	14-d	ACEGIK	5.0 ijk	3.3 kl	2.8 mn
+Non-Ionic Surfactant	0.25% v/v					
UC19-16	0.138 fl.oz.	14-d	ACEGIK	5.0 ijk	3.3 kl	3.3 lmn
+Non-Ionic Surfactant	0.25% v/v					
UC19-16	0.184 fl.oz.	14-d	ACEGIK	4.8 jk	3.5 jkl	3.0 lmn
+Non-Ionic Surfactant	0.25% v/v					
Tekken	3.0 fl.oz.	14/21-d	ACEHKN	6.0 e-i	6.0 b-e	6.5 cde
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	8.0 ab	8.5 a	7.5 bc
+Appear II	4.0 fl.oz.					
+Primo Maxx	0.125 fl.oz.					
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	8.5 a	9.0 a	8.5 ab
+Appear II	6.0 fl.oz.					
+Primo Maxx	0.125 fl.oz.					
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	6.3 d-h	5.5 c-g	5.0 g-j
Daconil Weatherstik	3.5 fl.oz.	14-d	ACEGIK	6.3 d-h	5.3 d-h	5.3 f-i
Navicon	0.85 fl.oz.	14-d	ACEGIK	7.5 abc	6.3 bcd	5.8 d-h
Maxtima	0.6 fl.oz.	14-d	ACEGIK	7.3 bcd	6.3 bcd	5.8 d-h
Velista	0.5 oz.	14-d	ACEGIK	6.5 c-g	5.3 d-h	5.3 f-i
ANOVA: Treatment (P > F)				0.0001	0.0001	0.0001
Days after treatment			14-d	2	3	10
			21-d	16	10	17

Continued…

Table 2b. 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 2019.

Treatment	Rate per 1000ft^2	Int	Application Dates	Turf Quality 4 Jul	19 Jul	26 Jul
				------------- 1-9; 6=min acceptable-------------		
Rotational Program 1		pgm		5.5 g-k	6.0 b-e	6.5 cde
-Downforce ETQ	0.5 fl.oz.		ACEI			
-Nivales	1.5 fl.oz.		ACE			
-Echo Dyad ETQ	5.0 fl.oz.		GK			
-Sipcam Clearscape ETQ	0.6 fl.oz.		GK			
-Endow 2SC	0.77 fl.oz.		GK			
-E-Pro ETQ	6.0 fl.oz.		I			
-0-29-30 Phosphite	3.0 fl.oz.		ACEGIK			
Rotational Program 2		pgm		6.8 c-f	7.0 b	6.5 cde
-Premion	8.0 fl.oz.		A			
-Harrell's Par	0.37 fl.oz.		A			
-Signature Xtra	4.0 oz.		CI			
-Previa	3.6 fl.oz.		CI			
-Velista	0.3 oz.		EK			
-Affirm	4.0 oz.		EK			
-Oximus	1.0 fl.oz.		G			
-Medallion SC	1.5 fl.oz.		G			
Rotational Program 3		pgm		8.0 ab	8.8 a	9.0 a
-Daconil Action	3.5 fl.oz.		ACEGIK			
-Velista	0.5 oz.		AG			
-Appear II	6.0 fl.oz.		ACEGIK			
-Primo Maxx	0.125 fl.oz.		ACEGIK			
-Briskway	0.5 fl.oz.		CI			
-Medallion SC	1.0 fl.oz.		EK			
Untreated				3.5 l	3.0 l	2.3 n
ANOVA: Treatment (P > F)				0.0001	0.0001	0.001
Days after treatment			14-d	2	3	10
			21-d	16	10	17

[z]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.

[y]Treatments were initiated on 22 May. Application date codes were as follows: A=22 May; C= 4 June; E=19 June; G=2 July; H=9 July; I=16 July; K=30 July.

[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 3a. Effect of various fungicides phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019

Treatment[z]	Rate per 1000ft^2	Int	Application Dates[y]	Phytotoxicity 24 May	7 Jun	14 Jun	21 Jun	28 Jun
				---------- 0-5; 2=max acceptable ----------				
UC19-2	0.725 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.3 de[x]	0.3 de	0.3 de
UC19-2	0.9 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.3 de	0.3 de
UC19-2	1.2 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.5 cd
UC19-6	0.5 oz.	14-d	ACEGIK	0.3 -	0.0 -	0.0 f	0.5 cde	0.0 e
UC19-4	0.0785 fl.oz.	14-d	ACEGIK	0.3 -	0.0 -	0.0 f	0.0 e	0.0 e
+UC19-3	0.118 fl.oz.							
+UC19-10	0.25 fl.oz.							
+UC19-11	0.00655 oz.							
UC19-4	0.157 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.3 de	0.0 e
+UC19-3	0.236 fl.oz.							
+UC19-10	0.5 fl.oz.							
+UC19-11	0.0131 fl.oz.							
Premion	4.0 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.3 de	0.0 e	0.0 e
+Harrell's Par	0.37 fl.oz.							
Premion	6.0 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.1 ef	0.3 de	0.0 e
+Harrell's Par	0.37 fl.oz.							
Premion	8.0 fl.oz.	14-d	ACEGIK	0.3 -	0.0 -	0.1 ef	0.0 e	0.0 e
+Harrell's Par	0.37 fl.oz.							
Autilis	6.0 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.1 ef	0.0 e	0.0 e
+Harrell's Par	0.37 fl.oz.							
Oximus	0.8 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.6 cd	0.3 de	0.5 cd
Oximus	1.0 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	1.2 abc	1.5 b	1.8 b
Oximus	1.6 fl.oz.	14-d	ACEGIK	0.3 -	0.3 -	1.5 ab	2.5 a	1.8 b
Mirage	.1.0 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	1.0 abc	1.0 bc	0.8 c
UC19-22	0.35 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	1.2 abc	0.5 cde	0.3 de
UC19-22	0.7 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.9 abc	0.8 cd	0.8 c
UC19-14	0.41 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.7 bcd	1.0 bc	0.5 cd
UC19-16	0.092 fl.oz.	14-d	ACEGIK	0.5 -	0.0 -	0.0 f	0.0 e	0.0 e
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.138 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
+Non-Ionic Surfactant	0.25% v/v							
UC19-16	0.184 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
+Non-Ionic Surfactant	0.25% v/v							
Tekken	3.0 fl.oz.	14/21-d	ACEHKN	0.0 -	0.3 -	1.7 a	2.8 a	2.3 a
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
+Appear II	4.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
+Appear II	6.0 fl.oz.							
+Primo Maxx	0.125 fl.oz.							
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
Daconil Weatherstik	3.5 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
Navicon	0.85 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
Maxtima	0.6 fl.oz.	14-d	ACEGIK	0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
Velista	0.5 oz.	14-d	ACEGIK	0.3 -	0.0 -	0.0 f	0.0 e	0.0 e
ANOVA: Treatment (P > F)				0.2483	0.4805	0.0001	0.0001	0.0001
Days after treatment			14-d	2	3	10	2	9
			21-d	-	-	-	2	9

Continued…

Table 3a. Effect of various fungicides phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019

Treatment	Rate per 1000ft^2	Int	Application Dates	Phytotoxicity 24 May	7 Jun	14 Jun	21 Jun	28 Jun
				-------------------------------- 0-5; 2=max acceptable----------------------------				
Rotational Program 1		pgm		0.0 -	0.0 -	0.1 ef	0.0 e	0.0 e
-Downforce ETQ	0.5 fl.oz.		ACEI					
-Nivales	1.5 fl.oz.		ACE					
-Echo Dyad ETQ	5.0 fl.oz.		GK					
-Sipcam Clearscape ETQ	0.6 fl.oz.		GK					
-Endow 2SC	0.77 fl.oz.		GK					
-E-Pro ETQ	6.0 fl.oz.		I					
-0-29-30 Phosphite	3.0 fl.oz.		ACEGIK					
Rotational Program 2		pgm		0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
-Premion	8.0 fl.oz.		A					
-Harrell's Par	0.37 fl.oz.		A					
-Signature Xtra	4.0 oz.		CI					
-Previa	3.6 fl.oz.		CI					
-Velista	0.3 oz.		EK					
-Affirm	4.0 oz.		EK					
-Oximus	1.0 fl.oz.		G					
-Medallion SC	1.5 fl.oz.		G					
Rotational Program 3		pgm		0.0 -	0.0 -	0.0 f	0.0 e	0.0 e
-Daconil Action	3.5 fl.oz.		ACEGIK					
-Velista	0.5 oz.		AG					
-Appear II	6.0 fl.oz.		ACEGIK					
-Primo Maxx	0.125 fl.oz.		ACEGIK					
-Briskway	0.5 fl.oz.		CI					
-Medallion SC	1.0 fl.oz.		EK					
Untreated				0.0 -	0.0 -	0.0 f	0.0 e	0.3 de
ANOVA: Treatment (P > F)				0.2483	0.4805	0.0001	0.0001	0.0001
Days after treatment			14-d	2	3	10	2	9
			21-d	-	-	-	2	9

[z]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.

[y]Treatments were initiated on 22 May. Application date codes were as follows: A=22 May; C= 4 June; E=19 June; G=2 July; H=9 July; I=16 July; K=30 July.

[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 3b. Effect of various fungicides on phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Phytotoxicity 4 Jul	Phytotoxicity 19 Jul
				--- 0-5; 2=max acceptable---	
UC19-2	0.725 fl.oz.	14-d	ACEGIK	0.0 e[x]	0.3 de
UC19-2	0.9 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
UC19-2	1.2 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
UC19-6	0.5 oz.	14-d	ACEGIK	0.0 e	0.0 e
UC19-4	0.0785 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+UC19-3	0.118 fl.oz.				
+UC19-10	0.25 fl.oz.				
+UC19-11	0.00655 oz.				
UC19-4	0.157 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+UC19-3	0.236 fl.oz.				
+UC19-10	0.5 fl.oz.				
+UC19-11	0.0131 fl.oz.				
Premion	4.0 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+Harrell's Par	0.37 fl.oz.				
Premion	6.0 fl.oz.	14-d	ACEGIK	0.3 de	0.5 de
+Harrell's Par	0.37 fl.oz.				
Premion	8.0 fl.oz.	14-d	ACEGIK	0.5 de	0.5 de
+Harrell's Par	0.37 fl.oz.				
Autilis	6.0 fl.oz.	14-d	ACEGIK	0.0 e	0.3 de
+Harrell's Par	0.37 fl.oz.				
Oximus	0.8 fl.oz.	14-d	ACEGIK	0.8 cd	1.3 bc
Oximus	1.0 fl.oz.	14-d	ACEGIK	1.3 c	1.5 ab
Oximus	1.6 fl.oz.	14-d	ACEGIK	2.0 b	2.0 a
Mirage	.1.0 fl.oz.	14-d	ACEGIK	0.8 cd	0.8 cd
UC19-22	0.35 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
UC19-22	0.7 fl.oz.	14-d	ACEGIK	0.0 e	0.3 de
UC19-14	0.41 fl.oz.	14-d	ACEGIK	0.5 de	0.0 e
UC19-16	0.092 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+Non-Ionic Surfactant	0.25% v/v				
UC19-16	0.138 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+Non-Ionic Surfactant	0.25% v/v				
UC19-16	0.184 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+Non-Ionic Surfactant	0.25% v/v				
Tekken	3.0 fl.oz.	14/21-d	ACEHKN	2.8 a	1.3 bc
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+Appear II	4.0 fl.oz.				
+Primo Maxx	0.125 fl.oz.				
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
+Appear II	6.0 fl.oz.				
+Primo Maxx	0.125 fl.oz.				
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
Daconil Weatherstik	3.5 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
Navicon	0.85 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
Maxtima	0.6 fl.oz.	14-d	ACEGIK	0.0 e	0.0 e
Velista	0.5 oz.	14-d	ACEGIK	0.0 e	0.0 e
ANOVA: Treatment (P > F)				0.0001	0.0001
Days after treatment			14-d	2	3
			21-d	16	10

Continued…

Table 3b. Effect of various fungicides on phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft^2	Int	Application Dates	Phytotoxicity 4 Jul	Phytotoxicity 19 Jul
				-- 0-5; 2=max acceptable--	
Rotational Program 1		pgm		0.5 de	0.3 de
-Downforce ETQ	0.5 fl.oz.		ACEI		
-Nivales	1.5 fl.oz.		ACE		
-Echo Dyad ETQ	5.0 fl.oz.		GK		
-Sipcam Clearscape ETQ	0.6 fl.oz.		GK		
-Endow 2SC	0.77 fl.oz.		GK		
-E-Pro ETQ	6.0 fl.oz.		I		
-0-29-30 Phosphite	3.0 fl.oz.		ACEGIK		
Rotational Program 2		pgm		0.0 e	0.0 e
-Premion	8.0 fl.oz.		A		
-Harrell's Par	0.37 fl.oz.		A		
-Signature Xtra	4.0 oz.		CI		
-Previa	3.6 fl.oz.		CI		
-Velista	0.3 oz.		EK		
-Affirm	4.0 oz.		EK		
-Oximus	1.0 fl.oz.		G		
-Medallion SC	1.5 fl.oz.		G		
Rotational Program 3		pgm		0.0 e	0.0 e
-Daconil Action	3.5 fl.oz.		ACEGIK		
-Velista	0.5 oz.		AG		
-Appear II	6.0 fl.oz.		ACEGIK		
-Primo Maxx	0.125 fl.oz.		ACEGIK		
-Briskway	0.5 fl.oz.		CI		
-Medallion SC	1.0 fl.oz.		EK		
Untreated				0.0 e	0.0 e
ANOVA: Treatment (P > F)				0.0001	0.0001
Days after treatment			14-d	2	3
			21-d	16	10

[z]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.

[y]Treatments were initiated on 22 May. Application date codes were as follows: A=22 May; C= 4 June; E=19 June; G=2 July; H=9 July; I=16 July; K=30 July.

[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 4. Effect of various fungicides on NDVI in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	NDVI 14 Jun	NDVI 24 Jul
				----------Vegetation Index---------	
UC19-2	0.725 fl.oz.	14-d	ACEGIK	0.769 d-i[x]	0.740 a-g
UC19-2	0.9 fl.oz.	14-d	ACEGIK	0.770 c-i	0.741 a-g
UC19-2	1.2 fl.oz.	14-d	ACEGIK	0.772 b-i	0.731 b-h
UC19-6	0.5 oz.	14-d	ACEGIK	0.791 a-d	0.754 abc
UC19-4	0.0785 fl.oz.	14-d	ACEGIK	0.790 a-d	0.741 a-g
+UC19-3	0.118 fl.oz.				
+UC19-10	0.25 fl.oz.				
+UC19-11	0.00655 oz.				
UC19-4	0.157 fl.oz.	14-d	ACEGIK	0.790 a-d	0.748 a-e
+UC19-3	0.236 fl.oz.				
+UC19-10	0.5 fl.oz.				
+UC19-11	0.0131 fl.oz.				
Premion	4.0 fl.oz.	14-d	ACEGIK	0.777 a-h	0.739 a-g
+Harrell's Par	0.37 fl.oz.				
Premion	6.0 fl.oz.	14-d	ACEGIK	0.785 a-g	0.738 a-g
+Harrell's Par	0.37 fl.oz.				
Premion	8.0 fl.oz.	14-d	ACEGIK	0.772 b-i	0.742 a-g
+Harrell's Par	0.37 fl.oz.				
Autilis	6.0 fl.oz.	14-d	ACEGIK	0.778 a-h	0.752 abc
+Harrell's Par	0.37 fl.oz.				
Oximus	0.8 fl.oz.	14-d	ACEGIK	0.786 a-e	0.737 a-g
Oximus	1.0 fl.oz.	14-d	ACEGIK	0.788 a-e	0.758 ab
Oximus	1.6 fl.oz.	14-d	ACEGIK	0.749 i	0.741 a-g
Mirage	.1.0 fl.oz.	14-d	ACEGIK	0.780 a-h	0.743 a-g
UC19-22	0.35 fl.oz.	14-d	ACEGIK	0.771 c-i	0.721 d-i
UC19-22	0.7 fl.oz.	14-d	ACEGIK	0.784 a-g	0.721 e-i
UC19-14	0.41 fl.oz.	14-d	ACEGIK	0.761 ghi	0.718 f-i
UC19-16	0.092 fl.oz.	14-d	ACEGIK	0.765 e-i	0.693 ij
+Non-Ionic Surfactant	0.25% v/v				
UC19-16	0.138 fl.oz.	14-d	ACEGIK	0.773 a-i	0.714 g-j
+Non-Ionic Surfactant	0.25% v/v				
UC19-16	0.184 fl.oz.	14-d	ACEGIK	0.772 b-i	0.705 hij
+Non-Ionic Surfactant	0.25% v/v				
Tekken	3.0 fl.oz.	14/21-d	ACEHKN	0.758 hi	0.750 a-d
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.793 abc	0.747 a-f
+Appear II	4.0 fl.oz.				
+Primo Maxx	0.125 fl.oz.				
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.796 a	0.751 abc
+Appear II	6.0 fl.oz.				
+Primo Maxx	0.125 fl.oz.				
Daconil Action	3.5 fl.oz.	14-d	ACEGIK	0.785 a-f	0.730 b-h
Daconil Weatherstik	3.5 fl.oz.	14-d	ACEGIK	0.772 b-i	0.729 c-h
Navicon	0.85 fl.oz.	14-d	ACEGIK	0.787 a-e	0.742 a-g
Maxtima	0.6 fl.oz.	14-d	ACEGIK	0.786 a-f	0.751 abc
Velista	0.5 oz.	14-d	ACEGIK	0.771 c-i	0.745 a-f
ANOVA: Treatment (P > F)				0.0102	0.0001
Days after treatment			14-d	10	8
			21-d	-	15

Continued…

Table 4. Effect of various fungicides on NDVI in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft^2	Int	Application Dates	NDVI 14 Jun	NDVI 24 Jul
				--------Vegetation Index-------	
Rotational Program 1		pgm		0.774 a-h	0.760 a
-Downforce ETQ	0.5 fl.oz.		ACEI		
-Nivales	1.5 fl.oz.		ACE		
-Echo Dyad ETQ	5.0 fl.oz.		GK		
-Sipcam Clearscape ETQ	0.6 fl.oz.		GK		
-Endow 2SC	0.77 fl.oz.		GK		
-E-Pro ETQ	6.0 fl.oz.		I		
-0-29-30 Phosphite	3.0 fl.oz.		ACEGIK		
Rotational Program 2		pgm		0.769 c-i	0.750 a-d
-Premion	8.0 fl.oz.		A		
-Harrell's Par	0.37 fl.oz.		A		
-Signature Xtra	4.0 oz.		CI		
-Previa	3.6 fl.oz.		CI		
-Velista	0.3 oz.		EK		
-Affirm	4.0 oz.		EK		
-Oximus	1.0 fl.oz.		G		
-Medallion SC	1.5 fl.oz.		G		
Rotational Program 3		pgm		0.795 ab	0.747 a-e
-Daconil Action	3.5 fl.oz.		ACEGIK		
-Velista	0.5 oz.		AG		
-Appear II	6.0 fl.oz.		ACEGIK		
-Primo Maxx	0.125 fl.oz.		ACEGIK		
-Briskway	0.5 fl.oz.		CI		
-Medallion SC	1.0 fl.oz.		EK		
Untreated				0.762 f-i	0.689 j
ANOVA: Treatment (P > F)				0.0102	0.0001
Days after treatment			14-d	10	8
			21-d	-	15

[z]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.

[y]Treatments were initiated on 22 May. Application date codes were as follows: A=22 May; C= 4 June; E=19 June; G=2 July; H=9 July; I=16 July; K=30 July.

[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)

EARLY CURATIVE ANTHRACNOSE CONTROL WITH A DEVELOPMENTAL FUNGICIDE ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2019

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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 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 April through 1 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 Pinpoint (0.21 oz.) was applied every 14-d between 21 May and 24 July to prevent dollar spot development. Acelepryn and Tempo were applied on 23 May for control of annual bluegrass weevil and white grubs.

Treatments consisted of commercially available and developmental fungicides. Initial applications for most treatments were made on 23 May immediately following the earlier than normal onset of symptoms in the trial area. Subsequent applications were made at specified intervals through 19 June. Two treatments were initially applied during higher disease pressure, on 5 June and 19 June respectively and were reapplied 14-d later. 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 severity was evaluated visually as the percent area blighted by *C. cereale* from 24 May through 26 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. 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 earlier than normal for our area on 20 May and increased slowly to approximately 8% plot area blighted in untreated control plots as of 7 June (Tables 1a + 1b). Disease pressure was moderate though the beginning of July, reaching 21% plot area blighted on 4 July, and then increased rapidly throughout the month, with untreated control plots reaching nearly 70% plot area blighted on 19 July and 80% on 26 July.

UC19-12 was applied at various rates and intervals. At the lower rates (0.0982 & 0.1309 fl.oz.; 14-d) UC19-12 provided very good control (<3% plot area blighted) through 12 July, 23 days after the final application (DAT). Anthracnose increased to ~10% for the lowest rate as of 19 July and 16% as of 26 July which, although unacceptable at this point, still represented a significant reduction of disease compared to untreated control plots despite being 37 DAT. At the 0.1309 fl.oz. rate, disease remained acceptable (<10%) for the duration of the trial. UC19-12 was also applied at 0.1963 fl.oz. on a 14-d interval for the first two applications, and then at 0.1309 fl.oz. for the final application. This treatment provided excellent (<1%) control through 12 July, and acceptable control through the end of the trial. Finally, UC19-12 was applied at the 0.1963 fl.oz. rate on a 28-d interval. This treatment maintained good (<5% plot area blighted) control for the entirety of the trial despite only receiving 2 total applications.

UC19-12 was applied curatively on 5 June (during "moderate" disease pressure) and on 19 June (during "severe" pressure). Both treatments were reapplied 14-d later (19 June and 3 July, respectively). The moderate curative treatment peaked at ~7% plot area blighted on 7 June, achieving an excellent level of control by 28 June (<1% plot area blighted). Anthracnose control was excellent through 12 July, and remained acceptable for the duration of the trial. The severe curative treatment displayed 10% plot area blighted on 14 June, 5 days before the initial fungicide application. It peaked at 30% blighted on 4 July, the day after the followup application, before steadily declining in severity through the month, reaching 11% as of 26 July. Additional fungicide applications may be necessary for complete curative control when using UC19-12 under such advanced levels of disease disease severity.

Several DMI fungicides were also evaluated in this trial, all of which were applied three times on a 14-d interval beginning on 23 May. Banner Maxx and Maxtima (a new DMI fungicide with enhanced phytosafety) both provided very good to excellent control through 12 July (23 DAT), and acceptable control for the rest of the trial. Torque, Mirage, and Navicon (a new DMI fungicide containing the active ingredient in Maxtima and pyraclostrobin) all provided good to excellent control for the entirety of the trial.

AUDPC

AUDPC was calculated for all treatments. Plots treated with Torque and Mirage Stressgard performed particularly well, as did UC19-12 (0.1309 oz., 14-d; 0.1963 oz., 28-d; and 14-d rotational program), as well as Banner Maxx, Maxtima and Navicon.

Turf Quality, Phytotoxicity, and NDVI

Due to earlier-than-expected anthracnose incidence, turf quality (Tables 2a + 2b) was low for all treatments until 14 June. As of this date, UC19-12 (all rates and intervals except the ones applied late), Torque, Maxtima, and Navicon recovered to have acceptable (>6) turf quality. Quality remained acceptable for these treatments as well as Mirage through 4 July. NDVI readings were largely influenced by disease incidence, with plots showing greater disease having lower NDVI readings (Table 4).

Typical DMI-induced phytoxicity was observed throughout the trial on plots treated with Banner Maxx, Torque, and Mirage (Table 3), leading to a reduction in turf quality. There was no phytotoxicity observed in plots treated with UC19-12, Maxtima, or Navicon.

Table 1a. Effect of various fungicides on early curative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

				Anthracnose Incidence					
Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	24 May	31 May	7 Jun	14 Jun	21 Jun	28 Jun
				--------------------- % plot area blighted					-----------------------
UC19-12	0.0982 fl.oz.	14-d	ACE	0.2[x] -	2.2 -	2.3 c[w]	2.8 c	2.0 bc	0.6 c
UC19-12	0.1309 fl.oz.	14-d	ACE	0.1 -	1.3 -	1.3 cd	0.5 de	0.3 de	0.0 d
UC19-12	0.1963 fl.oz.	28-d	AE	0.4 -	2.5 -	0.3 de	0.2 e	0.9 cd	0.1 d
UC19-12	0.1963 fl.oz.	pgm	AC	0.3 -	3.3 -	1.5 cd	0.4 e	0.2 de	0.0 d
- UC19-12	0.1309 fl.oz.		E						
UC19-12	0.1963 fl.oz.	cur-moderate	CE	0.3 -	3.3 -	7.3 ab	6.6 ab	2.9 b	0.8 c
UC19-12	0.1963 fl.oz.	cur-severe	EG	0.3 -	4.1 -	10.1 a	10.5 a	8.7 a	11.7 a
Banner Maxx II	2.0 fl.oz.	14-d	ACE	0.0 -	0.5 -	2.3 c	2.2 cd	1.6 bc	1.1 c
Torque	0.8 fl.oz.	14-d	ACE	0.8 -	4.4 -	1.2 cd	0.1 e	0.0 e	0.0 d
Mirage	1.5 fl.oz.	14-d	ACE	0.6 -	2.7 -	0.0 e	0.0 e	0.0 e	0.0 d
Maxtima	0.4 fl.oz.	14-d	ACE	0.1 -	3.4 -	2.2 c	3.7 bc	1.1 cd	0.1 d
Navicon	0.7 fl.oz.	14-d	ACE	0.3 -	4.3 -	3.1 bc	3.7 bc	0.2 de	0.0 d
Untreated				0.0 -	3.6 -	7.8 a	9.2 a	6.4 a	6.5 b
ANOVA: Treatment (P > F)				0.5866	0.3408	0.0001	0.0001	0.0001	0.0001
Days after treatment			14-d	1	7	2	9	2	9
			28-d	1	7	14	21	2	9
			cur-mod.	-	-	2	9	2	9
			cur-severe	-	-	-	-	2	9

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.
[y]Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July
[x]Anthracnose means were arc-sine transformed. Means are de-transformed 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 1b. Effect of various fungicides on early curative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

				Anthracnose Incidence				
Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	4 Jul	12 Jul	19 Jul	26 Jul	AUDPC
				--------------------------- % plot area blighted		----		-----------------------------
UC19-12	0.0982 fl.oz.	14-d	ACE	1.2 b	2.6 c	9.7 bc	16.3 b	288.0 c
UC19-12	0.1309 fl.oz.	14-d	ACE	0.0 c	1.0 cd	5.5 cde	8.7 bc	122.3 cd
UC19-12	0.1963 fl.oz.	28-d	AE	0.2 c	0.2 de	3.0 d-g	3.8 c	87.5 cd
UC19-12	0.1963 fl.oz.	pgm	AC	0.1 c	0.2 de	6.0 cd	7.4 bc	152.3 cd
- UC19-12	0.1309 fl.oz.		E					
UC19-12	0.1963 fl.oz.	cur-moderate	CE	0.2 c	0.9 cde	4.9 c-f	7.9 bc	280.4 c
UC19-12	0.1963 fl.oz.	cur-severe	EG	30.8 a	17.6 b	15.2 b	11.2 bc	830.4 b
Banner Maxx II	2.0 fl.oz.	14-d	ACE	0.3 c	1.1 cd	5.3 cde	5.6 bc	132.2 cd
Torque	0.8 fl.oz.	14-d	ACE	0.0 c	0.0 e	0.0 g	0.7 d	52.9 d
Mirage	1.5 fl.oz.	14-d	ACE	0.0 c	0.0 e	0.9 fg	0.3 d	37.2 d
Maxtima	0.4 fl.oz.	14-d	ACE	0.4 bc	1.6 c	5.1 c-f	6.1 bc	174.1 cd
Navicon	0.7 fl.oz.	14-d	ACE	0.0 c	0.2 de	1.3 efg	4.0 c	126.6 cd
Untreated				21.3 a	37.3 a	69.4 a	80.0 a	1476.7 a
ANOVA: Treatment (P > F)				0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment			14-d	15	23	30	37	--
			28-d	15	23	30	37	--
			cur-mod.	15	23	30	37	--
			cur-severe	1	9	18	25	--

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.
[y]Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July
[x]Anthracnose means were arc-sine transformed. Means are de-transformed 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 2a. 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 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Turf Quality 24 May	7 Jun	14 Jun	21 Jun
				-------------------- 1-9; 6=min acceptable			-------------------
UC19-12	0.0982 fl.oz.	14-d	ACE	3.5 -	4.5 cde[x]	6.3 bc	5.8 cd
UC19-12	0.1309 fl.oz.	14-d	ACE	3.5 -	5.0 bc	7.3 a	7.5 a
UC19-12	0.1963 fl.oz.	28-d	AE	4.0 -	5.8 a	7.0 ab	7.0 ab
UC19-12	0.1963 fl.oz.	pgm	AC	3.0 -	4.0 ef	6.0 cd	6.8 ab
- UC19-12	0.1309 fl.oz.		E				
UC19-12	0.1963 fl.oz.	cur-moderate	CE	3.5 -	3.8 f	5.0 ef	5.3 de
UC19-12	0.1963 fl.oz.	cur-severe	EG	3.3 -	4.0 ef	5.3 def	4.0 f
Banner Maxx II......................	2.0 fl.oz.	14-d	ACE	3.0 -	4.0 ef	4.8 f	5.0 de
Torque...................................	0.8 fl.oz.	14-d	ACE	3.8 -	4.8 bcd	6.0 cd	5.5 cd
Mirage...................................	1.5 fl.oz.	14-d	ACE	3.8 -	5.3 ab	5.8 cde	6.3 bc
Maxtima................................	0.4 fl.oz.	14-d	ACE	3.5 -	4.3 def	6.0 cd	6.3 bc
Navicon.................................	0.7 fl.oz.	14-d	ACE	3.8 -	5.3 ab	6.5 abc	6.8 ab
Untreated				3.8 -	3.8 f	5.0 ef	4.5 ef
ANOVA: Treatment (P > F)				0.1018	0.0001	0.0001	0.0001
Days after treatment			14-d	1	2	9	2
			28-d	1	14	21	2
			cur-mod.	-	2	9	2
			cur-severe	-	-	-	2

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.
[y]Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July
[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 2b. 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 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Turf Quality 28 Jun	4 Jul	19 Jul
				-------------- 1-9		--------------------
UC19-12	0.0982 fl.oz.	14-d	ACE	6.8 bc[x]	6.5 ab	5.3 d
UC19-12	0.1309 fl.oz.	14-d	ACE	7.8 a	7.5 a	5.8 cd
UC19-12	0.1963 fl.oz.	28-d	AE	7.8 a	7.0 ab	6.5 bc
UC19-12	0.1963 fl.oz.	pgm	AC	7.5 ab	6.8 ab	5.5 d
- UC19-12	0.1309 fl.oz.		E			
UC19-12	0.1963 fl.oz.	cur-moderate	CE	6.3 cd	6.5 ab	5.8 cd
UC19-12	0.1963 fl.oz.	cur-severe	EG	4.3 e	3.3 d	5.0 d
Banner Maxx II......................	2.0 fl.oz.	14-d	ACE	5.8 d	5.3 c	5.5 d
Torque...................................	0.8 fl.oz.	14-d	ACE	6.8 bc	6.8 ab	8.0 a
Mirage...................................	1.5 fl.oz.	14-d	ACE	6.3 cd	6.0 bc	6.8 b
Maxtima................................	0.4 fl.oz.	14-d	ACE	7.0 abc	6.0 bc	5.5 d
Navicon.................................	0.7 fl.oz.	14-d	ACE	7.5 ab	7.3 a	6.8 b
Untreated				4.8 e	4.0 d	3.0 e
ANOVA: Treatment (P > F)				0.0001	0.0001	0.0001
Days after treatment			14-d	9	15	30
			28-d	9	15	30
			cur-mod.	9	15	30
			cur-severe	9	1	18

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.
[y]Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July
[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. Effect of various fungicides on phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Phytotoxicity 7 Jun	14 Jun	21 Jun	28 Jun	4 Jul	19 Jul
				0-5; 2=max acceptable					
UC19-12	0.0982 fl.oz.	14-d	ACE	0.0 c[x]	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
UC19-12	0.1309 fl.oz.	14-d	ACE	0.0 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
UC19-12	0.1963 fl.oz.	28-d	AE	0.0 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
UC19-12	0.1963 fl.oz.	pgm	AC	0.0 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
- UC19-12	0.1309 fl.oz.		E						
UC19-12	0.1963 fl.oz.	cur-moderate	CE	0.1 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
UC19-12	0.1963 fl.oz.	cur-severe	EG	0.0 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
Banner Maxx II	2.0 fl.oz.	14-d	ACE	2.0 a	2.2 a	2.0 a	2.0 a	1.3 a	1.0 a
Torque	0.8 fl.oz.	14-d	ACE	0.6 b	0.7 c	1.0 b	0.9 b	1.5 a	0.0 c
Mirage	1.5 fl.oz.	14-d	ACE	0.0 c	1.2 b	0.0 c	1.0 b	1.1 a	0.3 b
Maxtima	0.4 fl.oz.	14-d	ACE	0.0 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
Navicon	0.7 fl.oz.	14-d	ACE	0.0 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
Untreated				0.0 c	0.0 d	0.0 c	0.0 c	0.0 b	0.0 c
ANOVA: Treatment (P > F)				0.0001	0.0001	1.0000	0.0001	0.0001	0.0001
Days after treatment			14-d	2	9	2	9	15	30
			28-d	14	21	2	9	15	30
			cur-mod.	2	9	2	9	15	30
			cur-severe	-	-	2	9	1	18

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.

[y]Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July

[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 4. Effect of various fungicides on NDVI in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft^2	Int	Application Dates[y]	NDVI 14 Jun	NDVI 2 Jul	NDVI 24 Jul
				---Vegetation Index---		
UC19-12	0.0982 fl.oz.	14-d	ACE	0.768 -	0.779 b[x]	0.696 a
UC19-12	0.1309 fl.oz.	14-d	ACE	0.788 -	0.781 ab	0.701 a
UC19-12	0.1963 fl.oz.	28-d	AE	0.775 -	0.780 b	0.717 a
UC19-12	0.1963 fl.oz.	pgm	AC	0.768 -	0.781 ab	0.718 a
- UC19-12	0.1309 fl.oz.		E			
UC19-12	0.1963 fl.oz.	cur-moderate	CE	0.760 -	0.777 b	0.711 a
UC19-12	0.1963 fl.oz.	cur-severe	EG	0.762 -	0.744 c	0.722 a
Banner Maxx II	2.0 fl.oz.	14-d	ACE	0.776 -	0.792 a	0.694 a
Torque	0.8 fl.oz.	14-d	ACE	0.775 -	0.780 b	0.723 a
Mirage	1.5 fl.oz.	14-d	ACE	0.731 -	0.773 b	0.721 a
Maxtima	0.4 fl.oz.	14-d	ACE	0.772 -	0.778 b	0.704 a
Navicon	0.7 fl.oz.	14-d	ACE	0.769 -	0.780 b	0.716 a
Untreated				0.768 -	0.754 c	0.624 b
ANOVA: Treatment (P > F)				0.3650	0.0001	0.0001
Days after treatment			14-d	9	4	35
			28-d	21	4	35
			cur-mod.	9	4	35
			cur-severe	-	4	23

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.

[y]Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July

[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)

PREVENTIVE ANTHRACNOSE CONTROL WITH VARIOUS FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2019

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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. The use of biofungicides to control turfgrass disease is an increasingly popular option for reducing the use, or enhancing the efficacy of conventional fungicides. The objective of this study was to examine the anthracnose control efficacy of biofungicides applied in conjunction with conventional fungicides.

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 April through 1 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 Pinpoint (0.21 oz.) was applied every 14-d between 21 May and 24 July to prevent dollar spot development. Enclave was applied on 6 June to mitigate the effects of an earlier-than-expected outbreak of anthracnose in the trial area. Acelepryn and Tempo were applied on 23 May for control of annual bluegrass weevil and white grubs.

Treatments consisted of commercially available and developmental fungicides. Initial applications for most treatments were made on 23 May immediately following the earlier than normal onset of symptoms in the trial area. Subsequent applications were made every 14-d through 17 July All treatments were applied using a air compressor powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose severity was evaluated visually as the percent area blighted by *C. cereale* from 24 May through 26 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. 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 24 May and increased slowly to approximately 8% plot area blighted in untreated control plots as of 7 June (Tables 1a + 1b). Disease pressure was moderate though the beginning of July, reaching 21% plot area blighted on 4 July, and then increased rapidly throughout the month, with untreated control plots reaching nearly 70% plot area blighted on 19 July and 80% on 26 July.

RESULTS & DISCUSSION

Anthracnose Severity
Anthracnose symptoms developed from a natural infestation on 24 May and increased slowly through early July, likely having been slowed down by the Enclave application in early June. All treatments including untreated control plots displayed acceptable <10% plot area blighted) levels of anthracnose though 4 July (Tables 1a + 1b). Disease then increased rapidly during July as high day and nighttime temperatures and humidity contributed to highly favorable disease conditions. Anthracnose in untreated control plots increased from 7% plot area blighted on 4 July to 48% on 26 July. Individual treatment differences were more apparent beginning in mid-July through the end of the trial.

Obtego, a biofungicide and plant symbiont, was applied as a tank-mix with Soteria (fluazinam) or Velista. As of 19 July, plots treated with Obtego + Soteria had unacceptable levels of anthracnose (>10%) for the remainder of the trial. The tank-mix did not provide any enhancement of disease control relative to Soteria alone, which also provided unacceptable control. In previous research at this site, fluazinam has had limited efficacy on anthracnose and so it was not expected that the addition of Soteria would enhance disease control relative to Obtego applied alone. The Obtego + Velista provided acceptable control for the entirety of the trial, but was no more efficacious than Velista applied alone.

Zio, another biofungicide, was also applied in conjunction with Soteria or Velista. Although the Zio + Soteria tank-mix did not provide acceptable control, the Zio + Velista tank-mix provided excellent control (<1% plot area blighted) through 19 July and very good control (<3%) through the end of the trial. However, the performance of this tank-mix was not statistically different from Velista applied alone, and so further work is needed to determine if Zio enhances the efficacy of traditional fungicides like Velista.

Zero-Tol 2.0 was used as a surface steriliant to explore whether clearing the microbiome on the leaf surfaces could enhance the efficacy of biofungicides. Zero-Tol was applied and allowed to dry for 3 hours before Zio + Velista applications were made on the same plots. This treatment remained statistically identical to untreated control plots for the entirety of the trial, and performed significantly worse than Zio + Velista applied without Zero-Tol. It is possible that the application of Zero-Tol is increasing the plant's susceptibility to infection, but further research is required to determine exactly why the addition of Zero-Tol reduced the efficacy of the Zio + Velista combination.

Turf Quality and Phytotoxicity

There were no statistical differences in Turf Quality, and as of 24 July, all treatments provided higher NDVI readings when compared to untreated control plots. (Table 2).

Table 1a. 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 2019.

Treatment[z]	Rate per 1000ft^2	Anthracnose Incidence					
		24 May	31 May	7 June	14 June	21 June	28 June
		---- % plot area blighted ----					
Obtego +Soteria	0.9 oz. 0.5 fl.oz.	0.0[y] -	0.7 -	0.1 -	1.2 -	0.5 -	0.0 -
Obtego +Velista	0.9 oz. 0.3 oz.	0.5 -	2.5 -	1.3 -	1.9 -	2.3 -	0.2 -
Zio +Soteria	0.9 oz. 0.5 fl.oz.	0.1 -	0.6 -	0.3 -	0.4 -	0.9 -	0.3 -
Zio +Velista	0.9 oz. 0.3 oz.	0.3 -	1.9 -	0.5 -	0.1 -	0.3 -	0.3 -
Soteria	0.5 fl.oz.	0.1 -	1.6 -	0.7 -	1.1 -	1.6 -	0.3 -
Velista	0.3 oz.	0.1 -	1.6 -	0.9 -	3.5 -	1.7 -	0.3 -
ZeroTol 2.0 +Zio +Velista	6.0 fl.oz. 0.9 oz. 0.3 oz.	0.2 -	2.2 -	2.2 -	4.0 -	2.7 -	0.3 -
Untreated		0.3 -	1.5 -	1.3 -	0.9 -	0.9 -	0.1 -
ANOVA: Treatment (P > F)		0.6858	0.2974	0.2021	0.1827	0.2751	0.7277
Days after treatment		1	7	2	9	2	9

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July; I=17 July.

[y]Anthracnose means were arc-sine transformed. Means are de-transformed for presentation.

Table 1b. 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 2019.

Treatment	Rate per 1000ft^2	Anthracnose Incidence			
		4 July	12 July	19 July	26 July
		---- % plot area blighted ----			
Obtego +Soteria	0.9 oz. 0.5 fl.oz.	3.1[y] -	2.9 b[x]	13.6 ab	17.5 ab
Obtego +Velista	0.9 oz. 0.3 oz.	2.3 -	3.8 b	5.6 bc	9.5 b
Zio +Soteria	0.9 oz. 0.5 fl.oz.	2.6 -	2.3 b	15.2 ab	20.2 ab
Zio +Velista	0.9 oz. 0.3 oz.	0.8 -	0.6 b	0.8 c	3.0 c
Soteria	0.5 fl.oz.	2.7 -	2.9 b	13.6 ab	18.3 ab
Velista	0.3 oz.	3.4 -	4.2 b	8.8 abc	9.5 bc
ZeroTol 2.0 +Zio +Velista	6.0 fl.oz. 0.9 oz. 0.3 oz.	7.0 -	8.7 a	19.1 a	31.2 a
Untreated		7.0 -	14.2 a	28.8 a	48.3 a
ANOVA: Treatment (P > F)		0.1206	0.0033	0.0063	0.0055
Days after treatment		1	8	16	9

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi.Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July; I=17 July.

[y]Anthracnose means were arc-sine 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 (α = 0.05)

Table 2. Effect of various fungicides on Turf Quality and NDVI in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z] Rate per 1000ft²	Turf Quality				NDVI	
	24 May	21 June	28 June	19 July	2 July	24 July
	% plot area blighted				Vegetation Index	
Obtego ....0.9 oz. +Soteria.................0.5 fl.oz.	3.6 -	6.7 -	7.2 -	5.5 -	0.783 -	0.751 a[y]
Obtego ....0.9 oz. +Velista....................0.3 oz.	3.4 -	6.6 -	6.7 -	6.2 -	0.778 -	0.759 a
Zio..............................0.9 oz. +Soteria................0.5 fl.oz.	3.3 -	6.3 -	7.1 -	5.2 -	0.784 -	0.737 a
Zio..............................0.9 oz. +Velista....................0.3 oz.	4.0 -	6.6 -	8.2 -	6.9 -	0.780 -	0.759 a
Soteria.....................0.5 fl.oz.	3.0 -	6.7 -	7.1 -	5.1 -	0.777 -	0.739 a
Velista........................0.3 oz.	3.2 -	6.2 -	6.6 -	5.5 -	0.780 -	0.734 a
ZeroTol 2.0 ....6.0 fl.oz. +Zio ....0.9 oz. +Velista....................0.3 oz.	3.0 -	4.8 -	6.8 -	4.4 -	0.781 -	0.736 a
Untreated	3.3 -	6.8 -	6.7 -	4.0 -	0.774 -	0.687 b
ANOVA: Treatment (P > F)	0.1350	0.2848	0.4287	0.0110	0.2771	0.0036
Days after treatment	1	2	9	16	13	7

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft $^{-2}$ at 40 psi.Treatments were initiated on 23 May. Application date codes were as follows: A=23 May; C= 5 June; E=19 June; G=3 July; I=17 July.

[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 BROWN PATCH CONTROL WITH FUNGICIDES ON A CREEPING BENTGRASS PUTTING GREEN TURF, 2019

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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 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 1.7 lb N 1000-ft^{-2} as water soluble sources from April through August. Acelepryn was applied on 23 May to control white grubs. To help alleviate dry surface conditions, the wetting agent Revolution was applied on 1 July and 26 July.

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 hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

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. 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

Brown Patch Incidence
Brown patch developed in the trial area beginning in early July, with untreated plots showing 4.3% plot area blighted (Table 1). The disease spread throughout the trial area over the following weeks, with 14% of untreated plot area blighted as of 12 July, 25% as of 19 July, and 47% on 30 July.

A majority of treatments in the trial provided complete oe nearly complete control of brown patch symptoms for the entirety of the trial. Plots treated with A12704A or A13703G showed no brown patch at any point regardless of rate or interval. A20581A also provided near-complete control of disease, although the 14-d interval (0.34 oz.) did have some minor breakthrough in early July compared with the 28-d interval which was applied at a higher rate (0.47 oz).

Two biofungicides, Obtego and Zio, were tank-mixed and applied with either Soteria (fluazinam) or Heritage (azoxystrobin). Soteria and Heritage were also applied as stand-alone treatments. All plots that received Heritage (whether stand-alone or in a tank-mix) provided complete control of disease for the duration of the trial. When applied alone, Soteria generally provided acceptable (<10% plot area blighted) control, except on 30 July. Tank-mixing Soteria with either Zio or Obtego did not have a significant impact on disease control compared to Soteria alone, except on 12 July when Soteria-alone plots were ~7% blighted, Obetgo + Soteria plots were ~1% blighted, and Zio + Soteria plots were disease-free. Zio + Soteria provided acceptable control for the entirety of the trial.

Pinpoint provided some control of disease when compared to untreated control plots beginning on July 12 and for the remainder of the trial, however disease was unacceptable as of 30 July with 27% plot area blighted. Affirm provided very good (<5% plot area blighted) control for the entirety of the trial.

Turf Quality, Phytotoxicity, and NDVI
Turf Quality (Table 2) was generally affected by disease incidence. All plots, including untreated, had acceptable quality (6 or greater) as of 3 July. As of 19 July, as disease spread through the trial area, quality became unacceptable in plots treated with Soteria alone and in untreated plots. Quality was especially high in plots treated with A12704A, A13703G, A20581A, and Heritage as of this date.

NDVI (Table 2) was also affected by disease incidence, with the lowest NDVI ratings occurring on untreated control plots. There was no significant phytoxicity observed at any point during the trial (Table 3).

Table 1. Effect of various fungicides on preventative brown patch control in a creeping bentgrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

				Brown Patch					
Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	21 Jun	3 Jul	10 Jul	12 Jul	19 Jul	30 Jul
				% plot area blighted					
A12704A	0.2 oz.	14-d	ACEG	0.0 -	0.0 c[x]	0.0 c	0.0 d	0.0 b	0.0 e
A13703G	0.5 fl.oz.	14-d	ACEG	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
A13703G	0.725 fl.oz.	14-d	ACEG	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
A20581A	0.34 fl.oz.	14-d	ACEG	0.0 -	5.3 a	5.1 ab	0.6 cd	0.0 b	0.0 e
A12704A	0.4 oz.	28-d	AE	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
A13703G	0.725 fl.oz.	28-d	AE	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
A13703G	0.9 fl.oz.	28-d	AE	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
A13703G	1.2 fl.oz.	28-d	AE	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
A20581A	0.47 fl.oz.	28-d	AE	0.0 -	0.0 c	0.0 c	0.0 d	0.2 b	0.0 e
Obtego +Soteria	0.92 oz. 0.505 fl.oz.	14-d	ACEG	0.0 -	0.0 c	6.4 ab	1.2 c	0.4 b	17.0 bc
Obtego +Heritage	0.92 oz. 0.2 oz.	14-d	ACEG	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
Zio +Soteria	0.92 oz. 0.505 fl.oz.	14-d	ACEG	0.0 -	0.0 c	4.6 b	0.0 d	0.5 b	9.0 cde
Zio +Heritage	0.92 oz. 0.2 oz.	14-d	ACEG	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
Soteria	0.505 fl.oz.	14-d	ACEG	0.0 -	0.0 c	9.0 ab	7.3 ab	0.8 b	16.0 bcd
Heritage	0.2 oz.	14-d	ACEG	0.0 -	0.0 c	0.0 c	0.0 d	0.0 b	0.0 e
PinPoint	0.31 fl.oz.	14-d	ACEG	0.0 -	3.5 ab	11.5 a	5.0 b	0.8 b	27.0 b
Affirm	0.88 oz.	14-d	ACEG	0.0 -	0.8 bc	3.3 b	0.0 d	0.0 b	3.0 de
Untreated				0.0 -	4.3 a	11.8 a	14.2 a	25.0 a	47.5 a
ANOVA: Treatment (P > F)				1.0000	0.0065	0.0001	0.0001	0.0001	0.0001
Days after treatment			14-d	2	14	4	6	2	12
			28-d	2	14	21	23	2	12

[z]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.
[y]A=19 June; C=6 July; E=17 July; G=1 August
[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 2. Effect of various fungicides on turf quality and NDVI in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft^2	Int	Application Dates[y]	Turf Quality 3 Jul	Turf Quality 12 Jul	Turf Quality 19 Jul	NDVI 2 Jul	NDVI 31 Jul
				---------------- 1-9; 6=min acceptable		---------------	-----Vegetation Index-----	
A12704A	0.2 oz.	14-d	ACEG	7.5 ab[x]	6.5 b-f	7.0 abc	0.765 abc	0.763 -
A13703G	0.5 fl.oz.	14-d	ACEG	7.8 a	7.0 a-d	8.0 a	0.776 a	0.760 -
A13703G	0.725 fl.oz.	14-d	ACEG	8.0 a	7.5 ab	7.8 ab	0.773 ab	0.762 -
A20581A	0.34 fl.oz.	14-d	ACEG	6.5 bcd	6.0 def	7.8 ab	0.771 ab	0.760 -
A12704A	0.4 oz.	28-d	AE	7.8 a	6.5 b-f	6.8 abc	0.772 ab	0.756 -
A13703G	0.725 fl.oz.	28-d	AE	7.5 ab	6.5 b-f	6.5 bc	0.780 a	0.757 -
A13703G	0.9 fl.oz.	28-d	AE	7.8 a	7.0 a-d	6.8 abc	0.779 a	0.761 -
A13703G	1.2 fl.oz.	28-d	AE	8.0 a	7.3 abc	7.8 ab	0.775 a	0.760 -
A20581A	0.47 fl.oz.	28-d	AE	7.5 ab	8.0 a	8.0 a	0.771 ab	0.760 -
Obtego +Soteria	0.92 oz. 0.505 fl.oz.	14-d	ACEG	7.5 ab	6.5 b-f	7.8 ab	0.767 abc	0.753 -
Obtego +Heritage	0.92 oz. 0.2 oz.	14-d	ACEG	7.5 ab	6.3 c-f	7.0 abc	0.771 ab	0.758 -
Zio +Soteria	0.92 oz. 0.505 fl.oz.	14-d	ACEG	7.8 a	6.8 b-e	7.8 ab	0.770 ab	0.760 -
Zio +Heritage	0.92 oz. 0.2 oz.	14-d	ACEG	7.3 abc	6.0 def	6.8 abc	0.767 abc	0.751 -
Soteria	0.505 fl.oz.	14-d	ACEG	7.3 abc	5.5 fg	4.8 de	0.752 cd	0.751 -
Heritage	0.2 oz.	14-d	ACEG	7.3 abc	6.3 c-f	7.0 abc	0.763 abc	0.761 -
PinPoint	0.31 fl.oz.	14-d	ACEG	6.3 cd	5.8 ef	6.0 cd	0.768 abc	0.749 -
Affirm	0.88 oz.	14-d	ACEG	7.3 abc	5.8 ef	6.3 c	0.757 bcd	0.747 -
Untreated				6.0 d	4.5 g	3.8 e	0.745 d	0.753 -
ANOVA: Treatment (P > F)				0.0113	0.0002	0.0001	0.0113	0.1109
Days after treatment			14-d	14	6	2	13	13
			28-d	14	23	2	13	13

[z]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.
[y]A=19 June; C=6 July; E=17 July; G=1 August
[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. Effect of various fungicides on phytotoxicity on a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[x]	Rate per 1000ft²	Int	Application Dates[y]	Phyto 12 Jul	Phyto 19 Jul
				------ 0-5; 2=max acceptable ------	
A12704A	0.2 oz.	14-d	ACEG	0.0 -	0.0 -
A13703G	0.5 fl.oz.	14-d	ACEG	0.0 -	0.0 -
A13703G	0.725 fl.oz.	14-d	ACEG	0.0 -	0.0 -
A20581A	0.34 fl.oz.	14-d	ACEG	0.0 -	0.0 -
A12704A	0.4 oz.	28-d	AE	0.0 -	0.3 -
A13703G	0.725 fl.oz.	28-d	AE	0.0 -	0.0 -
A13703G	0.9 fl.oz.	28-d	AE	0.0 -	0.0 -
A13703G	1.2 fl.oz.	28-d	AE	0.0 -	0.0 -
A20581A	0.47 fl.oz.	28-d	AE	0.0 -	0.0 -
Obtego	0.92 oz.	14-d	ACEG	0.0 -	0.0 -
+Soteria	0.505 fl.oz.				
Obtego	0.92 oz.	14-d	ACEG	0.0 -	0.0 -
+Heritage	0.2 oz.				
Zio	0.92 oz.	14-d	ACEG	0.0 -	0.0 -
+Soteria	0.505 fl.oz.				
Zio	0.92 oz.	14-d	ACEG	0.0 -	0.0 -
+Heritage	0.2 oz.				
Soteria	0.505 fl.oz.	14-d	ACEG	0.0 -	0.3 -
Heritage	0.2 oz.	14-d	ACEG	0.0 -	0.0 -
PinPoint	0.31 fl.oz.	14-d	ACEG	0.0 -	0.0 -
Affirm	0.88 oz.	14-d	ACEG	0.0 -	0.0 -
Untreated				0.0 -	0.0 -
ANOVA: Treatment (P > F)				1.0000	0.4736
Days after treatment			14-d	6	2
			28-d	23	2

[z]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.
[y]A=19 June; C=6 July; E=17 July; G=1 August

PREVENTIVE DOLLAR SPOT CONTROL WITH VARIOUS FUNGICIDES ON A CREEPING BENTGRASS FAIRWAY TURF, 2019

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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 'Nintety-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. Nitrogen was applied at a total of 1.15 lb N 1000-ft^{-2} as water soluble sources from April through August. Acelepryn was applied on 23 May to control white grubs. Segway was applied on 17 July for prevention of Pythium blight.

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 16 May, prior to disease developing in the trial area. Subsequent applications were made at specified intervals through 6 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 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 were 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. Dollar spot data were log-transformed, and means are de-transformed for presentation. 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

Dollar spot symptoms were first observed on 24 May and progressed slowly through 14-June, when untreated control (UTC) plots averaged 20 dollar spot infection centers (DSIC) per plot (Tables 1a + 1b). Favorable conditions for dollar spot led to a rapid increase in symptoms, reaching 85 DSIC $plot^{-1}$ just 7 days later on 21 June, and 109 DSIC $plot^{-1}$ on 26 June. For the remainder of the trial conditions remained moderate, with disease on UTC plots oscillating between ~100-150 DSIC $plot^{-1}$ from July through early August. All treatments that received fungicide maintained excellent (<3 DSIC $plot^{-1}$) control of dollar spot through 14 June. Differences between treatments started to become apparent beginning on 21 June wih the onset of higher disease pressure.

Daconil Ultrex and Chipco 26GT were applied in a 14-d rotational program for the first 4 applications of their respective treatments (through 26 June). Subsequent applications consisted of either ESTC 120, ESTC 125, ESTC 132, or ESTC 135 and were made on 10 July and 31 July (21-d apart). Although differences in disease severity between these treatments were detected prior to 10 July, it is unlikely that these differences were due to treatments as they were treated identically up to this point. As of 12 July, all of these treatments provided excellent control of disease and all treatments remained acceptable through the end of the trial. UC19-25 and UC19-26 were particularly effective at controlling dollarspot, with less than 6 DSIC $plot^{-1}$ as of the final rating date on 9 August.

Several DMI fungicides were applied on a 21-d basis, including Maxtima, a new DMI fungicide containing mefentrifluconazole, Banner Maxx II, and Torque, as well as Tourney (DMI + Strobilurin) and Navicon, another new DMI fungicide containing mefentrifluconazole and pyraclostribin. As of 21 June (17 days after previous treatment; DAT), plots treated with Banner Maxx II or Torque had unacceptable levels of control, averaging over 50 DSIC $plot^{-1}$. On 26 June, Maxtima, Tourney, and Tartan also had unacceptable levels of disease, however it should be noted that this was at the very end of the 21-d reapplication interval (22 DAT), and it is possible that these fungicides require a shorter reapplication interval under high disease pressure. All DMI treatments recovered somewhat following additional applications and a moderation of disease pressure, however disease remained unacceptable on Banner Maxx II-treated plots for the remainder of the trial, and remained relatively high (~13-30 DSIC plot-1) for plots treated with Torque. Maxtima-treated plots recovered to ~12 DSIC $plot^{-1}$ on 5 July (9 DAT) and fell below 1 DSIC $plot^{-1}$ on 19 July and for the remainder of the trial. Tartan-treated plots also recovered to acceptable disease-levels as of 5 July, and Tourney-treated plots were acceptable as of 19 July and for the remainder of the trial. Plots treated with Navicon had near-complete control of dollar spot for the entirety of the trial

Xzemplar, an SDHI fungicide, was applied at 0.21 oz and 0.26 oz every 21-d. Both rates provided excellent (<3 DSIC $plot^{-1}$) control on all dates except for 26 June, when both treatments still provided very good (<10 DSIC $plot^{-1}$) control of disease. Kabuto, another SDHI, was applied at 0.5 oz. every 14 or 21-d. The 14-d treatment provided acceptable control except on 26 June, whereas the 21-d treatment failed to provide acceptable control from 21-June through mid-July before recovering somewhat (~20 DSIC $plot^{-1}$) for the remainder of the trial.

A number of fungicides containing fluazinam were applied including Secure (0.5 oz.; 14-d), Secure Action (fluazinam + acibenzolar-S-methyl; 0.5 oz.; 21-d), Downforce (fluazinam + pigment; 0.5 oz.; 14-d), and Traction (fluazinam + tebuconazole; 1.3 oz.; 14 and 21-d). Each of these treatments provided very good control for the duration of the trial. Several SDHI fungicides (Posterity, Xzemplar, and Exteris Stressgard) were also applied in an alternating 21-d rotation with Secure Action. Posterity—Secure Action provided near-complete control of disease for the entirety of the trial. Xzemplar—Secure Action provided good (<15 DSIC $plot^{-1}$) to excellent control of disease for much of the trial, except for 26 June (22 DAT), although disease severity remained acceptable. Exteris—Secure Action failed to provide adequate control after 14 June, indicating that this rotation may need higher application rates or a shorter reapplication interval under high disease pressure. Secure Action was also applied in a staggered 21-d rotation with Posterity, with Posterity being applied either 16 May (at trial initiation), 26 June (midway through the trial) or 6 August (at the end of the trial). All three staggered regimes provided very good to excellent control of disease for the duration of the trial.

UC19-15 provided excellent control of disease at all rates and reapplication intervals. UC19-20 and UC19-21 provided very good control of disease when applied individually or when tank-mixed on a 14-d basis. The tank-mix also provided acceptable control when applied every 21-d, except on 26 June. UC19-19 + Daconil Weatherstik provided near complete control of disease when applied every 14 or 21-d, but the 28-d interval failed to provide acceptable control under high disease pressure in late June/early July. A shorter reapplication interval should therefore be used when dollar spot pressure is high.

Tekken (21-d) provided adequate control of disease for the entirety of the trial.

Turf Quality and Phytotoxicity

Turf quality (Table 2) was generally influenced by disease incidence. Quality was particularly high throughout the trial on plots treated with UC19-15, Navicon, Downforce, Secure, Secure Action + Posterity, and Traction. Moderate phytotoxicty (Table 3) was observed during mid-July on plots treated with Banner Maxx II and Tartan, contributing to poor turf quality ratings for these treatments. Maxtima, a new DMI-fungicide with enhanced phytosafety, showed no phytotoxicity for the duration of the trial.

Table 1a. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

				Dollar Spot Severity				
Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	24 May	7 Jun	14 Jun	21 Jun	26 Jun
				# dollar spot infection centers plot^{-1}				
Daconil Ultrex	3.2 oz.	pgm	AE	0.5[x] b-e[w]	0.0 c	0.2 c	0.0 g	7.6 g-k
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-13	1.5 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	0.6 b-e	0.0 c	0.5 bc	3.3 g	21.9 c-f
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-24	2.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	0.6 b-e	0.0 c	0.0 c	2.0 g	15.0 e-h
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-25	3.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	0.1 e	0.0 c	0.0 c	0.0 g	3.7 i-m
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-26	1.3 fl.oz.		IL					
Tekken	3.0 fl.oz.	21-d	ADGJM	0.1 e	0.0 c	0.0 c	13.0 efg	30.0 b-e
UC19-15	0.107 fl.oz.	14-d	ACEGIKM	0.4 cde	0.0 c	0.0 c	0.0 g	1.3 m-p
UC19-15	0.16 fl.oz.	21-d	ADGJM	0.9 a-e	0.3 bc	0.3 bc	1.5 g	3.4 i-m
Maxtima	0.4 fl.oz.	21-d	ADGJM	0.4 cde	0.0 c	0.0 c	9.0 fg	30.9 b-e
Xzemplar	0.26 fl.oz.	21-d	ADGJM	0.1 de	0.0 c	0.0 c	1.0 g	10.3 f-i
Banner Maxx II	1.0 fl.oz.	21-d	ADGJM	0.7 b-e	0.3 bc	0.4 bc	51.8 bc	90.9 a
Torque	0.6 fl.oz.	21-d	ADGJM	0.5 b-e	2.0 b	0.4 bc	56.8 b	79.4 ab
Navicon	0.85 fl.oz.	21-d	ADGJM	1.5 a-d	0.0 c	0.0 c	0.0 g	1.4 m-p
Tourney	0.37 oz.	21-d	ADGJM	0.1 de	0.0 c	0.4 bc	24.5 def	48.2 a-d
Tartan	1.5 fl.oz.	21-d	ADGJM	1.1 a-e	0.0 c	0.2 c	15.8 efg	50.4 abc
Downforce	0.5 fl.oz.	14-d	ACEGIKM	0.3 cde	0.0 c	0.0 c	0.0 g	0.0 p
Secure	0.5 fl.oz.	14-d	ACEGIKM	1.8 abc	0.0 c	0.0 c	0.0 g	0.2 op
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	0.7 b-e	0.0 c	0.0 c	0.0 g	17.5 d-g
UC19-21	0.5 fl.oz.	14-d	ACEGIKM	1.7 a-d	0.5 bc	0.0 c	0.0 g	2.0 l-o
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	1.7 a-d	0.0 c	0.0 c	0.0 g	0.2 op
+UC19-21	0.5 fl.oz.							
UC19-20	0.28 fl.oz.	21-d	ADGJM	0.5 b-e	0.3 bc	0.0 c	6.3 g	33.1 b-e
+UC19-21	0.5 fl.oz.							
Xzemplar	0.21 fl.oz.	21-d	ADGJM	2.0 abc	0.0 c	0.0 c	0.8 g	6.9 g-l
Traction	1.3 fl.oz.	14-d	ACEGIKM	1.5 a-d	1.0 bc	0.3 bc	0.0 g	0.0 p
Traction	1.3 fl.oz.	21-d	ADGJM	0.1 e	0.0 c	0.0 c	0.0 g	1.3 m-p
UC19-19	0.203 fl.oz.	14-d	ACEGIKM	0.1 e	0.0 c	0.0 c	0.0 g	0.0 p
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	21-d	ADGJM	0.5 b-e	0.0 c	0.0 c	0.0 g	5.6 h-l
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	28-d	AEIM	0.5 b-e	2.0 b	1.4 b	0.5 g	7.1 g-k
+Daconil Weatherstik	3.6 fl.oz.							
Kabuto	0.5 fl.oz.	14-d	ACEGIKM	3.5 a	0.0 c	0.0 c	7.0 g	33.5 b-e
Kabuto	0.5 fl.oz.	21-d	ADGJM	1.7 a-d	0.3 bc	0.2 c	39.0 cd	57.4 abc

Continued…

Table 1a. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft^2	Int	Application Dates[v]	Dollar Spot Severity 14 Jun	14 Jun	14 Jun	21 Jun	26 Jun
				# dollar spot infection centers plot^{-1}				
Posterity	0.16 fl.oz.	pgm	DJ	0.6 b-e	0.0 c	0.4 bc	0.3 g	2.7 k-n
-Secure Action	0.5 fl.oz.		AGM					
Xzemplar	0.21 fl.oz.	pgm	DJ	2.4 ab	0.0 c	0.2 c	2.3 g	17.8 d-g
-Secure Action	0.5 fl.oz.		AGM					
Exteris StressGard	3.25 fl.oz.	pgm	DJ	0.3 cde	0.0 c	0.3 bc	28.0 de	53.8 abc
-Secure Action	0.5 fl.oz.		AGM					
Secure Action	0.5 fl.oz.	21-d	ADGJM	1.9 abc	0.0 c	0.0 c	0.5 g	8.2 f-k
Posterity	0.16 fl.oz.	pgm	A	1.1 a-e	0.8 bc	0.0 c	0.0 g	0.6 nop
-Secure Action	0.5 fl.oz.		DGJM					
Posterity	0.16 fl.oz.	pgm	G	0.4 cde	0.0 c	0.0 c	0.0 g	3.2 j-m
-Secure Action	0.5 fl.oz.		ADJM					
Posterity	0.16 fl.oz.	pgm	M	0.8 b-e	0.5 bc	0.0 c	1.5 g	9.4 f-j
-Secure Action	0.5 fl.oz.		ADGJ					
Untreated				2.4 ab	4.0 a	20.6 a	85.3 a	109.1 a
ANOVA: Treatment (P > F)				0.0324	0.0421	0.0001	0.0001	0.0001
Days after treatment			14-d	8	9	2	9	14
			21-d	8	3	10	17	22
			28-d	8	22	2	9	14

[z]All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi.
[y]A=16 May; C=29 May; D=4 June; E=12 June; G=26 June; I=10 July; J=16 July; K=24 July; L=31 July; M=6 August
[x]Dollar spot data were log-transformed. Means are de-transformed 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 1b. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Dollar Spot Severity 5 Jul	12 Jul	19 Jul	26 Jul	9 Aug
				# dollar spot infection centers plot⁻¹				
Daconil Ultrex	3.2 oz.	pgm	AE	2.4[x] ghi[w]	0.5 g	0.3 i	2.6 f-k	10.6 def
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-13	1.5 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	11.3 de	3.0 fg	0.9 ghi	9.4 cde	17.6 cd
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-24	2.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	7.9 ef	2.3 fg	0.2 i	2.9 e-j	4.4 f-i
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-25	3.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	2.8 fgh	1.5 g	0.7 hi	3.4 e-i	5.4 e-h
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-26	1.3 fl.oz.		IL					
Tekken	3.0 fl.oz.	21-d	ADGJM	12.8 cde	3.0 fg	0.6 hi	2.5 g-k	3.4 hi
UC19-15	0.107 fl.oz.	14-d	ACEGIKM	0.6 ijk	0.0 g	0.3 i	0.7 h-m	1.5 ijk
UC19-15	0.16 fl.oz.	21-d	ADGJM	1.0 h-k	0.0 g	0.3 i	0.0 m	0.9 jkl
Maxtima	0.4 fl.oz.	21-d	ADGJM	12.3 cde	4.3 efg	0.2 i	0.2 lm	0.6 jkl
Xzemplar	0.26 fl.oz.	21-d	ADGJM	1.9 hi	0.0 g	0.2 i	0.0 m	0.2 kl
Banner Maxx II	1.0 fl.oz.	21-d	ADGJM	58.9 ab	43.0 bc	32.6 b	38.1 b	42.0 b
Torque	0.6 fl.oz.	21-d	ADGJM	47.7 ab	24.0 cde	13.8 bcd	23.7 bc	30.7 bc
Navicon	0.85 fl.oz.	21-d	ADGJM	2.0 hi	0.0 g	0.6 hi	0.0 m	0.0 l
Tourney	0.37 oz.	21-d	ADGJM	27.4 bcd	25.0 cd	9.6 cde	11.7 cd	16.3 cd
Tartan	1.5 fl.oz.	21-d	ADGJM	16.6 cde	9.5 d-g	6.1 c-f	4.0 d-g	13.7 cd
Downforce	0.5 fl.oz.	14-d	ACEGIKM	0.0 k	0.0 g	0.0 i	0.4 j-m	0.6 jkl
Secure	0.5 fl.oz.	14-d	ACEGIKM	0.0 k	0.0 g	0.0 i	0.4 j-m	0.4 jkl
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	6.6 efg	1.8 g	0.6 hi	2.0 g-l	1.9 hij
UC19-21	0.5 fl.oz.	14-d	ACEGIKM	0.6 ijk	3.0 fg	0.2 i	8.9 c-f	9.1 d-g
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	0.2 jk	0.0 g	0.0 i	0.0 m	0.2 kl
+UC19-21	0.5 fl.oz.							
UC19-20	0.28 fl.oz.	21-d	ADGJM	6.4 efg	5.5 d-g	1.6 f-i	0.7 h-m	0.2 kl
+UC19-21	0.5 fl.oz.							
Xzemplar	0.21 fl.oz.	21-d	ADGJM	3.6 fgh	0.3 g	0.0 i	0.0 m	0.0 l
Traction	1.3 fl.oz.	14-d	ACEGIKM	0.2 jk	0.0 g	0.2 i	0.3 klm	0.2 kl
Traction	1.3 fl.oz.	21-d	ADGJM	0.2 jk	0.3 g	0.4 i	0.0 m	0.0 l
UC19-19	0.203 fl.oz.	14-d	ACEGIKM	0.0 k	0.0 g	0.3 i	0.3 klm	0.6 jkl
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	21-d	ADGJM	1.6 hij	0.8 g	0.4 i	0.4 j-m	0.4 jkl
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	28-d	AEIM	27.6 bcd	22.5 c-f	1.4 f-i	0.7 h-m	0.6 jkl
+Daconil Weatherstik	3.6 fl.oz.							
Kabuto	0.5 fl.oz.	14-d	ACEGIKM	24.1 bcd	16.8 d-g	4.2 d-g	9.0 c-f	13.1 cde
Kabuto	0.5 fl.oz.	21-d	ADGJM	43.2 ab	57.8 b	18.7 bc	20.8 bc	20.7 bcd

Continued…

Table 1b. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft^2	Int	Application Dates	Dollar Spot Severity 5 Jul	12 Jul	19 Jul	26 Jul	9 Aug
				--------------------------- # dollar spot infection centers plot^{-1}				-----------------------
Posterirty	0.16 fl.oz.	pgm	DJ	0.6 ijk	1.3 g	1.7 f-i	0.2 lm	0.4 jkl
-Secure Action	0.5 fl.oz.		AGM					
Xzemplar	0.21 fl.oz.	pgm	DJ	6.5 efg	13.0 d-g	11.4 b-e	2.8 e-j	1.5 ijk
-Secure Action	0.5 fl.oz.		AGM					
Exteris StressGard	3.25 fl.oz.	pgm	DJ	29.9 bc	37.8 bc	18.6 bc	41.5 b	42.9 b
-Secure Action	0.5 fl.oz.		AGM					
Secure Action	0.5 fl.oz.	21-d	ADGJM	1.9 hi	3.5 efg	4.4 d-g	2.3 g-l	1.9 hij
Posterity	0.16 fl.oz.	pgm	A	0.0 k	0.5 g	0.5 hi	0.8 g-m	0.2 kl
-Secure Action	0.5 fl.oz.		DGJM					
Posterity	0.16 fl.oz.	pgm	G	0.2 jk	0.0 g	0.0 i	0.6 i-m	0.7 jkl
-Secure Action	0.5 fl.oz.		ADJM					
Posterity	0.16 fl.oz.	pgm	M	2.8 fgh	4.8 d-g	3.4 e-h	3.5 d-h	3.6 ghi
-Secure Action	0.5 fl.oz.		ADGJ					
Untreated				103.6 a	128.3 a	110.8 a	125.6 a	148.6 a
ANOVA: Treatment (P > F)				0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment			14-d	9	2	9	2	3
			21-d	9	16	3	10	3
			28-d	23	2	9	16	3

[z]All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi.
[y]A=16 May; C=29 May; D=4 June; E=12 June; G=26 June; I=10 July; J=16 July; K=24 July; L=31 July; M=6 August
[x]Dollar spot data were log-transformed. Means are de-transformed 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. Effect of various fungicides on turf quality in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Int	Application Dates[y]	Turf Quality				
				7 Jun	5 Jul	12 Jul	19 Jul	26 Jul
				1-9; 6=min acceptable				
Daconil Ultrex	3.2 oz.	pgm	AE	7.0 -	7.0 e-i[x]	8.3 a	8.3 ab	7.3 c-g
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-13	1.5 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	7.0 -	6.3 hij	8.0 ab	8.8 a	6.8 e-h
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-24	2.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	7.0 -	6.0 ijk	7.5 a-d	7.8 a-d	8.0 a-d
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-25	3.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	7.0 -	7.3 d-h	8.0 ab	7.5 b-e	7.3 c-g
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-26	1.3 fl.oz.		IL					
Tekken	3.0 fl.oz.	21-d	ADGJM	7.0 -	6.0 ijk	7.0 b-e	6.5 e-i	7.3 c-g
UC19-15	0.107 fl.oz.	14-d	ACEGIKM	7.0 -	8.3 a-d	7.5 a-d	7.5 b-e	8.0 a-d
UC19-15	0.16 fl.oz.	21-d	ADGJM	7.0 -	8.0 a-e	7.5 a-d	7.3 b-f	8.0 a-d
Maxtima	0.4 fl.oz.	21-d	ADGJM	7.0 -	5.0 klm	6.8 c-f	7.5 b-e	8.8 a
Xzemplar	0.26 fl.oz.	21-d	ADGJM	7.0 -	7.3 d-h	7.8 abc	7.5 b-e	7.5 b-f
Banner Maxx II	1.0 fl.oz.	21-d	ADGJM	7.0 -	3.0 op	3.5 i	4.3 k	4.8 k
Torque	0.6 fl.oz.	21-d	ADGJM	7.0 -	3.8 no	5.3 gh	5.5 ij	5.8 h-k
Navicon	0.85 fl.oz.	21-d	ADGJM	7.0 -	8.0 a-e	8.3 a	7.5 b-e	8.3 abc
Tourney	0.37 oz.	21-d	ADGJM	7.0 -	4.5 lmn	5.0 h	6.0 g-j	5.8 h-k
Tartan	1.5 fl.oz.	21-d	ADGJM	7.0 -	5.3 jkl	6.3 efg	5.5 ij	6.3 g-j
Downforce	0.5 fl.oz.	14-d	ACEGIKM	7.0 -	9.0 a	8.3 a	8.3 ab	8.3 abc
Secure	0.5 fl.oz.	14-d	ACEGIKM	7.0 -	8.5 abc	8.3 a	8.3 ab	8.5 ab
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	6.8 -	6.8 f-i	7.3 a-e	6.8 d-h	7.8 a-e
UC19-21	0.5 fl.oz.	14-d	ACEGIKM	7.0 -	8.3 a-d	7.0 b-e	7.8 a-d	7.0 d-g
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	7.0 -	8.3 a-d	8.0 ab	8.0 abc	8.5 ab
+UC19-21	0.5 fl.oz.							
UC19-20	0.28 fl.oz.	21-d	ADGJM	7.0 -	6.8 f-i	7.3 a-e	6.8 d-h	7.5 b-f
+UC19-21	0.5 fl.oz.							
Xzemplar	0.21 fl.oz.	21-d	ADGJM	7.0 -	7.3 d-h	7.5 a-d	7.5 b-e	8.0 a-d
Traction	1.3 fl.oz.	14-d	ACEGIKM	7.0 -	8.0 a-e	8.0 ab	7.5 b-e	8.3 abc
Traction	1.3 fl.oz.	21-d	ADGJM	7.0 -	8.5 abc	8.0 ab	7.3 b-f	8.3 abc
UC19-19	0.203 fl.oz.	14-d	ACEGIKM	7.0 -	9.0 a	8.0 ab	7.5 b-e	8.5 ab
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	21-d	ADGJM	7.0 -	7.5 c-g	7.8 abc	6.5 e-i	8.0 a-d
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	28-d	AEIM	7.0 -	5.0 klm	5.3 gh	7.0 c-g	8.0 a-d
+Daconil Weatherstik	3.6 fl.oz.							
Kabuto	0.5 fl.oz.	14-d	ACEGIKM	7.0 -	5.3 jkl	5.8 fgh	6.5 e-i	6.5 f-i
Kabuto	0.5 fl.oz.	21-d	ADGJM	7.0 -	4.0 mno	5.0 h	5.3 jk	5.5 ijk

Continued…

Table 2. Effect of various fungicides on turf quality in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft²	Int	Application Dates	Turf Quality 7 Jun	5 Jul	12 Jul	19 Jul	26 Jul
				------------------------------ 1-9; 6=min acceptable --------------------------------				
Posterirty	0.16 fl.oz.	pgm	DJ	7.0 -	8.5 abc	8.0 ab	7.0 c-g	8.3 abc
-Secure Action	0.5 fl.oz.		AGM					
Xzemplar	0.21 fl.oz.	pgm	DJ	7.0 -	6.5 ghi	6.5 def	6.0 g-j	7.3 c-g
-Secure Action	0.5 fl.oz.		AGM					
Exteris StressGard	3.25 fl.oz.	pgm	DJ	7.0 -	4.5 lmn	5.3 gh	5.8 hij	5.3 jk
-Secure Action	0.5 fl.oz.		AGM					
Secure Action	0.5 fl.oz.	21-d	ADGJM	7.0 -	8.5 abc	7.0 b-e	6.3 f-j	7.0 d-g
Posterity	0.16 fl.oz.	pgm	A	6.8 -	8.8 ab	7.8 abc	7.5 b-e	8.3 abc
-Secure Action	0.5 fl.oz.		DGJM					
Posterity	0.16 fl.oz.	pgm	G	7.0 -	7.8 b-f	7.8 abc	7.5 b-e	8.0 a-d
-Secure Action	0.5 fl.oz.		ADJM					
Posterity	0.16 fl.oz.	pgm	M	7.0 -	7.3 d-h	7.0 b-e	6.5 e-i	7.0 d-g
-Secure Action	0.5 fl.oz.		ADGJ					
Untreated				7.0 -	2.5 p	3.0 i	2.81	2.81
ANOVA: Treatment (P > F)				0.4816	0.0001	0.0001	0.0001	0.0001
Days after treatment			14-d	9	9	2	9	2
			21-d	3	9	16	3	10
			28-d	22	23	2	9	16

[z]All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi.
[y]A=16 May; C=29 May; D=4 June; E=12 June; G=26 June; I=10 July; J=16 July; K=24 July; L=31 July; M=6 August
[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. Effect of various fungicides on phytotoxicity in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

				Phytoxicity				
Treatment[z]	Rate per 1000ft^2	Int	Application Dates[y]	7 Jun	5 Jul	12 Jul	19 Jul	26 Jul
				0-5; 2=max acceptable				
Daconil Ultrex	3.2 oz.	pgm	AE	0.0 -	0.0 -	0.0 d[x]	0.0 d	0.0 c
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-13	1.5 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-24	2.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-25	3.0 fl.oz.		IL					
Daconil Ultrex	3.2 oz.	pgm	AE	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Chipco 26GT	4.0 fl.oz.		CG					
-UC19-26	1.3 fl.oz.		IL					
Tekken	3.0 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.8 c	0.3 cd	0.0 c
UC19-15	0.107 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
UC19-15	0.16 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
Maxtima	0.4 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
Xzemplar	0.26 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.3 d	0.0 d	0.0 c
Banner Maxx II	1.0 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	1.3 b	2.5 a	1.0 a
Torque	0.6 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.3 d	0.0 d	0.0 c
Navicon	0.85 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.3 d	0.5 c	0.0 c
Tourney	0.37 oz.	21-d	ADGJM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
Tartan	1.5 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	2.0 a	1.0 b	0.3 b
Downforce	0.5 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
Secure	0.5 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
UC19-21	0.5 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
UC19-20	0.28 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
+UC19-21	0.5 fl.oz.							
UC19-20	0.28 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
+UC19-21	0.5 fl.oz.							
Xzemplar	0.21 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.3 d	0.0 d	0.0 c
Traction	1.3 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.8 c	0.3 cd	0.0 c
Traction	1.3 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
UC19-19	0.203 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.3 d	0.0 d	0.0 c
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
+Daconil Weatherstik	3.6 fl.oz.							
UC19-19	0.203 fl.oz.	28-d	AEIM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
+Daconil Weatherstik	3.6 fl.oz.							
Kabuto	0.5 fl.oz.	14-d	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
Kabuto	0.5 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c

Continued…

Table 3. Effect of various fungicides on phytotoxicity in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft²	Int	Application Dates	Phytoxicity 7 Jun	5 Jul	12 Jul	19 Jul	26 Jul
				---------- 0-5; 2=max acceptable ----------				
Posterirty	0.16 fl.oz.	pgm	DJ	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Secure Action	0.5 fl.oz.		AGM					
Xzemplar	0.21 fl.oz.	pgm	DJ	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Secure Action	0.5 fl.oz.		AGM					
Exteris StressGard	3.25 fl.oz.	pgm	DJ	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Secure Action	0.5 fl.oz.		AGM					
Secure Action	0.5 fl.oz.	21-d	ADGJM	0.0 -	0.0 -	0.3 d	0.0 d	0.0 c
Posterity	0.16 fl.oz.	pgm	A	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Secure Action	0.5 fl.oz.		DGJM					
Posterity	0.16 fl.oz.	pgm	G	0.0 -	0.0 -	0.3 d	0.0 d	0.0 c
-Secure Action	0.5 fl.oz.		ADJM					
Posterity	0.16 fl.oz.	pgm	M	0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
-Secure Action	0.5 fl.oz.		ADGJ					
Untreated				0.0 -	0.0 -	0.0 d	0.0 d	0.0 c
ANOVA: Treatment (P > F)				1.0000	1.0000	0.0001	0.0001	0.0001
Days after treatment			14-d	9	9	2	9	2
			21-d	3	9	16	3	10
			28-d	22	23	2	9	16

[z]All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi.
[y]A=16 May; C=29 May; D=4 June; E=12 June; G=26 June; I=10 July; J=16 July; K=24 July; L=31 July; M=6 August
[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)

PREVENTIVE DOLLAR SPOT CONTROL WITH VARIOUS FUNGICIDES ON A CREEPING BENTGRASS PUTTING GREEN TURF, 2019

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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 1.7 lb N 1000-ft^{-2} as water soluble sources from April through August. Acelepryn was applied on 23 May to control white grubs. To help alleviate dry surface conditions, the wetting agent Revolution was applied on 1 July and 26 July.

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 17 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 and copper spot incidence were assessed as a count of individual disease foci within each plot. Brown patch was assessed as a percentage of plot area blighted by disease 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
Dollar spot symptoms first manifested in early June and increased rapidly throughout the month, with untreated control (UTC) plots reaching 65 dollar spot infection centers (DSIC) per plot on 21 June and 201 DSIC $plot^{-1}$ on 28 June (Tables 1a + 1b). Conditions remained favorable for disease for the duration of the trial with UTC plots increasing to 281 DSIC $plot^{-1}$ on 3 August.

Although all rates of UC19-2 reduced disease relative to UTC plots, the 0.5 oz. rate failed to provide acceptable (<20 DSIC $plot^{-1}$) control as of 26 June and for the remainder of the trial. The 0.725 oz. and 0.9 oz. rates fared somewhat better, providing acceptable or nearly-acceptable control of disease through mid-July before climbing to 40 and 27 DSIC $plot^{-1}$, respectively, on 26 July and remaining high through the end of the trial. The 1.2 oz. rate provided nearly complete control through 26 July and very good (<10 DSIC $plot^{-1}$) to acceptable control thereafter, indicating that while UC19-2 is efficacious for controlling dollar spot, it requires higher application rates for acceptable control. UC19-4, UC19-3, UC19-10, and UC19-11 were tank-mixed and applied in two different rate-schemes: low and high (see Tables 1a + 1b for rate breakdown). Both schemes provided nearly complete control for the entirety of the trial.

Several DMI-fungicdes (two high rates of Maxtima [2x and 4x label rate for dollar spot control], a new DMI-fungicide with enhanced phytosafety, as well as Torque and Banner Maxx) were applied every 14-d following two initial applications of Daconil Weatherstik 14-d apart, with the final application of Weatherstik occurring on 30 May and the initial application of the DMI-fungicide occurring on 11 June. All of these treatments showed acceptable control through 21 June, followed by a rapid increase in disease beginning 26 June causing all four treatments to exhibit unacceptable levels of dollar spot (ranging from 40-90 DSIC $plot^{-1}$ as of 28 June). As of 4 July (after 2 applications of DMIs), plots treated with Maxtima began to show a reduction of disease (<15 DSIC $plot^{-1}$), with these plots displaying virtually no disease from mid-July through the end of the trial. Conversely, plots treated with Torque or Banner Maxx continued to exhibit unacceptable levels of disease for the duration of the trial, although disease was reduced relative to UTC plots. It is possible that the *Clarireedia* population at the trial site has developed DMI insensitivity. Whether Maxtima is affected by this insensivity or not cannot be determined in this trial, as it was applied above the label rate.

UC19-20 and UC19-21 provided inconsistent control throughout the trial when applied individually, however a tank-mix of the two fungicides provided at least good control through 19 July, and acceptable control until the end of the trial.

Daconil Action + Signature Xtra provided acceptable control for much of the trial, although disease did tend to increase towards the end of the 14-d application interval (e.g., ratings on 28 June and 12 July). Daconil Action + Appear II (4.0 oz) provided acceptable control until 3 August, however Daconil Action + Appear II (6.0 oz.) failed to provide adequate control after 12 July. It is possible that the higher-rate experienced greater disease pressure than the lower-rate.

Daconil Weatherstik was applied every 14-d following an initial application of Xzemplar + Segway, Banol, or Chipco Signature on 17 May (Xzemplar+). The purpose of these initial applications was to determine whether these early applications could mitigate the effects of Pythium later in the growing season. These Xzemplar+ applications were repeated on 26 June. Pythium never developed in the trial area, and all of these treatments failed to adequately control dollar spot following the final application of Xzemplar+.

Kabuto reduced disease relative to UTC plots, however it not not provide acceptable control after 26 June and for the remainder of the trial. UC19-6 provided variable, albiet acceptable control, and Xzemplar provided excellent to near-complete control for the entirety of the trial.

Brown Patch, Copper Spot, and Algae Severity
Brown patch (Table 2) developed in the trial area in July August, with the epidemic peaking at 18% plot area blighted on untreated plots on 26 July. Although most of the treatments provided complete or near-complete control of the disease, brown patch severity was unacceptable (>10% plot area blighted) on plots treated with Maxtima, Banner Maxx, and UC19-21 as of 26 July. Brown patch symptoms were especially severe on plots treated with Kabuto, where % plot area blighted exceeded UTC plots on every observation date, peaking at almost 40% plot area blighted on 26 July.

Copper Spot (Table 3) developed in the trial area during July although most treatments provided complete control of the disease. At the peak of the epidemic (19 July), Xzemplar, Kabuto, and UC19-6 displayed 23, 18, and 44 copper spot infection centers (CSIC) $plot^{-1}$, respectively. All three treatments displayed more CSIC than UTC plots (6 CSIC $plot^{-1}$ as of this date). Xzemplar and Kabuto are in the same fungicide class (SDHI), and although there has been some evidence at this site in previous years of SDHI fungicides increasing copper spot severity, it is difficult attribute this trial's copper spot severity to the SDHI chemistry as it is not known whether UTC plots truly had lower levels of the disease, or whether the copper spot in UTC plots was obscured by severe brown patch and dollar spot infections within the same plot.

On 23 June, heavy precipitation led to the development of algae throughout the trial area (Table 3). Virtually all treatments showed unacceptable levels of algae (1-5 rating; 2=max acceptable) except those treated with chlorothalonil.

Turf Quality, Phytotoxicity, and NDVI
Turf Quality (Table 4) and NDVI (Table 5) were generally a function of disease incidence, and plots with less disease tended to have higher turf quality. Quality was especially high on plots treated with: UC19-2 (highest rate); the UC19-4, UC19-3, UC19-10, and UC19-11 tank-mix; and Daconil Action + Appear II (low rate).

Some phytotoxicity (Table 6) was observed on plots treated with Banner Maxx, a DMI-fungicide. No phytotoxicity was observed on plots treated with Torque or Maxtima, even though the latter was applied at 2x and 4x the normal label rates for dollar spot, verifying its phytosafety on fairway bentgrass.

Table 1a. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft^2	Application Dates[x]	Dollar Spot Incidence 14 Jun	21 Jun	26 Jun	28 Jun
			------------------ # of dollar spot infection centers ---------------			
UC19-2	0.5 fl.oz.	ACEGIKM	1.3 -	0.9 c[w]	42.8 bc	39.1 bcd
UC19-2	0.725 fl.oz.	ACEGIKM	0.0 -	0.0 c	21.1 cde	21.0 c-f
UC19-2	0.9 fl.oz.	ACEGIKM	5.8 -	0.0 c	9.0 d-h	10.5 e-h
UC19-2	1.2 fl.oz.	ACEGIKM	0.0 -	0.0 c	3.2 h-k	2.3 i-l
UC19-4	0.0785 fl.oz.	ACEGIKM	3.6 -	0.0 c	0.3 kl	1.2 kl
+UC19-3	0.118 fl.oz.					
+UC19-10	0.25 fl.oz.					
+UC19-11	0.00655 oz.					
UC19-4	0.157 fl.oz.	ACEGIKM	1.8 -	0.0 c	0.0 l	0.7 l
+UC19-3	0.236 fl.oz.					
+UC19-10	0.5 fl.oz.					
+UC19-11	0.0131 oz.					
UC19-6	0.5 oz.	ACEGIKM	0.0 -	0.0 c	9.5 d-h	16.0 c-g
Maxtima	0.8 fl.oz.	EGIK	1.2 -	1.1 c	35.8 bc	40.8 bcd
-Daconil Weatherstik	3.5 fl.oz.	AC				
Maxtima	1.6 fl.oz.	EGIK	0.6 -	1.1 c	34.1 bc	45.9 bc
-Daconil Weatherstik	3.5 fl.oz.	AC				
Torque	0.6 fl.oz.	EGIK	0.0 -	0.9 c	31.2 bcd	44.5 bc
-Daconil Weatherstik	3.5 fl.oz.	AC				
Banner Maxx II	1.0 fl.oz.	EGIK	0.6 -	8.3 b	80.7 ab	88.6 ab
-Daconil Weatherstik	3.5 fl.oz.	AC				
UC19-20	0.28 fl.oz.	ACEGIKM	0.3 -	0.0 c	15.5 c-g	21.8 c-f
UC19-21	0.5 fl.oz.	ACEGIKM	1.2 -	0.0 c	5.6 f-i	15.1 c-g
UC19-20	0.28 fl.oz.	ACEGIKM	0.0 -	0.0 c	2.2 h-l	5.3 g-k
+UC19-21	0.5 fl.oz.					
Xzemplar	0.16 fl.oz.	ACEGIKM	0.6 -	0.0 c	1.4 i-l	1.2 kl
Traction	1.3 fl.oz.	ACEGIKM	1.0 -	0.0 c	1.6 i-l	2.9 h-l
Signature XTRA	4.0 oz.	ACEGIKM	0.0 -	0.0 c	5.4 ghi	10.3 e-h
+Daconil Action	3.5 fl.oz.					
Appear II	4.0 fl.oz.	ACEGIKM	0.3 -	0.0 c	0.8 jkl	2.3 jkl
+Daconil Action	3.5 fl.oz.					
Appear II	6.0 fl.oz.	ACEGIKM	0.5 -	0.0 c	6.6 e-i	9.8 e-i
+Daconil Action	3.5 fl.oz.					
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.3 -	0.0 c	5.4 ghi	23.3 c-f
-Segway	0.9 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.8 -	0.0 c	14.1 c-g	11.8 d-g
-Banol	4.0 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.8 -	0.0 c	4.8 g-j	8.6 f-j
-Chipco Signature	4.0 oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Kabuto	0.5 fl.oz.	ACEGIKM	1.2 -	0.0 c	20.3 c-f	30.9 b-e
Untreated			5.5 -	65.6 a	176.3 a	201.7 a
ANOVA: Treatment ($P > F$)			0.1972	0.0001	0.0001	0.0001
Days after treatment		14-d	3	10	15	2

[z]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.
[y]Treatments were watered-in with the equivalent of 0.2-in of precipitation immediately following application using watering cans.
[x]A=17 May; C=30 May; G= 26 June; I=11 July; K=25 July; M=7 August
[w]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 1b. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft^2	Application Dates[x]	Dollar Spot Incidence 5 Jul	12 Jul	19 Jul	26 Jul	3 Aug
			# of dollar spot infection centers				
UC19-2	0.5 fl.oz.	ACEGIKM	29.9 bc[w]	33.0 c-f	32.3 bc	77.3 cde	95.1 bcd
UC19-2	0.725 fl.oz.	ACEGIKM	9.6 c-h	16.3 d-g	9.6 def	40.0 fgh	53.7 c-f
UC19-2	0.9 fl.oz.	ACEGIKM	5.6 d-h	8.0 efg	0.7 hi	26.8 ghi	29.0 e-h
UC19-2	1.2 fl.oz.	ACEGIKM	0.0 l	0.0 g	0.0 i	6.0 jk	14.3 hij
UC19-4	0.0785 fl.oz.	ACEGIKM	0.4 jkl	0.0 g	0.0 i	0.0 k	0.0 k
+UC19-3	0.118 fl.oz.						
+UC19-10	0.25 fl.oz.						
+UC19-11	0.00655 oz.						
UC19-4	0.157 fl.oz.	ACEGIKM	0.0 l	0.0 g	0.0 i	0.0 k	0.2 k
+UC19-3	0.236 fl.oz.						
+UC19-10	0.5 fl.oz.						
+UC19-11	0.0131 oz.						
UC19-6	0.5 oz.	ACEGIKM	3.5 f-j	3.5 g	0.0 i	7.0 jk	9.7 j
Maxtima	0.8 fl.oz.	EGIK	14.9 cde	0.0 g	0.0 i	0.0 k	0.0 k
-Daconil Weatherstik	3.5 fl.oz.	AC					
Maxtima	1.6 fl.oz.	EGIK	11.4 c-f	0.5 g	0.0 i	0.0 k	0.2 k
-Daconil Weatherstik	3.5 fl.oz.	AC					
Torque	0.6 fl.oz.	EGIK	31.1 bc	48.8 c	32.1 bc	69.5 c-f	77.4 bcd
-Daconil Weatherstik	3.5 fl.oz.	AC					
Banner Maxx II	1.0 fl.oz.	EGIK	74.9 ab	82.3 b	65.1 b	121.2 b	141.9 ab
-Daconil Weatherstik	3.5 fl.oz.	AC					
UC19-20	0.28 fl.oz.	ACEGIKM	8.0 d-h	9.5 efg	3.4 fgh	19.6 hij	25.6 f-i
UC19-21	0.5 fl.oz.	ACEGIKM	17.4 cd	34.5 cde	39.6 bc	53.2 def	63.8 b-e
UC19-20	0.28 fl.oz.	ACEGIKM	2.5 g-k	9.3 efg	1.2 hi	11.7 ij	12.2 ij
+UC19-21	0.5 fl.oz.						
Xzemplar	0.16 fl.oz.	ACEGIKM	0.0 l	0.0 g	0.0 i	0.0 k	0.3 k
Traction	1.3 fl.oz.	ACEGIKM	0.0 l	4.5 fg	0.0 i	9.7 ij	15.8 hij
Signature XTRA	4.0 oz.	ACEGIKM	1.0 i-l	12.8 d-g	5.4 efg	20.4 hij	30.6 e-h
+Daconil Action	3.5 fl.oz.						
Appear II	4.0 fl.oz.	ACEGIKM	0.2 kl	3.5 g	1.6 ghi	13.4 ij	21.4 g-j
+Daconil Action	3.5 fl.oz.						
Appear II	6.0 fl.oz.	ACEGIKM	2.2 h-l	34.5 cde	13.7 cde	72.5 cde	79.4 bcd
+Daconil Action	3.5 fl.oz.						
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	10.3 c-g	46.0 c	34.9 bc	99.4 bc	114.3 bc
-Segway	0.9 fl.oz.[y]	AG					
-Xzemplar	0.16 fl.oz.[y]	AG					
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	6.0 d-h	41.3 cd	42.4 b	78.4 cd	93.1 bcd
-Banol	4.0 fl.oz.[y]	AG					
-Xzemplar	0.16 fl.oz.[y]	AG					
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	4.1 e-i	24.8 c-g	23.3 bcd	45.3 efg	53.2 c-f
-Chipco Signature	4.0 oz.[y]	AG					
-Xzemplar	0.16 fl.oz.[y]	AG					
Kabuto	0.5 fl.oz.	ACEGIKM	33.5 bc	45.3 c	23.6 bcd	40.6 fgh	43.9 d-g
Untreated			245.4 a	241.0 a	234.7 a	268.8 a	281.6 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	9	1	8	1	8

[z]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.
[y]Treatments were watered-in with the equivalent of 0.2-in of precipitation immediately following application using watering cans.
[x]A=17 May; C=30 May; G= 26 June; I=11 July; K=25 July; M=7 August
[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. Effect of various fungicides on brown patch severity in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Application Dates[x]	Brown Patch Severity 10 Jul	12 Jul	19 Jul	26 Jul
			% Plot Area Blighted			
UC19-2	0.5 fl.oz.	ACEGIKM	0.0 d[w]	0.0 e	0.0 d	0.0 d
UC19-2	0.725 fl.oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
UC19-2	0.9 fl.oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
UC19-2	1.2 fl.oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
UC19-4	0.0785 fl.oz.	ACEGIKM	0.0 d	0.8 de	0.0 d	0.0 d
+UC19-3	0.118 fl.oz.					
+UC19-10	0.25 fl.oz.					
+UC19-11	0.00655 oz.					
UC19-4	0.157 fl.oz.	ACEGIKM	0.0 d	0.8 de	0.0 d	0.0 d
+UC19-3	0.236 fl.oz.					
+UC19-10	0.5 fl.oz.					
+UC19-11	0.0131 oz.					
UC19-6	0.5 oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
Maxtima	0.8 fl.oz.	EGIK	1.5 cd	3.8 bcd	10.0 bc	16.3 b
-Daconil Weatherstik	3.5 fl.oz.	AC				
Maxtima	1.6 fl.oz.	EGIK	4.0 bc	4.5 bc	8.8 bc	10.8 bc
-Daconil Weatherstik	3.5 fl.oz.	AC				
Torque	0.6 fl.oz.	EGIK	0.0 d	0.0 e	0.0 d	0.0 d
-Daconil Weatherstik	3.5 fl.oz.	AC				
Banner Maxx II	1.0 fl.oz.	EGIK	0.8 cd	1.0 cde	5.3 bcd	14.5 b
-Daconil Weatherstik	3.5 fl.oz.	AC				
UC19-20	0.28 fl.oz.	ACEGIKM	0.0 d	1.0 cde	2.5 cd	5.0 cd
UC19-21	0.5 fl.oz.	ACEGIKM	6.0 ab	5.0 b	12.3 b	12.5 bc
UC19-20	0.28 fl.oz.	ACEGIKM	1.5 cd	1.5 b-e	0.0 d	0.3 d
+UC19-21	0.5 fl.oz.					
Xzemplar	0.16 fl.oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
Traction	1.3 fl.oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
Signature XTRA	4.0 oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	1.3 d
+Daconil Action	3.5 fl.oz.					
Appear II	4.0 fl.oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
+Daconil Action	3.5 fl.oz.					
Appear II	6.0 fl.oz.	ACEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
+Daconil Action	3.5 fl.oz.					
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.0 d	0.0 e	0.0 d	4.5 cd
-Segway	0.9 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.0 d	0.0 e	0.0 d	1.3 d
-Banol	4.0 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.0 d	0.0 e	0.0 d	0.0 d
-Chipco Signature	4.0 oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Kabuto	0.5 fl.oz.	ACEGIKM	9.0 a	12.8 a	23.8 a	39.8 a
Untreated			3.5 bcd	4.0 bcd	10.0 bc	18.8 b
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	15	1	8	1

[z]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.
[y]Treatments were watered-in with the equivalent of 0.2-in of precipitation immediately following application using watering cans.
[x]A=17 May; C=30 May; G= 26 June; I=11 July; K=25 July; M=7 August
[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. Effect of various fungicides on copper spot incidence and algae severity in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Application Dates[x]	Copper Spot Incidence 10 Jul	Copper Spot Incidence 12 Jul	Copper Spot Incidence 19 Jul	Algae Severity 21 Jun
			------------ # copper spot foci plot⁻¹	------------	------------	--0-5; 2=max acceptable--
UC19-2	0.5 fl.oz.	ACEGIKM	0.0 c[w]	0.0 b	0.0 d	3.3 abc
UC19-2	0.725 fl.oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	3.3 abc
UC19-2	0.9 fl.oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	3.3 abc
UC19-2	1.2 fl.oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	3.8 a
UC19-4	0.0785 fl.oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	3.0 abc
+UC19-3	0.118 fl.oz.					
+UC19-10	0.25 fl.oz.					
+UC19-11	0.00655 oz.					
UC19-4	0.157 fl.oz.	ACEGIKM	0.0 c	0.3 b	0.0 d	3.5 ab
+UC19-3	0.236 fl.oz.					
+UC19-10	0.5 fl.oz.					
+UC19-11	0.0131 oz.					
UC19-6	0.5 oz.	ACEGIKM	28.8 a	33.5 a	43.8 a	2.5 c
Maxtima	0.8 fl.oz.	EGIK	0.8 bc	0.0 b	0.0 d	0.5 d
-Daconil Weatherstik	3.5 fl.oz.	AC				
Maxtima	1.6 fl.oz.	EGIK	1.0 bc	0.5 b	0.0 d	0.5 d
-Daconil Weatherstik	3.5 fl.oz.	AC				
Torque	0.6 fl.oz.	EGIK	0.8 bc	0.3 b	0.0 d	0.3 d
-Daconil Weatherstik	3.5 fl.oz.	AC				
Banner Maxx II	1.0 fl.oz.	EGIK	0.5 bc	0.0 b	0.0 d	0.3 d
-Daconil Weatherstik	3.5 fl.oz.	AC				
UC19-20	0.28 fl.oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	2.8 bc
UC19-21	0.5 fl.oz.	ACEGIKM	0.8 bc	0.8 b	0.0 d	2.8 bc
UC19-20	0.28 fl.oz.	ACEGIKM	0.3 bc	0.0 b	0.0 d	3.3 abc
+UC19-21	0.5 fl.oz.					
Xzemplar	0.16 fl.oz.	ACEGIKM	9.3 bc	8.3 b	23.5 b	2.8 bc
Traction	1.3 fl.oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	2.8 bc
Signature XTRA	4.0 oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	0.0 d
+Daconil Action	3.5 fl.oz.					
Appear II	4.0 fl.oz.	ACEGIKM	0.5 bc	0.0 b	0.0 d	0.8 d
+Daconil Action	3.5 fl.oz.					
Appear II	6.0 fl.oz.	ACEGIKM	0.0 c	0.0 b	0.0 d	0.0 d
+Daconil Action	3.5 fl.oz.					
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	1.0 bc	0.5 b	0.0 d	0.5 d
-Segway	0.9 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	1.3 bc	0.5 b	0.0 d	0.0 d
-Banol	4.0 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.0 c	0.0 b	0.0 d	0.0 d
-Chipco Signature	4.0 oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Kabuto	0.5 fl.oz.	ACEGIKM	9.5 b	8.3 b	17.8 bc	3.5 ab
Untreated			5.0 bc	4.5 b	5.8 cd	3.5 ab
ANOVA: Treatment (P > F)			0.0001	0.0003	0.0001	0.0001
Days after treatment		14-d	15	1	8	10

[z]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.
[y]Treatments were watered-in with the equivalent of 0.2-in of precipitation immediately following application using watering cans.
[x]A=17 May; C=30 May; G= 26 June; I=11 July; K=25 July; M=7 August
[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 4. Effect of various fungicides on turf quality in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft^2	Application Dates[x]	Turf Quality					
			14 Jun	28 Jun	5 Jul	12 Jul	19 Jul	26 Jul
			-1-9; 6=min acceptable -					
UC19-2	0.5 fl.oz.	ACEGIKM	6.5 cde	4.8 hi	4.8 hi	5.5 fgh	5.8 d-h	4.3 hij
UC19-2	0.725 fl.oz.	ACEGIKM	6.8 bcd	6.0 c-h	6.0 d-g	6.8 cde	7.0 a-e	5.0 e-h
UC19-2	0.9 fl.oz.	ACEGIKM	6.3 cde	6.0 c-h	6.5 c-f	7.5 a-d	7.5 abc	5.5 efg
UC19-2	1.2 fl.oz.	ACEGIKM	6.5 cde	7.3 abc	7.0 a-d	8.0 ab	8.0 ab	7.5 b
UC19-4	0.0785 fl.oz.	ACEGIKM	6.5 cde	7.0 a-d	6.5 c-f	8.0 ab	7.5 abc	8.8 a
+UC19-3	0.118 fl.oz.							
+UC19-10	0.25 fl.oz.							
+UC19-11	0.00655 oz.							
UC19-4	0.157 fl.oz.	ACEGIKM	6.3 cde	7.5 ab	7.3 abc	8.0 ab	8.3 a	8.8 a
+UC19-3	0.236 fl.oz.							
+UC19-10	0.5 fl.oz.							
+UC19-11	0.0131 oz.							
UC19-6	0.5 oz.	ACEGIKM	5.8 de	6.3 b-g	5.8 e-h	6.0 efg	5.8 d-h	6.0 cde
Maxtima	0.8 fl.oz.	EGIK	5.8 de	5.0 ghi	5.5 fgh	7.8 abc	6.8 a-f	6.8 bcd
-Daconil Weatherstik	3.5 fl.oz.	AC						
Maxtima	1.6 fl.oz.	EGIK	6.5 cde	5.0 ghi	6.0 d-g	7.3 a-d	7.3 a-d	7.0 bc
-Daconil Weatherstik	3.5 fl.oz.	AC						
Torque	0.6 fl.oz.	EGIK	6.5 cde	5.0 ghi	4.8 hi	5.0 gh	5.3 fgh	4.5 g-j
-Daconil Weatherstik	3.5 fl.oz.	AC						
Banner Maxx II	1.0 fl.oz.	EGIK	6.8 bcd	4.0 i	4.0 i	3.5 i	4.3 h	4.0 hij
-Daconil Weatherstik	3.5 fl.oz.	AC						
UC19-20	0.28 fl.oz.	ACEGIKM	5.8 de	5.5 e-h	6.0 d-g	6.5 def	6.5 b-f	5.8 def
UC19-21	0.5 fl.oz.	ACEGIKM	6.0 de	5.8 d-h	5.8 e-h	5.0 gh	5.8 d-h	4.5 g-j
UC19-20	0.28 fl.oz.	ACEGIKM	6.5 cde	6.8 a-e	5.8 e-h	6.8 cde	7.3 a-d	7.0 bc
+UC19-21	0.5 fl.oz.							
Xzemplar	0.16 fl.oz.	ACEGIKM	5.5 e	6.5 b-f	6.5 c-f	7.3 a-d	6.8 a-f	7.3 b
Traction	1.3 fl.oz.	ACEGIKM	6.0 de	7.0 a-d	6.8 b-e	7.0 b-e	7.5 abc	6.8 bcd
Signature XTRA	4.0 oz.	ACEGIKM	8.0 a	6.8 a-e	7.8 ab	6.8 cde	6.5 b-f	5.5 efg
+Daconil Action	3.5 fl.oz.							
Appear II	4.0 fl.oz.	ACEGIKM	7.3 abc	8.0 a	8.0 a	8.3 a	6.5 b-f	6.8 bcd
+Daconil Action	3.5 fl.oz.							
Appear II	6.0 fl.oz.	ACEGIKM	7.8 ab	6.3 b-g	7.3 abc	5.5 fgh	6.3 c-g	4.8 f-i
+Daconil Action	3.5 fl.oz.							
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	5.8 de	5.5 e-h	5.5 fgh	4.5 hi	5.3 fgh	3.8 ij
-Segway	0.9 fl.oz.[y]	AG						
-Xzemplar	0.16 fl.oz.[y]	AG						
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	5.8 de	5.3 f-i	5.3 gh	5.0 gh	5.5 e-h	4.3 hij
-Banol	4.0 fl.oz.[y]	AG						
-Xzemplar	0.16 fl.oz.[y]	AG						
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	6.8 bcd	5.8 d-h	6.0 d-g	5.5 fgh	6.0 c-g	5.0 e-h
-Chipco Signature	4.0 oz.[y]	AG						
-Xzemplar	0.16 fl.oz.[y]	AG						
Kabuto	0.5 fl.oz.	ACEGIKM	6.0 de	5.3 f-i	5.0 ghi	4.5 hi	4.8 gh	3.5 j
Untreated			5.5 e	2.0 j	1.8 j	1.8 j	1.8 i	1.5 k
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	3	2	9	1	8	1

[z]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.
[y]Treatments were watered-in with the equivalent of 0.2-in of precipitation immediately following application using watering cans.
[x]A=17 May; C=30 May; G= 26 June; I=11 July; K=25 July; M=7 August
[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 5. Effect of various fungicides on phytotoxicity in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Application Dates[x]	Phytotoxicity 14 Jun	28 Jun	12 Jul	19 Jul
			------------------------0-5; 2=max acceptable-------------------------			
UC19-2	0.5 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.5 bc[w]	0.0 b
UC19-2	0.725 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
UC19-2	0.9 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.3 cd	0.0 b
UC19-2	1.2 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.5 bc	0.0 b
UC19-4	0.0785 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
+UC19-3	0.118 fl.oz.					
+UC19-10	0.25 fl.oz.					
+UC19-11	0.00655 oz.					
UC19-4	0.157 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.3 cd	0.0 b
+UC19-3	0.236 fl.oz.					
+UC19-10	0.5 fl.oz.					
+UC19-11	0.0131 oz.					
UC19-6	0.5 oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
Maxtima	0.8 fl.oz.	EGIK	0.0 -	0.0 -	0.0 d	0.0 b
-Daconil Weatherstik	3.5 fl.oz.	AC				
Maxtima	1.6 fl.oz.	EGIK	0.0 -	0.0 -	0.0 d	0.0 b
-Daconil Weatherstik	3.5 fl.oz.	AC				
Torque	0.6 fl.oz.	EGIK	0.0 -	0.0 -	0.0 d	0.0 b
-Daconil Weatherstik	3.5 fl.oz.	AC				
Banner Maxx II	1.0 fl.oz.	EGIK	0.0 -	0.0 -	1.3 a	2.3 a
-Daconil Weatherstik	3.5 fl.oz.	AC				
UC19-20	0.28 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
UC19-21	0.5 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
UC19-20	0.28 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
+UC19-21	0.5 fl.oz.					
Xzemplar	0.16 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
Traction	1.3 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.8 b	0.0 b
Signature XTRA	4.0 oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
+Daconil Action	3.5 fl.oz.					
Appear II	4.0 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
+Daconil Action	3.5 fl.oz.					
Appear II	6.0 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
+Daconil Action	3.5 fl.oz.					
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.0 -	0.0 -	0.5 bc	0.0 b
-Segway	0.9 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
-Banol	4.0 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
-Chipco Signature	4.0 oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Kabuto	0.5 fl.oz.	ACEGIKM	0.0 -	0.0 -	0.0 d	0.0 b
Untreated			0.0 -	0.0 -	0.0 d	0.0 b
ANOVA: Treatment (P > F)			1.0000	1.0000	0.0001	0.0001
Days after treatment		14-d	3	2	1	8

[z]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.
[y]Treatments were watered-in with the equivalent of 0.2-in of precipitation immediately following application using watering cans.
[x]A=17 May; C=30 May; G= 26 June; I=11 July; K=25 July; M=7 August
[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 6. Effect of various fungicides on NDVI in a creeping bentgrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft^2	Application Dates[x]	NDVI 14 Jun		NDVI 31 Jul	
			-Vegetation Index -			
UC19-2	0.5 fl.oz.	ACEGIKM	0.715	-	0.750	a-e[w]
UC19-2	0.725 fl.oz.	ACEGIKM	0.721	-	0.755	ab
UC19-2	0.9 fl.oz.	ACEGIKM	0.728	-	0.757	a
UC19-2	1.2 fl.oz.	ACEGIKM	0.710	-	0.754	abc
UC19-4	0.0785 fl.oz.	ACEGIKM	0.717	-	0.756	ab
+UC19-3	0.118 fl.oz.					
+UC19-10	0.25 fl.oz.					
+UC19-11	0.00655 oz.					
UC19-4	0.157 fl.oz.	ACEGIKM	0.720	-	0.756	ab
+UC19-3	0.236 fl.oz.					
+UC19-10	0.5 fl.oz.					
+UC19-11	0.0131 oz.					
UC19-6	0.5 oz.	ACEGIKM	0.677	-	0.759	a
Maxtima	0.8 fl.oz.	EGIK	0.689	-	0.742	b-f
-Daconil Weatherstik	3.5 fl.oz.	AC				
Maxtima	1.6 fl.oz.	EGIK	0.714	-	0.748	a-e
-Daconil Weatherstik	3.5 fl.oz.	AC				
Torque	0.6 fl.oz.	EGIK	0.702	-	0.749	a-e
-Daconil Weatherstik	3.5 fl.oz.	AC				
Banner Maxx II	1.0 fl.oz.	EGIK	0.710	-	0.733	f
-Daconil Weatherstik	3.5 fl.oz.	AC				
UC19-20	0.28 fl.oz.	ACEGIKM	0.704	-	0.754	abc
UC19-21	0.5 fl.oz.	ACEGIKM	0.694	-	0.742	b-f
UC19-20	0.28 fl.oz.	ACEGIKM	0.716	-	0.758	a
+UC19-21	0.5 fl.oz.					
Xzemplar	0.16 fl.oz.	ACEGIKM	0.700	-	0.755	a-e
Traction	1.3 fl.oz.	ACEGIKM	0.704	-	0.755	ab
Signature XTRA	4.0 oz.	ACEGIKM	0.737	-	0.751	a-d
+Daconil Action	3.5 fl.oz.					
Appear II	4.0 fl.oz.	ACEGIKM	0.719	-	0.739	def
+Daconil Action	3.5 fl.oz.					
Appear II	6.0 fl.oz.	ACEGIKM	0.722	-	0.742	b-f
+Daconil Action	3.5 fl.oz.					
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.702	-	0.741	c-f
-Segway	0.9 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.694	-	0.743	b-f
-Banol	4.0 fl.oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Daconil Weatherstik	3.5 fl.oz.	CEGIKM	0.716	-	0.747	a-e
-Chipco Signature	4.0 oz.[y]	AG				
-Xzemplar	0.16 fl.oz.[y]	AG				
Kabuto	0.5 fl.oz.	ACEGIKM	0.702	-	0.736	ef
Untreated			0.702	-	0.643	g
ANOVA: Treatment (P > F)			0.0930		0.0001	
Days after treatment		14-d	3		6	

[z]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.
[y]Treatments were watered-in with the equivalent of 0.2-in of precipitation immediately following application using watering cans.
[x]A=17 May; C=30 May; G= 26 June; I=11 July; K=25 July; M=7 August
[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 USING THE SMITH-KERNS DOLLAR SPOT MODEL ON A CREEPING BENTGRASS FAIRWAY TURF, 2019

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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. Typically, fungicide applications are mde on a calendar-basis throughout the season when disease is active. Recently, the Smith-Kerns dollar spot forecast model has been utilized in order to help guide fungicide applications based on weather conditions. This has the potential to reduce the number of overall applications by eliminating applications when conditions are not favorable to disease. The model can be used using locally-generated weather data, or through tracker websites such as Greencast. The objective of this study was to evaluate the efficacy of rotational fungicide programs using the Smith Kerns model on Greencast compared to locally-calculated and calendar-based applications.

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. Nitrogen was applied at a total of 1.3 lb N $1000\text{-}ft^{-2}$ as water soluble sources from April through September. Acelepryn was applied on 23 May to control white grubs.

Treatments consisted of a rotation of various fungicides (Table 1) either tank-mixed or applied individually, depending on the application. Initial applications were made on 16 May, prior to disease developing in the trial area. Subsequent applications were made either on a calendar-basis, or by using thresholds determined by the Smith-Kerns dollar spot forecast model. Reapplications of these treatments occurred no sooner than 14-d after the previous application. Model-based applications occurred at either the 20 or 30% threshold as determined by the GreenCast website, or calculated locally using weather data from the research farm. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual disease foci within each plot. 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
Dollar spot symptoms first manifested in late May and increased steadily throughout the summer, with untreated control (UTC) plots reaching 16 dollar spot infection centers (DSIC) per plot on 14 June, 65 DSIC $plot^{-1}$ on 5 July, and 107 DSIC $plot^{-1}$ on 26 July (Tables 1a + 1b). Disease remained active for the duration of the trial, remaining above 100 DSIC $plot^{-1}$ though the end of August before declining to 40 DSIC plot-1 as of 10 October.

All treated plots displayed acceptable (<25 DSIC $plot^{-1}$) levels of control for the duration of the trial, with all but the Greencast 30% Threshold remaining completely free of disease (peaking at 6 DSIC $plot^{-1}$) on 26 July.

Model Performance
The Greencast-based programs had fewer overall applications compared to their locally-calculated counterparts (Table 2). At the 20% threshold, using the Greencast website resulted in 1 less fungicide application. At the 30% threshold, using the Greencast website resulted in 3 less applications, with no significant difference in disease prevention. The Greencast 30% threshold also reduced the number of applications compared to both calendar-based treatments.

Results from this study indicate that the Smith-Kerns dollar spot model can be effectively used with a fungicide program to provide acceptable dollar spot control. Total number of applications per year was dependent on the selected risk threshold and source of weather data used in model calculations. These data indicate that Smith-Kerns action thresholds (i.e., risk threshold) may vary depending on the source of the weather data. Practitioners should do their own on-site experimentation consistently using the same weather source for model inputs to identify appropriate action thresholds to control disease and minimize fungicide applications.

Table 1a. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment[z]	Rate per 1000ft²	Application Codes/ Numbers[y]	Dollar Spot Incidence							
			24 May	7 June	14 June	21 June	5 July	12 July	19 July	26 July
			# of dollar spot foci 18 ft^{-2}							
Greencast 20% Threshold			0.3[x]	0.0	0.0	0.0 b[w]	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	1								
-Daconil Action	1.6 fl.oz.	1,5								
-Secure Action	0.5 fl.oz.	2-4, 6-11								
-Velista	0.5 oz.	5								
-Primo Maxx	0.2 fl.oz.	all dates								
UConn 20% Threshold			0.3	0.0	0.3	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	1								
-Daconil Action	1.6 fl.oz.	1,5								
-Secure Action	0.5 fl.oz.	2-4, 6-11								
-Velista	0.5 oz.	5								
-Primo Maxx	0.2 fl.oz.	all dates								
Greencast 30% Threshold			0.3	0.0	0.0	0.0 b	0.0 b	0.0 b	0.0 b	6.5 b
-Posterity	0.16 fl.oz.	1								
-Daconil Action	1.6 fl.oz.	1,5								
-Secure Action	0.5 fl.oz.	2-4, 6-11								
-Velista	0.5 oz.	5								
-Primo Maxx	0.2 fl.oz.	all dates								
UConn 30% Threshold			0.3	0.0	0.0	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	1								
-Daconil Action	1.6 fl.oz.	1,5								
-Secure Action	0.5 fl.oz.	2-4, 6-11								
-Velista	0.5 oz.	5								
-Primo Maxx	0.2 fl.oz.	all dates								
14/21-day Calendar Program			0.5	0.0	1.0	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	A								
-Daconil Action	1.6 fl.oz.	AK								
-Secure Action	0.5 fl.oz.	D-U								
-Briskway	0.5 fl.oz.	G								
-Velista	0.5 oz.	K								
-Primo Maxx	0.25 fl.oz.	ADG								
-Primo Maxx	0.2 fl.oz.	I-U								
14-day Calendar Program			0.3	0.0	0.8	0.0 b	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	A								
-Daconil Action	1.6 fl.oz.	AI								
-Secure Action	0.5 fl.oz.	C-U								
-Velista	0.5 oz.	I								
-Primo Maxx	0.2 fl.oz.	all dates								
Untreated			1.3	1.5	16.5	55.3 a	65.0 a	86.3 a	91.0 a	107.3 a
ANOVA: Treatment ($P > F$)			0.8503	0.2077	0.0867	0.0001	0.0001	0.0001	0.0001	0.0001

[z]All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi.
[y]Application dates depended on model thresholds. See table 2 for a complete breakdown. Application dates for calendar-based treatments were as follows: 14/21-day program: A=16 May; C=29 May; D=4 June; E=12 June; G=26 June; I=10 July; J=16 July; K=24 July; L=31 July; M=6 August; O=22 August; Q=5 Sept; S=19 Sept; U=3 Oct
[x]Dollar spot data were log-transformed. Means are de-transformed 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 ($\alpha = 0.05$)

Table 1b. Effect of various fungicides on preventative dollar spot control in a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2019.

Treatment	Rate per 1000ft²	Application Codes/ Numbers	Dollar Spot Incidence: 9 Aug	23 Aug	13 Sep	27 Sep	10 Oct
			----------------- # of dollar spot foci 18 ft^{-2}				------------------
Greencast 20% Threshold			0.0 c	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	1					
-Daconil Action	1.6 fl.oz.	1,5					
-Secure Action	0.5 fl.oz.	2-4, 6-11					
-Velista	0.5 oz.	5					
-Primo Maxx	0.2 fl.oz.	all dates					
UConn 20% Threshold			0.0 c	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	1					
-Daconil Action	1.6 fl.oz.	1,5					
-Secure Action	0.5 fl.oz.	2-4, 6-11					
-Velista	0.5 oz.	5					
-Primo Maxx	0.2 fl.oz.	all dates					
Greencast 30% Threshold			1.2 b	0.8 b	1.5 b	2.8 b	0.8 b
-Posterity	0.16 fl.oz.	1					
-Daconil Action	1.6 fl.oz.	1,5					
-Secure Action	0.5 fl.oz.	2-4, 6-11					
-Velista	0.5 oz.	5					
-Primo Maxx	0.2 fl.oz.	all dates					
UConn 30% Threshold			0.0 c	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	1					
-Daconil Action	1.6 fl.oz.	1,5					
-Secure Action	0.5 fl.oz.	2-4, 6-11					
-Velista	0.5 oz.	5					
-Primo Maxx	0.2 fl.oz.	all dates					
14/21-day Calendar Program			0.0 c	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	A					
-Daconil Action	1.6 fl.oz.	AK					
-Secure Action	0.5 fl.oz.	D-U					
-Briskway	0.5 fl.oz.	G					
-Velista	0.5 oz.	K					
-Primo Maxx	0.25 fl.oz.	ADG					
-Primo Maxx	0.2 fl.oz.	I-U					
14-day Calendar Program			0.0 c	0.0 b	0.0 b	0.0 b	0.0 b
-Posterity	0.16 fl.oz.	A					
-Daconil Action	1.6 fl.oz.	AI					
-Secure Action	0.5 fl.oz.	C-U					
-Velista	0.5 oz.	I					
-Primo Maxx	0.2 fl.oz.	all dates					
Untreated			101.0 a	106.5 a	85.3 a	80.8 a	40.3 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001

[z]All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi.
[y]Application dates depended on model thresholds. See table 2 for a complete breakdown. Application dates for calendar-based treatments were as follows: 14/21-day program: A=16 May; C=29 May; D=4 June; E=12 June; G=26 June; I=10 July; J=16 July; K=24 July; L=31 July; M=6 August; O=22 August; Q=5 Sept; S=19 Sept; U=3 Oct
[x]Dollar spot data were log-transformed. Means are de-transformed 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. Application dates and totals

Treatment	App 1	App 2	App 3	App 4	App 5	App 6	App 7	App 8	App 9	App 10	App 11	Total Apps
Greencast 20% Threshold	16 May	30 May	17 June	2 July	16 July	1 Aug	16 Aug	30 Aug	13 Sept	27 Sept		**10**
UConn 20% Threshold	16 May	4 June	20 June	4 July	19 July	2 Aug	16 Aug	30 Aug	13 Sept	27 Sept	11 Oct	**11**
Greencast 30% Threshold	16 May	18 June	2 July	16 July	1 Aug	16 Aug	3 Sept	26 Sept				**8**
UConn 30% Threshold	16 May	4 June	20 June	4 July	19 July	2 Aug	16 Aug	30 Aug	13 Sept	27 Sept	11 Oct	**11**
14/21-day Calendar Program	16 May	5 June	26 June	10 July	24 July	8 Aug	22 Aug	5 Sept	19 Sept	3 Oct		**10**
14-day Calendar Program	16 May	29 May	20 June	26 June	10 July	24 July	8 Aug	22 Aug	5 Sept	19 Sept	3 Oct	**11**

PREVENTIVE TAKE ALL PATCH CONTROL WITH VARIOUS FUNGICIDES ON A COLONIAL BENTGRASS FAIRWAY TURF, 2018-19

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INTRODUCTION

Take all patch, caused by *Gaeumannomyces graminis*, is a root-colonizing disease of bentgrass (*Agrostis spp.*). Newly established bentgrass fairways and greens are often most commonly affected. Symptoms appear in late-spring or early summer as wilting to reddish-brown patches of turf as the infected root system fails during environmental stress. Disease can be managed culturally by maintaining low soil pH, providing adequate manganese, phosphosus and potassium fertility, and maintaining adequately drained soils. Curative control of the disease can be difficult and disease can reoccur over multiple years, so fungicidal control is most effective when used preventively on areas that are known to have disease. Fungicide application during the fall and early spring are often most effective. The objective of this trial was to evaluate the effectiveness of various fungicides applied both during the fall and spring on control of take-all patch on a colonial bentgrass fairway turf.

MATERIALS & METHODS

A field study was conducted on an SR-7150 colonial bentgrass (*Agrostis capillaris*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Plots were layed out over areas of turf expressing take-all patch symptoms during spring and summer of 2018. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. A total of 2.1 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from September 2018 through July 2019. Acelepryn was applied on 23 May 2019 to control white grubs, and Prostar (1.5 oz) was applied on 24 June to prevent brown patch.

Treatments consisted of commercially available and developmental fungicides. The study was initiated on 19 October 2018 with initial treatments applied on this date or 9 November to assess early versus late fall applications. Subsequent applications were made at specified intervals in fall 2018 and spring 2019. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal $1000\text{-}ft^{-2}$ at 40 psi. Treatments were watered in immediately following application with the equivalent of 0.2-in of water using overhead irrigation. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with six replications.

Take-all patch was determined visually as the percent area blighted from 21 June to 10 July, 2019. 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. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Take-all patch severity data were log transformed as necessary for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS & DISCUSSION

Take All Patch Severity
Disease was first observed in the trial area in summer 2018,and had recovered prior to of the first application in October 2018. Symptoms reappeared in mid-June 2019, with untreated plots averaging 10.9% plot area blighted as of 28 June (Table 1). ESTC111, regardless of rate, and UC19-14 did not differfrom untreated control plots. Mirage (1.5 oz.), Tekken, Headway + Heritage Action, UC19-8, Posterity + Heritage Action, and Heritage TL all provided good control (< 3% plot area blighted) as of this date. There was no significant difference between early and late fall applications of Tekken .

Mean take all patch severity on untreated control plots reached 13.4 % plot area blighted as of 10 July, with individual plots exhibiting as much as 40% plot area blighted. ESTC111 remained no different than untreated plots regardless of rate, along with the low rate of Mirage (1.0 oz.) and UC19-14. All other treatments continued to provide good control and acceptable, or nearly acceptable, turf quality.

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Table 1. Effect of preventive fungicides on Take-all patch severity and turf quality in a colonial bentgrass fairway turf at the Plant Science Research Facility in Storrs, CT, 2018-19

Treatment[z]	Rate per 1000ft^2	App. Dates[y]	Take All Patch 21 Jun	28 Jun	5 Jul	10 Jul	Turf Quality 10 Jul
			------------------ % plot area blighted			-----------------	--1-9; 6=min accept.--
UC19-12	0.1963 fl.oz.	ADEI	3.5	8.9[x] abc[w]	9.7 ab	9.9 ab	4.3 cd
UC19-12	0.3927 fl.oz.	ADEI	8.0	10.7 a	14.7 a	14.5 a	3.5 d
Mirage Stressgard	1.0 fl.oz.	ADEI	4.5	4.7 a-d	6.4 abc	8.3 abc	4.3 cd
Mirage Stressgard	1.5 fl.oz.	ADEI	1.2	2.7 de	2.4 cd	2.8 cd	6.0 ab
Tekken	3.0 fl.oz.	AEI	1.0	2.5 de	2.5 cd	2.3 d	6.0 ab
Tekken	3.0 fl.oz.	DEI	0.8	2.4 de	2.6 cd	3.0 bcd	6.3 a
Headway	3.0 fl.oz.	AI	0.5	0.9 e	2.3 cd	2.3 d	6.0 ab
-Heritage Action	0.4 oz.	DE					
UC19-8	3.0 fl.oz.	ADEI	0.5	1.2 de	1.6 d	2.1 d	6.2 a
Posterity	0.16 fl.oz.	AI	0.5	2.8 cde	3.4 bcd	2.8 cd	5.8 abc
-Heritage Action	0.4 oz.	ADEI					
UC19-14	0.41 fl.oz.	ADEI	4.5	9.1 ab	9.0 ab	11.3 a	4.5 bcd
Heritage TL	2.0 fl.oz.	ADEI	0.8	2.9 b-e	3.7 bcd	3.1 bcd	5.5 abc
Untreated			7.7	10.9 a	11.3 a	13.4 a	3.8 d
ANOVA: Treatment (P > F)			0.0906	0.0010	0.0008	0.0014	0.0028

[z]All treatments were applied using a hand held CO2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft^{-2} at 40 psi. Treatments were watered-in with 0.2-inches of irrigation immediately following application.
[y]A=19 October 2018; D=9 November 2018; E=9 April 2019; I=9 May 2019
[x]Take-all patch means were log-transformed from this date forward. Means are de-transformed 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)

EVALUATING A NICHE-CLEARING METHOD TO ENHANCE BIOLOGICAL CONTROL OF GRAY LEAF SPOT IN PERENNIAL RYEGRASS TURF, 2019

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INTRODUCTION

An increase in public concern over the use of pesticides on turfgrass areas has recently led to pesticide bans in the Northeast. With a reduction in the use of synthetic pesticides allowed, alternative options for pest control are necessary. An alternative use to synthetic fungicides are biological fungicides (biofungicides) that contain microbial organisms as the active ingredient. However, their use is often limited due to cost, unreliable control, and/or reduced shelf life.

Maintaining high quality turf stands becomes difficult with high disease incidence. One common pathogen in turf, *Pyricularia grisea* causes gray leaf spot, which is a devastating disease of many cool-season turfgrasses. The disease often progresses rapidly, infecting entire leaves and eventually spreading to cover large, irregular patches of blighted turf. Stopping this pathogen can be very difficult and often requires several chemical fungicide applications to prevent further damage to the turf. However, with increasing bans on synthetic pesticides, alternative methods are needed to help control these detrimental pathogens.

The use of biofungicides on turf has often shown marginal and inconsistent efficacy. Latin (2011) summarized results of 24 Plant Disease Management Reports, which evaluated the efficacy of biofungicides on several turfgrass diseases, and only 33% of the studies resulted in less disease among turf treated with biofungicides than untreated controls. The decreased efficacy in biofungicides compared to chemical fungicides is in part due to the application of these biological control agents into an established community (Baker, 1987). The turfgrass foliage, thatch, and roots contain a diverse microbial community, which likely reduce the persistence of the applied biocontrol agents in these environments.

Decreasing the microbial competition through a niche-clearing process in these turfgrass environments could allow the biocontrol agents to establish better and persist for longer periods of time. Commercially available products containing hydrogen dioxide, hydrogen peroxide, or peroxyacetic acid, which are often used as disinfectants in plant management systems, work on contact to reduce microbial populations. Applying these products before biofungicide applications could potentially result in a less competitive environment that these microbial agents are being introduced into, resulting in increased establishment and greater disease control.

The objective of this study was to evaluate a niche-clearing method on the efficacy of introduced biological control agents for controlling gray leaf spot disease.

MATERIALS & METHODS

This field study was conducted during August through September 2019 at the Plant Science Research and Education Facility in Storrs, CT on 50:50 blend of ‘Home run’ and ‘Insight’ perennial ryegrass (*Lolium perenne*) turf. The field was seeded on 28 June at a rate of 10 lb. 1000 ft^2 and was fertilized at the time of seeding at a rate of 1 lb. P 1000 ft^{-2} and 0.8 lb. N 1000 ft^{-2}. Additional fertilizer applications were applied on 24 July and 26 July at the rate of 0.25 lb. N 1000 ft^{-2}. Quicksilver (0.048 fl. oz. 1000 ft^{-2}) was applied on 10 July, Speedzone (1.8 fl.oz. 1000 ft^{-2}) was applied on 24 July, and Acclaim Extra (0.9 fl.oz. 1000 ft^{-2}) was applied on 23 July for control of broadleaf weeds and crabgrass, respectively. Segway (0.45 fl.oz. 1000ft^{-2}) was applied on 17 July, and Banol (1.3 fl.oz. 1000 ft^{-2}) + Prostar (1.5 fl.oz. 1000 ft^{-2}) were applied on 29 July for prevention of Pythium blight. Turf was mowed at 2 inches twice a week. Irrigation was applied as needed to prevent drought stress.

Experimental and Treatment Design
The study was conducted as a strip-plot design arranged as a 2 × 5 factorial. The first factor was type of fungicide, which included Zio (*Pseudomonas chlororaphis* AFS009), Rhapsody (*Bacillus subtilis* QST713), W9 experimental *Bacillus* sp, 3336F (thiophanate-methyl), and no fungicide. The second factor was niche-clearing which comprised of either applications of Zero-Tol (hydrogen peroxide and peroxyacetic acid) or no Zero-Tol. Individual plots were 6 ft × 6 ft with a 0.5 ft border.

Zero-Tol was applied with a handheld CO_2 pressurized sprayer with a single TP8010E flat fan nozzle calibrated to deliver 3.0 gal 1000 ft^{-2}. Zero-Tol was applied approximately 3 hours before fungicide applications at a rate of 6.0 fl.oz. 1000 ft^{-2}. All fungicides were applied with an air compressor sprayer outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal 1000 ft^{-2}. Zio was applied at a rate of 4.0 fl.oz. 1000 ft^{-2}, Rhapsody was applied at a rate of 5.0 fl.oz. 1000 ft^{-2}, and thiophanate-methyl was applied at a rate of 4.0 fl.oz. 1000 ft^{-2}. W9 experimental *Bacillus* sp. was applied at varying rates depending on how much was cultured with an average rate of $2.4 \times 10^7 \pm 9.9 \times 10^6$ colony forming units (CFU) mL^{-1} for all applications. The *Bacillus* sp. was grown on nutrient agar and incubated for 48 hours at 28˚C under constant light. Bacterial culture was scraped off agar plates and suspended in sterile deionized water. CFUs were calculated by plating serial dilutions of the bacterial suspension.

Plots were inoculated with spores of *Pyricularia grisea* three times throughout the study in a water carrier rate of 2 gal 1000 ft^{-2}. The fungus was grown on V8 agar at 28˚C under constant light prior to inoculation. Spores were suspended in water and a 10% Potato Dextrose Broth solution and applied at a rate of

28,524 spores mL^{-1} on 21 August, 24,747 spores mL^{-1} on 28 August, and 135,204 spores mL^{-1} on 11 September.

Data Collection and Statistical Analysis

Percent gray leaf spot disease was calculated using a grid with 275 intersections, which was placed on both halves of every plot for a total of 550 intersections per plot. The total number of intersections with disease directly below was calculated as a percentage of the total 550 intersections. Gray leaf spot disease severity was also determined visually on a 0 to 9 scale where 9 represented all turf infected with disease and 0 represented no disease. Turf was also assessed visually for turf quality on a 1 to 9 scale where 9 represented the highest quality turf, 6 was the minimum acceptable quality, and 1 represented the lowest quality turf. Percent green cover was assessed using four digital images of each plot within a 1.5 × 2.0 ft. aluminum lightbox containing LED lights. The lightbox excluded any additional light, allowing for consistent exposure between all photos. Photos were analyzed for percent green cover using Turf Analyzer software (Green Research Services LLC, Arkansas, USA) and the average of the four photos from each plot were used. Normalized difference vegetative index (NDVI) was calculated as the average of 10 readings per plot using a FieldScout TCM 500 NDVI Turf Color Meter (Spectrum Technologies, Aurora, IL).

All data were analyzed for treatment differences (fungicide, niche-clearing, and fungicide × niche-clearing) by using analysis of variance with Fisher's least significant difference test for mean separation in the MIXED procedure in SAS 9.4 (SAS Institute, Cary, NC).

RESULTS & DISCUSSION

Gray Leaf Spot Disease Percent and Severity

Percent gray leaf spot disease was influenced by the fungicide main effect on 27 August, 11 September, and 19 September. Thiophanate-methyl was the only fungicide that was significantly different from the no fungicide turf for percent gray leaf spot disease, with the exception of Rhapsody on 27 August.

The fungicide main effect was significant for gray leaf spot disease severity on 5 September, 11 September, 19 September, and 25 September. When disease incidence was greatest, the two commercially available biofungicides, Zio and Rhapsody, showed a significantly lower gray leaf spot disease severity than the no fungicide turf and no significant difference to the thiophanate-methyl (Fig. 1). This suggests that Zio and Rhapsody are comparable to thiophanate-methyl in gray leaf spot disease control.

Percent Green Cover

Percent green cover was used as a measure for disease incidence in this study. A higher percent green cover indicated that the turf had less gray leaf spot disease.

Both the fungicide and niche-clearing main effects influenced percent green cover of turf. There was a significant fungicide effect on 20 September and 27 September. Zio and Rhapsody treated turf had equivalent percent green cover to the synthetic fungicide thiophanate-methyl on 20 September. On the last observation date, Zio and Rhapsody remained equivalent to each other and had a higher percent green cover than the no fungicide. However, Zio was no longer equivalent to the thiophanate-methyl (Fig. 2). These results suggest that the turf that received thiophanate-methyl, Zio, and Rhapsody applications had comparable percent green cover, suggesting that they provided similar disease control to gray leaf spot.

There was a significant niche-clearing effect on 9 September, 20 September, and 27 September (Table 3). As the disease progressed, niche-clearing treated turf had a significantly lower percent green cover, due to greater gray leaf spot disease (Fig. 3). These results indicate that applying a niche-clearing process to turf foliage before the application of biofungicides does not increase its efficacy against controlling gray leaf spot disease.

SUMMARY

While the hypothesis of this study was that the niche-clearing may increase biofungicide efficacy. However, no interaction between niche-clearing and biofungicide was observed. The preliminary results suggest that a niche-clearing process does not lead to a decrease in disease incidence. The data indicates that percent green cover, which was used as a measure for disease incidence, was lower among niche-clearing treated turf, suggesting a greater amount of gray leaf spot disease.

The data also indicates that disease control by the biofungicides, except the W9 experimental *Bacillus* sp., were comparable to a low rate of the synthetic pesticide thiophanate-methyl. When disease incidence was the highest, Zio and Rhapsody treated turf showed no significant difference to the thiophanate-methyl turf for percent gray leaf spot, gray leaf spot severity, and percent green cover. Zio, Rhapsody, and thiophanate-methyl also had significantly lower gray leaf spot disease percent and severity and significantly higher percent green cover than the no fungicide turf.

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Table 1. Mean percent gray leaf spot disease in relation to treatments and analysis of variance *P* values.

	Percent Gray Leaf Spot Disease				
	27 Aug	**5 Sept**	**11 Sept**	**19 Sept**	**25 Sept**
Niche-clearing	---------- Gray leaf spot % ----------				
None	3.1	6.8	10.1	12.7	16.0
Zero-Tol	3.5	6.4	14.3	17.0	20.6
Fungicide					
No fungicide	3.8 ab†	6.3	13.7 a	15.5 a	18.3
Thiophanate-methyl	2.1 b	5.6	9.4 b	11.9 b	15.5
Zio	3.4 ab	5.9	13.1 a	16.0 a	19.9
Rhapsody	2.3 b	7.1	11.3 ab	14.2 ab	17.2
W9 Experimental *Bacillus* sp.	5.0 a	8.0	13.7 a	16.6 a	20.7
Source of Variation	---------- *P* values ----------				
Niche-clearing	0.6864	0.4567	0.0643	0.0680	0.0573
Fungicide	0.0500	0.1614	0.0184	0.0257	0.1625
Niche-clearing × Fungicide	0.6211	0.8184	0.1673	0.1246	0.2364

†Means followed by the same letter are not significantly different according to Fisher's LSD test (α=0.05).

Table 2. Mean gray leaf spot disease severity in relation to treatments and analysis of variance *P* values.

	Gray Leaf Spot Disease Severity				
	27 Aug	**5 Sept**	**11 Sept**	**19 Sept**	**25 Sept**
Niche-clearing	---------- 0-9 ----------				
None	1.0	1.3	2.1	2.4	2.5
Zero-Tol	1.1	1.2	2.7	3.0	3.1
Fungicide					
No fungicide	1.1	1.2 ab†	2.6 ab	2.8 b	2.9 ab
Thiophanate-methyl	0.7	1.0 b	1.8 c	2.1 c	2.3 c
Zio	1.1	1.0 b	2.3 b	2.6 b	2.7 bc
Rhapsody	0.9	1.3 ab	2.3 b	2.7 b	2.7 bc
W9 Experimental *Bacillus* sp.	1.5	1.5 a	2.8 a	3.3 a	3.3 a
Source of Variation	---------- *P* values ----------				
Niche-clearing	0.8523	0.5195	0.0833	0.1894	0.0586
Fungicide	0.1633	0.0349	0.0003	0.0004	0.0070
Niche-clearing × Fungicide	0.1860	0.7719	0.0704	0.2322	0.3123

†Means followed by the same letter are not significantly different according to Fisher's LSD test (α=0.05).

Table 3. Mean turf percent green cover in relation to treatments and analysis of variance *P* values.

	Percent Green Cover							
	5 Aug	**14 Aug**	**19 Aug**	**27 Aug**	**5 Sept**	**9 Sept**	**20 Sept**	**27 Sept**
Niche-clearing	---------- green cover % ----------							
None	98.7	99.1	98.9	98.3	96.7	90.7 a†	83.2 a	77.5 a
Zero-Tol	98.5	99.1	98.8	98.2	96.7	85.9 b	75.3 b	70.1 b
Fungicide								
No fungicide	98.3	98.9	98.8	98.1	96.4	87.4	76.1 b	69.1 d
Thiophanate-methyl	98.6	99.1	98.9	98.3	96.8	87.9	81.6 a	80.0 a
Zio	98.6	99.1	98.9	98.2	96.9	89.5	80.6 a	73.7 bc
Rhapsody	98.6	99.1	89.9	98.4	97.1	89.4	81.7 a	76.1 ab
W9 Experimental *Bacillus* sp.	98.6	99.1	98.9	98.2	96.4	87.5	76.2 b	70.1 cd
Source of Variation	---------- *P* values ----------							
Niche-clearing	0.6287	0.9600	0.0917	0.4268	0.9182	0.0309	0.0202	0.0294
Fungicide	0.9241	0.2585	0.4062	0.3275	0.0851	0.0878	0.0164	0.0010
Niche-clearing × Fungicide	0.9330	0.6051	0.2729	0.4495	0.6110	0.2668	0.4076	0.8180

†Means followed by the same letter are not significantly different according to Fisher's LSD test (α=0.05).

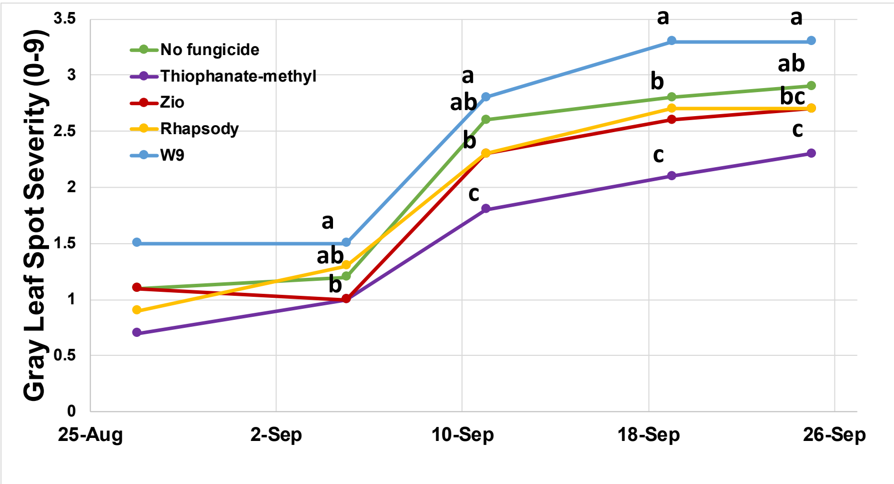

Figure 1. Fungicide main effect on gray leaf spot severity (0-9. Means followed by the same letter are not statistically different according to Fisher's LSD test (α=0.05).

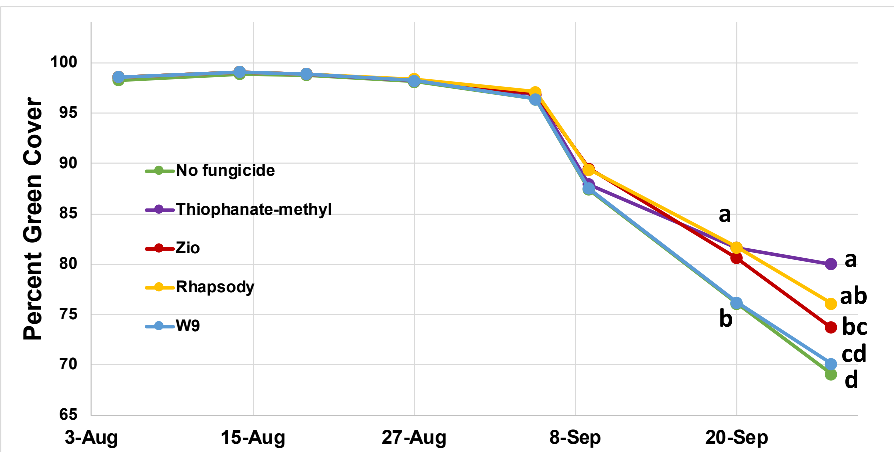

Figure 2. Fungicide main effect on percent green cover. Means followed by the same letter are not statistically different according to Fisher's LSD test (α=0.05).

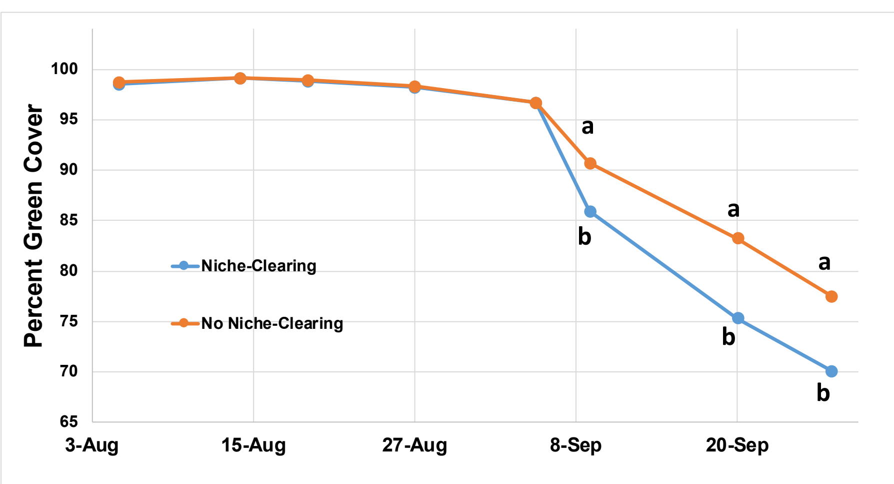

Figure 3. Niche-clearing main effect on percent green cover. Means followed by the same letter are not statistically different according to Fisher's LSD test (α=0.05).

EFFECT OF TURF SPECIES, SEEDING RATE AND MOWING TIMING ON WEED POPULATIONS DURING AND POST TURFGRASS ESTABLISHMENT

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INTRODUCTION

The pressure to reduce/eliminate pesticide use on turfgrass areas continues to increase due to potential human exposure and concerns regarding subsequent negative health impacts. Conventional turfgrass management includes the use of different types of pesticides to control a variety of pests; such as herbicides (weeds), fungicides (diseases) and insecticides (Insects). However, herbicides are one of the more commonly used products due to the prolific seed bank inherently in the soil and traffic associated with many turfgrass areas.

Cultural management of weeds in turfgrass is important because it can reduce the dependence on synthetic pesticides. Though synthetic pesticides have been shown to be very effective in managing weeds, concerns regarding their potential negative impact on human and environmental health have sparked legislative actions that severely restrict or ban their use in many areas. For example, Connecticut has banned the use of all EPA registered pesticides on the grounds of all public and private school's pre-K to 8th grade. The state of New York has a similar ban that extends through grade 12. EPA 25b products, or minimum risk pesticides, can be used in these areas, but are expensive, largely ineffective for selective weed control and/or require several follow up applications. Additionally, there is limited data on the efficacy of many of the products. For municipal turfgrass workers, these restrictions have resulted in considerable reduction in turfgrass quality and a sense of urgency to find alternative management methods.

Herbicides have been researched extensively and are widely popular to control both broadleaf and grassy weeds in turfgrass management. Chemical weed control has many factors that affect its efficacy including matching the appropriate active ingredient to the target weed species, maturity of a weed, and application rate/timing. Overall, when used correctly, herbicides are effective and minimally phytotoxic to a desirable turf. For example, utilizing active ingredients such as topramezone and mesotrione, resulted in 65% control of smooth crabgrass *(Digitaria ischaemum)* and 62% control of white clover *(Trifolium repens)* six weeks after one application at 280 g a.i. ha^{-1} (Brewer, 2017). Topramezone resulted in 87% control of smooth crabgrass and 90% control of white clover six weeks after one application at 36.8 g a.i. ha^{-1} (Brewer, 2017).

Though chemical control is effective, the new laws and heightened health concerns have increased interest in alternative methods of weed control, particularly cultural methods.

Cultural practices are aimed at developing a dense turf stand to crowd out young weed seedlings, as weeds can only exist if there is space for them (Landschoot, 2006). Effective cultural practices include but are not limited to proper turfgrass species selection, proper mowing practices, adequate liming and fertilization, and irrigating effectively (Landschoot, 2006).

Turfgrass species selection could be one of the most important methods in minimizing weed colonization. A turfgrass species ability to establish quickly will reduce weed encroachment as the turf matures. Perennial ryegrass *(Lolium perenne)* has been shown to greatly reduce weed biomass compared to Kentucky bluegrass *(Poa pratensis)* during establishment (Par, 1985). In another study, a 100% perennial ryegrass (PRG) stand resulted in the fewest broadleaf weeds with <1% of weed cover one year after seeding compared to other seeding ratios with Kentucky bluegrass (KBG) such as 70/30 and 95/5 (KBG/PRG) (Stier, 2008).

Proper mowing practices on established turfgrass areas have also been shown to influence weed populations. The turf industry has moved toward mowing at the high end of the recommended range for a species to limit the colonization of annual weeds. Generally, higher mowing heights have more impact on crabgrass cover than broadleaf weed populations (Dernoeden et al., 1993, Voigt et. al., 2001). Dernoeden et. al., 1993 concluded that an 8.9cm mowing height was the best cultural strategy for reducing smooth crabgrass encroachment and maintaining tall fescue cover. Abu-Dieyeh observed that out of seventeen different species of broadleaf weeds, only populations of dandelion *(Taraxacum officinale)* and white clover *(Trifolium repens)* resulted in greater populations at 3cm-5cm turf height compared to 7cm-10cm (Abu-Dieyeh, 2005).

Mowing height and timing during establishment is another cultural practice that could considerably enhance turfgrass density and reduce weed competitiveness. A study conducted to evaluate the effects of close mowing on the establishment and development of KBG/PRG mixes and monocultures indicated that monocultures of both species became denser when exposed to closer and earlier mowing treatments (Brede and Duich, 1984). In mixes of 95% KBG, greater shoot density was observed when the first mowing took place at two weeks from planting under a low height of cut compared to the first mowing taking place at five weeks from planting at a high height of cut (Brede and Duich, 1984). The opposite was true of PRG (Brede and Duich, 1984) Certain species may respond with greater vigor and density under low mowing during establishment. This cultural practice could provide turfgrasses a competitive advantage by shading out weed seedlings quickly

Seeding rate has also been shown to influence the encroachment of undesirable species during the establishment phase of turfgrass swards. Higher seeding rates can result in higher shoot density up to almost four years after seeding. Regardless of species, as seeding rate increased, weed numbers decreased (Ayan et. al. 2017).

This research was designed to assess the impact of turfgrass species, seeding rate and mowing regime on weed populations during turfgrass establishment. The objectives were to determine the effects of turfgrass species, seeding rate and mowing height/timing on percent cover, turfgrass density and color, percent weed cover.

MATERIALS AND METHODS

This field study was conducted at the University of Connecticut Plant Science Research and Education Facility in Storrs CT (41° 47' 44.9268" N, 72° 13'46.8156" W). The study was arranged in a split-split plot design as a 2x2x4x2 factorial with three replications. The main plots were set out as a randomized complete block and each block size was 7.3m x 7.3m. Each block was split by herbicide that had two levels: herbicides used and no herbicides used. Each herbicide plot was split by mowing strategy and had two levels: mowed at 3.2cm (1.25in.) early during establishment (M1) and mowed at 8.2cm (3.25in.) (M2). The sub-plot factor was turfgrass species randomized by seeding rate. Four turfgrass species were seeded as blends: fine fescue *(Festuca ovina and Festuca rubra),* perennial ryegrass *(Lolium perenne),* Kentucky bluegrass *(Poa pratensis)* and tall fescue (Festuca arundinacea). These were each seeded at the recommended rate and twice the recommended rate. Individual experimental plots were 1.8m x 1.8m. The blends and seeding rates were as follows: fine fescue blend (Viking H20 hard fescue 39.75%, Ambrose chewings fescue 29.99%, Shadow II chewings fescue 29.93%) was seeded at 279.7kg PLS ha^{-1} and 559.4kg PLS ha^{-1}. Perennial ryegrass blend (Fiesta 4 33.72%, Dasher 3 31.98%, Express II 31.94%) was seeded at 376.5kg PLS ha^{-1} and 753kg PLS ha^{-1}. Kentucky bluegrass blend (Shannon 30%, SPF30 Texas Hybrid 25%, Jumpstart 25%, Hampton 20%) was seeded at 118.3kg PLS ha^{-1} and 236.6kg PLS ha^{-1}. Tall fescue blend (Regenerate 33.78%, Reflection 33.09%, Maestro 32.76%) was seeded at 376.5kg PLS ha^{-1} and 753kg PLS ha^{-1}. Fifty seeds each of white clover *(Trifolium repens)*, buckhorn plantain *(Plantago lanceolata)* and dandelion *(Taraxacum officianale)* were distributed into each individual plot at the time of seeding.

The study was seeded on Sep 10, 2019 on a Paxton, fine sandy loam soil (coarse-loamy, mixed, active, mesic Oxyaquic Dystrudepts). Following seedbed preparations, turfgrass and weed seeds were mixed and then spread in each plot using a handheld shaker in two directions at 90° angles. Hand weasels were then used to lightly incorporate the seed into the soil 0.6cm to 1.2cm. Shaw's starter fertilizer (14-25-10) (Knox Fertilizer Co, Knox, IN) was applied at a rate of 49kg P_2O_5 ha^{-1} using a broadcast spreader.

A germination blanket (Covertan Pro 19, Suntex CP, Sarasota, FL) (85% light transmission) was placed over the entire research area and held in place with plastic stakes. The site was lightly irrigated by hand as needed to maintain adequate soil moisture for seed germination for 15 days. The cover was removed on Sep 18, 2019. Thereafter, no additional irrigation was applied. M1 plots received the first mowing when the turf reached a height of 7.6cm with clippings removed on Oct 2,2019. M2 plots received the first mowing when the turf reached a height of approximately 10.1cm with clippings removed on Oct 4, 2019. Subsequent mowings were completed weekly until mowing ceased on Oct 18, 2019.

Herbicide treated plots received T-Zone™ (3,5,6-Trichloro-2-pyridinyloxyacetic acid, 2,4-dichloro-5-[4-(difluoromethyl)-4,5 dihydro-3-methyl-5-oxo-1h-1,2,4-triazol-1-yl]phenyl] methanesulfonamide, 2 4-dichlorophenoxyacetic acid, 3 6-dichloro-o-anisic acid) (PBI Gordon, Shawnee, KS) on Nov 6, 2019. T-Zone™ was applied with a Toro Multipro 1250 sprayer (The Toro Company, Bloomington, MN) using air induction nozzles calibrated to 818L/ha^{-1}. T-Zone™, at a rate of 4.3L/ ha^{-1} in 144L/ ha^{-1} of total water carrier volume.

Percent weed cover was quantified using the line intersect method weekly in Oct 2019. In addition to the weed species that were seeded, natural pressure from species included thistle (Cirsium spp.), Mouse-ear chickweed (Cerastium fontanum), Common Lambsquarter (Chenopodium album), Ground Ivy (Glechoma hederacea), and Shepards Purse (Capsella bursa-pastoris).

Results

Significant differences between treatments resulted primarily from turfgrass species, seeding rate and mowing height main effects (Table 1). The only significant interaction observed was between turfgrass species and mowing height on 25 October.

Turfgrass species main effects were observed in every date data was collected (Table 1). Perennial ryegrass consistently had the lowest percent weed cover compared to other species, except in week 6 where it was not significantly different from tall fescue. Tall fescue and fine fescue were not significantly different except in week 6 where tall fescue had slightly higher percent weed cover. Kentucky bluegrass had the highest percent weed cover throughout all 4 weeks (Figure 1).

Significant seeding rate main effects were observed during weeks 3 and 4 (30 September to 11 October) (Table 1). The high seeding rates, regardless of turfgrass species, had less percent weed cover than the recommended (low) seeding rates. However, in weeks 5 and 6 (14 October to 25 October), percent weed cover was not significantly different across seeding rates (Figure 2)

A significant mowing height main effect was not observed until week 6. However, a significant turfgrass species X mowing height interaction was also observed (Table 1, Figure 3). The interaction shows that a lower mowing height during establishment significantly reduces percent weed cover for fine fescues and Kentucky bluegrass (Figure 4). A lower mowing height, however, did not reduce percent weed cover for both perennial ryegrass and tall fescue. It's worth noting that the percent weed cover in the perennial ryegrass and the tall fescue were low regardless of mowing height.

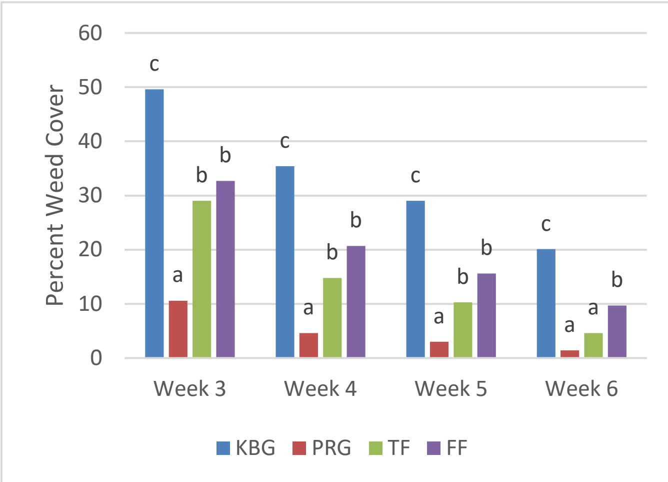

Figure 1. Turfgrass species main effect on percent weed cover

Table 1. Analysis of variance for percent weed cover

Main Effects	**WAS[a] 3**	**WAS 4**	**WAS 5**	**WAS 6**
Variation Source				
Species	***	***	***	***
Rate	**	**	NS	NS
Mowing Height	NS	NS	NS	**
Interactions				
Species*rate	NS	NS	NS	NS
Species*MH	NS	NS	NS	*
Rate*MH	NS	NS	NS	NS
Species*rate* MH	NS	NS	NS	NS

Levels of significance obtained with PROC MIXED in SAS
[a] Weeks after seeding
**P<0.05*
***P<0.01*
****P<0.001*

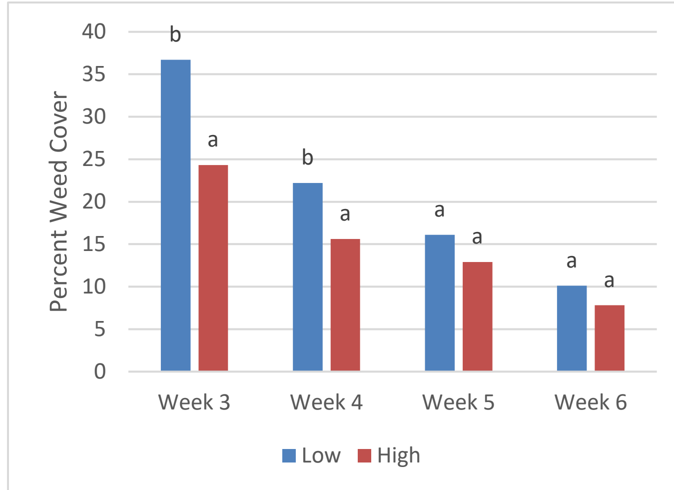

Figure 2. Seeding rate main effect on percent weed cover

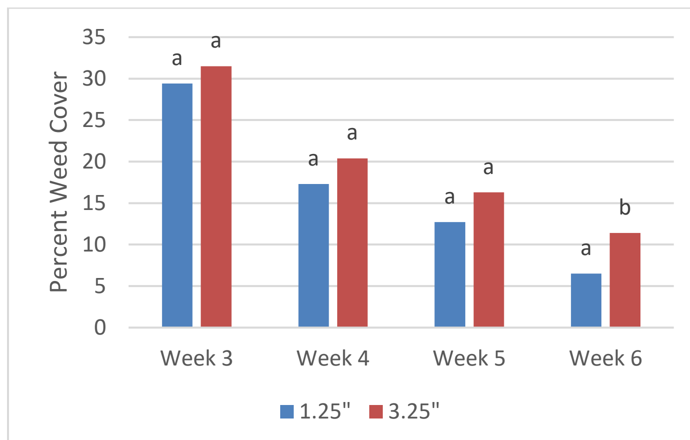

Figure 3. Mowing strategy main effect on percent weed cover

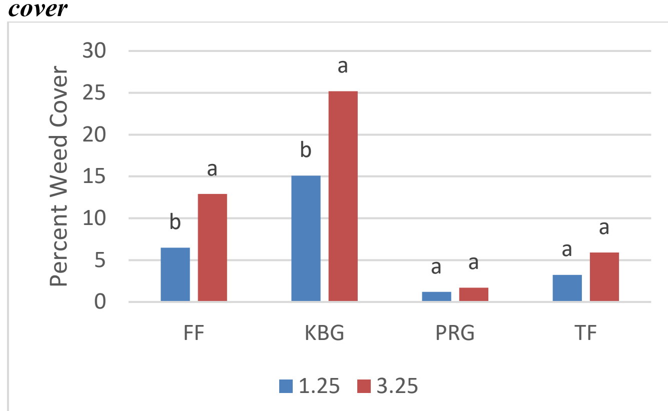

Figure 4. The interaction of turfgrass species and mowing regime on percent weed cover, week 6 (Oct. 2019)

DISCUSSION & CONCLUSION

The ability or inability of a weed species to germinate and compete with desirable turfgrasses during establishment depends on many factors such as the level of weed seeds inherently in the soil, germination rate of the turfgrass species, growth/development rate of the turfgrass, turfgrass growth habit, etc. The primary objective of this research was to identify key factors or combinations of factors that the turfgrass manager can control such as turfgrass species selection, seeding rate, and mowing height to minimize weed pressure when establishing turfgrass areas without the use of herbicides. Based on the results to date, utilizing turfgrass species such as perennial ryegrass, tall fescue and fine fescues can help reduce weed populations during establishment. Increasing seeding rate seems to help early but was no longer effective by weeks 5 and 6. Reducing the mowing height was an effective tool when seeding Kentucky bluegrass and/or the fine fescues but was not necessary when using perennial ryegrass or tall fescue.

Turf managers seeking to establish a quality turfgrass stand with fewer weeds should consider using seed mixtures and/or blends that are predominantly perennial ryegrass, tall fescue and/or fine fescue. If the mix is mostly fine fescues and/or Kentucky bluegrass, mowing early and low can help reduce weed pressure. In this research, low weed pressure was observed throughout all weeks in perennial ryegrass. This is consistent with other research showing the species ability to establish quickly and minimize weed colonization (Parr, 1985).

These results are for one year of data only. This study will be repeated in fall 2020 to observe another year of weed colonization during establishment.

ACKNOWLEDGEMENTS

Funding for this research is provided by the New England Regional Turfgrass Foundation. Kentucky bluegrass seed was donated by Atlantic Golf and Turf, Turner Falls, MA. Tall fescue seed was donated by Noble Turf, Mt. Laurel, NJ.

Thank you to Kevin Miele, Mark Oliver, Steve Olsen and Scott Vose for assisting in creating the research area and staking the germination blanket. Thank you to Alyssa Siegel-Miles for assisting in seeding the plots. Thank you to Kate Goodridge, Karl Guillard and Brendan Noons for assisting with statistical analyses. Thank you to Connor Stevenson for assisting in data collection.

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CLIPPINGS SAP NITRATE-N CONCENTRATIONS AND RELATIONSHIP TO NDVI AND DGCI IN KENTUCKY BLUEGASS AND TALL FESCUE, 2019

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INTRODUCTION

Annual grasses usually store N as nitrate (NO_3) in the bases of stems and shoots, and this NO_3 pool is closely related to soil N availability. Perennial turfgrasses also store N as NO_3, but this pool is dynamic throughout the growing season. In the spring and summer, rapid growth and frequent mowing lead to NO_3 being largely assimilated into leaf proteins as new leaf blades are formed. Consequently, the storage of NO_3 is generally low during this period. In autumn, however, new leaf blade formation in perennial turfgrasses declines as the onset of winter dormancy begins. During this time, N storage as NO_3 increases since the amount of N assimilated into leaf proteins is reduced because overall leaf formation declines. A measure of this NO_3 pool could be useful in the N fertilizer management of turfgrasses.

Nitrate-N concentrations in plant tissues are typically measured on a dry weight basis, which entails the drying and grinding of samples prior to extraction and analysis. The availability of field-use plant sap NO_3 meters has provided an alternative to drying and grinding of samples, which is a time-consuming process and delays results. In other horticulturally important crops such as potatoes, cotton, and numerous vegetables, sap is expressed from fresh plant parts and analyzed directly for NO_3 or NO_3–N. This then serves as a guide for N fertilization based on previous calibration studies with those crops.

There are limited data that report on NO_3–N concentrations in turfgrass clippings across the growing season. Therefore, the objective of this study was to determine the relationship between clippings sap NO_3–N concentrations and Normalized Difference Vegetative Index (NDVI) and Dark Green Color Index (DCGI) of turfgrasses throughout the growing season in Connecticut. These reflectance readings serve as a measure of turfgrass color. If a relationship exists, this may be useful in guiding N fertilization.

MATERIALS & METHODS

This study was conducted during May through November 2019 on two separate cool-season turfgrass stands—Kentucky bluegrass (*Poa pratensis*) (KBG) and tall fescue (*Festuca arundinacea*) (TF) —established on a fine sandy-loam soil. The experiments were set out as randomized complete block designs with three replicates for each species. Plot size was 1.83 × 3.05 m. Stands were fertilized every month from May through November with 11 N application rates (0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 kg N ha^{-1}) using a 25-0-10 N–P–K fertilizer with 60% slow-release N. Fertilizer was applied in the first week of each month. Two to three weeks after fertilizer application, NDVI of each plot was measured with a TCM500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Aurora, IL) and FieldScout GreenIndex+ mobile app (version 2.0) (Spectrum Technologies, Inc., Aurora, IL) running on an Apple iPad to determine DGCI.

After reflectance readings, clipping samples were collected from each plot by using a Toro Personal Pace Recycler mower (The Toro Company, Bloomington, MN) with a bagger set at a mowing height of 57 mm. Fresh clipping samples were placed in a hydraulic plant sap press (Spectrum Technologies, Inc., Aurora, IL) to expel the sap. The sap was placed into the sample well of a LAQUA Twin Nitrate Meter (Spectrum Technologies, Inc., Aurora, IL), and measurements were made for concentrations of NO_3–N. Measurements for all dates were taken between 1030 and 1600 hr. The clippings collection and sap NO_3–N readings were conducted one block at a time. The meter was recalibrated after all the plots in each block (11 samples) were measured. The electrode membrane surface was rinsed with deionized H_2O and dried between each measurement.

Mean clippings sap NO_3–N concentrations were analyzed for treatment differences (N rates and dates) by using analysis of variance of a repeated-measures model with date as the repeated measure by using the MIXED procedure of SAS 9.4 (SAS Institute, Cary, NC). The relationship between clippings sap NO_3–N concentrations and N rate was modeled with a simple linear regression using the REG procedure in SAS.

RESULTS & DISCUSSION

Monthly Clippings Sap Nitrate-N Concentrations

Across the growing season, clippings sap NO_3–N concentrations were relatively low and stable for both species during May, June, and July (Fig. 1). Significant ($P < 0.05$) differences among N rate treatments within each month were not observed until September in KBG and August in TF. Accumulation of NO_3 was greatest from September to November and greater for the higher N rates. Averaged across N rates, monthly sap NO_3-N concentrations were greatest for November followed by October in both species (Fig. 2). The greatest rates of increase for sap NO_3–N concentrations across N rates was observed for November and October, followed by September, for both species (Fig. 3 and Table 1).

The lower clippings sap NO_3–N concentrations at the beginning and middle of the growing season were probably a result of active leaf growth in late spring and summer months that assimilated a large amount of NO_3 within plant. Whereas, a rapid accumulation of NO_3 at the end of the growing season in September to November was most likely attributed to a decline in leaf growth and more storage of NO_3 at the onset of winter dormancy. The sap NO_3–N concentration dynamics in the growing season could be divided into two different phases: the stable phase (May–July/August), and accumulation phase (August/September–November).

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Across the entire growing season for KBG and TF, clippings sap NO_3–N concentrations showed considerable variation within each N rate. However, significant ($P < 0.05$) linear increases were observed in each month as N rates increased, except in June and July for KBG and June for TF (Fig. 3 and Table 1). Slopes of the regression model were lower in the stable phase (May–July/August) when compared to the greater slope values in the accumulation stage (August/September–November) (Table 1).

Response of NDVI and DGCI as a Function of Clippings Sap Nitrate-N Concentrations

For both species, NDVI and DGCI increased linearly ($P < 0.05$) in relation to clippings sap NO_3–N concentration from August through November, except for KBG DGCI in September (Fig. 4 and Table 1). The lack of a response during May–July was most likely attributed to the rapid assimilation of NO_3 into leaf proteins during this period, leading to a stable concentration of NO_3–N. Whereas, the accumulation of NO_3 from August through November suggests less conversion of NO_3 to leaf proteins and a more defined relationship could be observed. The distinct accumulation of NO_3 during August/September–November, and the relationship to turf canopy reflectance may offer potential in using this relationship to guide fall N fertilization of cool-season turfgrass.

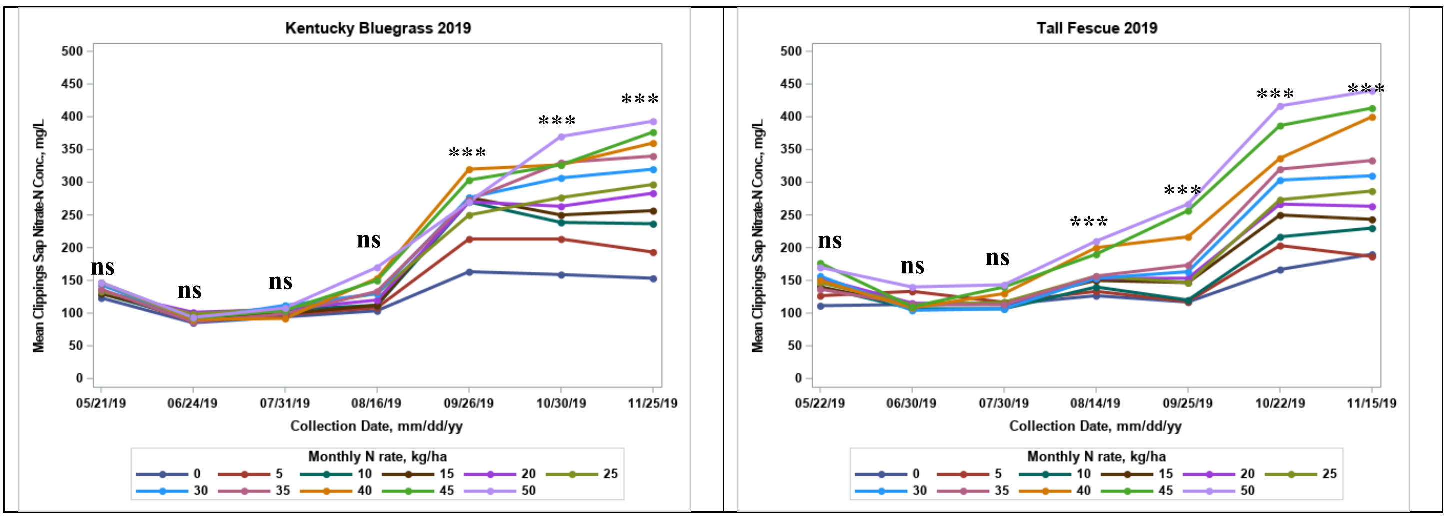

Fig. 1. Mean clippings sap NO_3–N concentrations for each N rate across the monthly sampling dates. Significance of the *F*-test for differences of N rate means within each date: ns, not significant; *, *P* <0.001.**

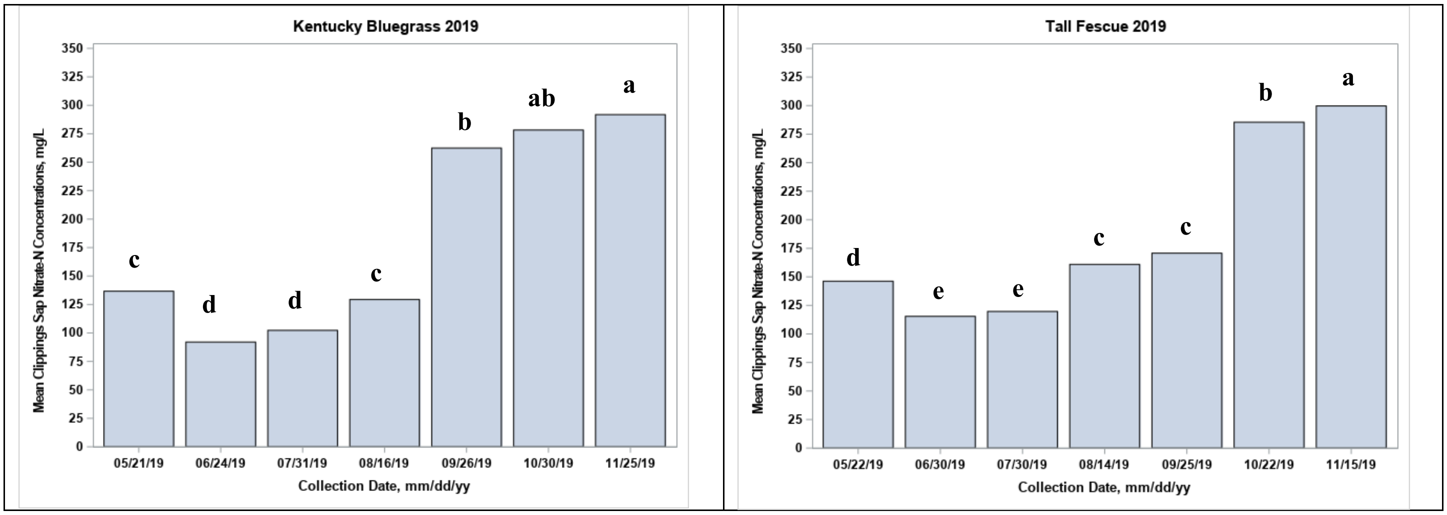

Fig. 2. Mean clippings sap NO_3–N concentrations for each monthly sampling date averaged across N rates. Means with the same letters within each species are not different according to Fisher's Protected LSD (α=0.05).

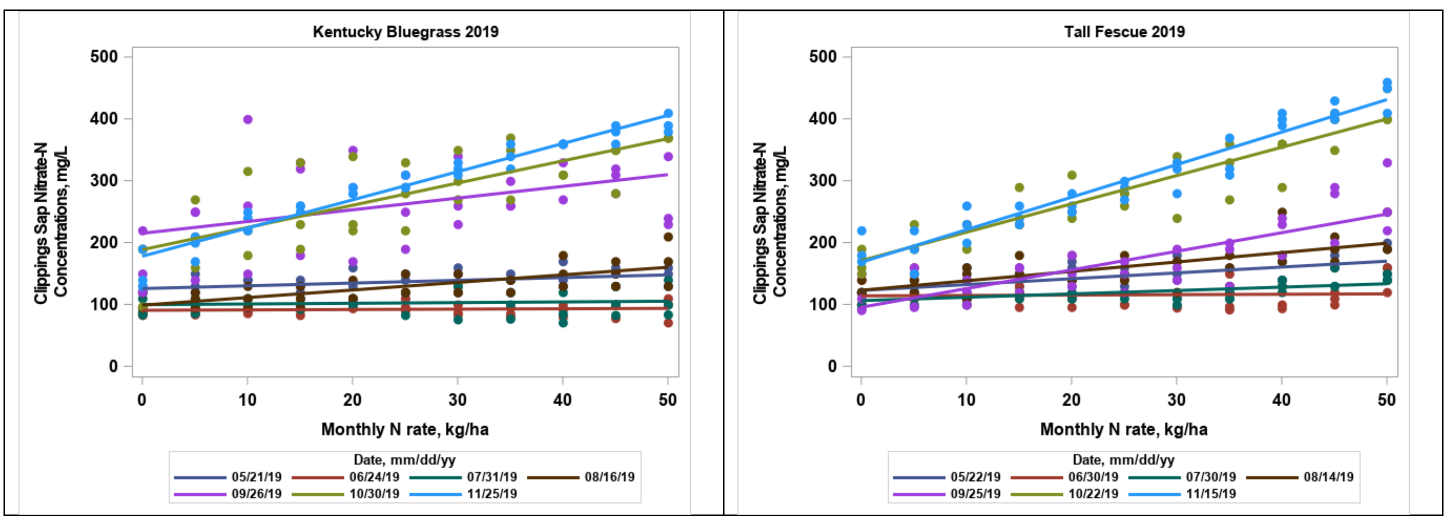

Fig. 3. Linear response of clippings sap NO_3–N concentrations for each sampling date as a function of N rate. Model statistics and coefficients are presented in Table 1.

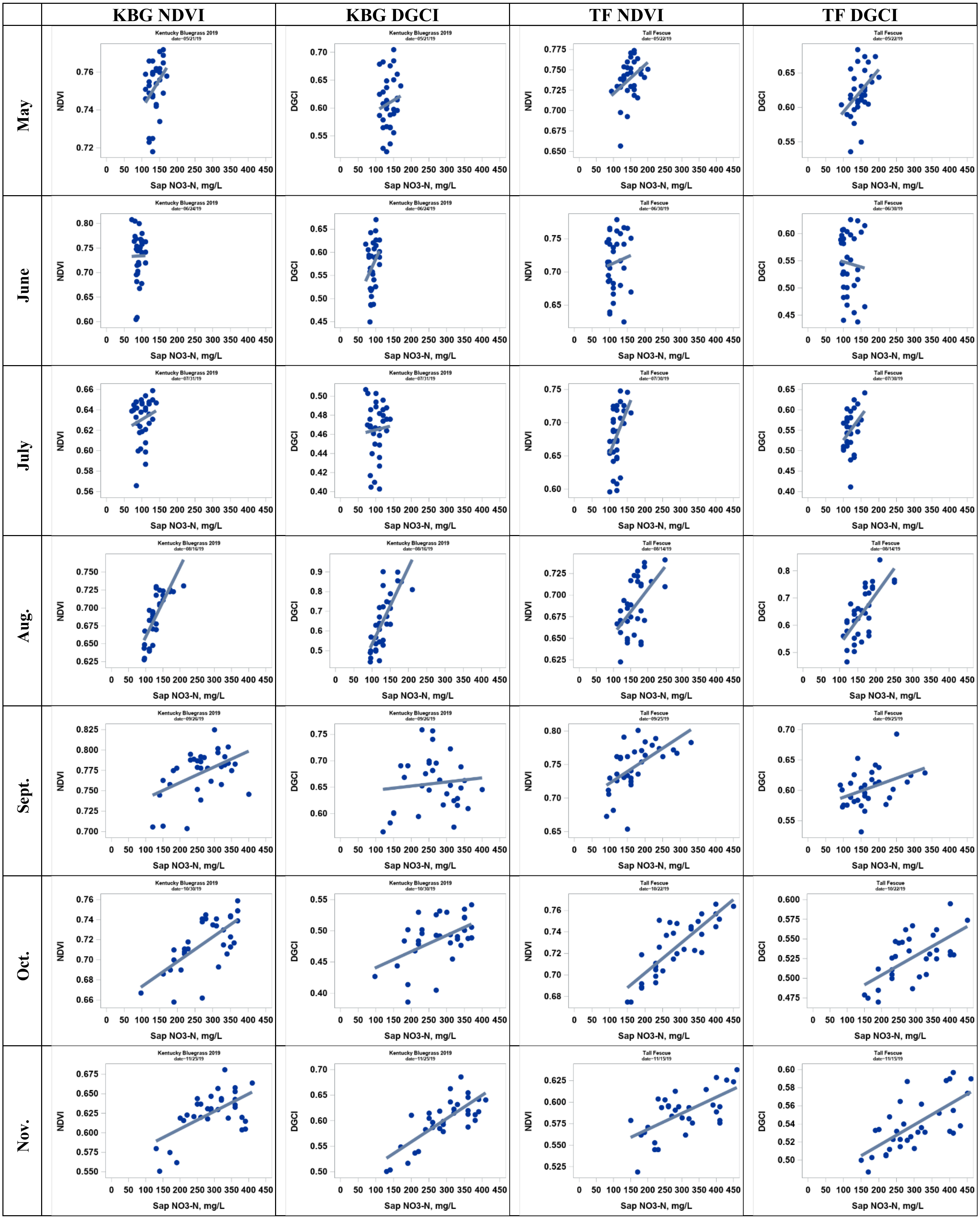

Figure 4. Response of monthly Kentucky bluegrass (KBG) and tall fescue (TF) NDVI and DGCI readings as function of clippings sap nitrate-N concentrations.

Table 1. Model coefficients and statistics for Kentucky bluegrass (KBG) and tall fescue (TF) sap NO_3–N concentrations as a function of N rates, and NDVI and DGCI responses to sap NO_3–N concentrations, 2019.

	Month						
	May	June	July	Aug.	Sept.	Oct.	Nov.
KBG Sap NO_3–N vs. N rate, Fig. 3							
Intercept	125.61	90.45	99.53	98.71	215.00	188.47	177.88
Slope	0.4424	0.0618	0.1109	1.2261	1.897	3.5921	4.5576
r^2	0.1892	0.0099	0.0100	0.5503	0.1891	0.6133	0.9452
P value	0.0114	0.5826	0.5792	<0.0001	0.0114	<0.0001	<0.0001
TF Sap NO_3–N vs. N rate, Fig.3							
Intercept	122.55	113.80	106.06	122.88	95.38	170.91	168.18
Slope	0.9455	0.0636	0.5455	1.5212	3.0139	4.5818	5.2606
r^2	0.4062	0.0026	0.3665	0.5041	0.6695	0.8548	0.9232
P value	<0.0001	0.7789	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
KBG NDVI vs. Clippings Sap NO_3–N, Fig.4							
Intercept	0.710	0.730	0.610	0.562	0.722	0.649	0.560
Slope	0.00031	0.00004	0.00021	0.00098	0.00019	0.00025	0.00022
r^2	0.1292	0.0001	0.0309	0.6092	0.2308	0.4759	0.3633
P value	0.0400	0.9636	0.3278	<0.0001	0.0047	<0.0001	0.0002
TF NDVI vs. Clippings Sap NO_3–N, Fig.4							
Intercept	0.6825	0.6866	0.5190	0.6031	0.6874	0.6471	0.5309
Slope	0.00038	0.00024	0.00134	0.00052	0.00035	0.00027	0.00019
r^2	0.1406	0.0127	0.2023	0.3115	0.3484	0.6877	0.4021
P value	0.0315	0.5326	0.0086	0.0007	0.0003	<0.0001	<0.0001
KBG DCGI vs. Clippings Sap NO_3–N, Fig.4							
Intercept	0.556	0.418	0.455	0.143	0.637	0.415	0.467
Slope	0.0004	0.0017	0.0001	0.0039	0.0001	0.0003	0.0005
r^2	0.0176	0.0967	0.0036	0.5762	0.0117	0.2558	0.6063
P value	0.4616	0.0782	0.7394	<0.0001	0.5489	0.0027	<0.0001
TF DCGI vs. Clippings Sap NO_3–N, Fig.4							
Intercept	0.5317	0.5676	0.4068	0.3406	0.5676	0.4544	0.4706
Slope	0.00062	-0.00019	0.00119	0.00187	0.00021	0.00025	0.00023
r^2	0.1884	0.0046	0.1284	0.4952	0.1720	0.4165	0.4693
P value	0.0116	0.7068	0.0406	<0.0001	0.0164	<0.0001	<0.0001

SUMMARY

The results for 2019 suggest that clippings sap NO_3–N concentrations are relatively stable during the active leaf growing periods of the growing season (May–July/August). However, commencing at the onset of winter dormancy preparation, clippings sap NO_3–N concentrations significantly increase from August/September to November.

The data also suggests that NDVI and DGCI are correlated to clippings sap NO_3–N concentrations, and could potentially serve as a guide to N fertilization.

GREENHOUSE GAS EMISSIONS AND SOIL LABILE N AND C CONCENTRATIONS FROM URBAN GRASSLAND LAWNS FERTILIZED WITH SYNTHETIC AND ORGANIC NITROGEN FERTILIZER SOURCES, 2019

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INTRODUCTION

The three most consequential greenhouse gases in turfgrass systems are carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4). CO_2 is emitted from landscapes at much higher rates than N_2O and CH_4, but the warming potential of N_2O and CH_4 is 15 to 70 and 200 to 300 times greater than CO_2, respectively. Managed turfgrass areas have shown potential for high soil C sequestration, but the emission of greenhouse gases from these fertilized landscapes may offset sequestration. The addition of N fertilizers to turfgrass has shown to increase the amount of N_2O emissions compared to non-fertilized turfgrass (Maggiotto et al., 2000). However, the emission of N_2O from fertilized turfgrass soils may vary by source of N. While several studies have evaluated greenhouse gas emissions from synthetic fertilizers, there are limited data that report on organic N fertilizer sources and no studies have compared greenhouse gas emissions between urban grassland lawns fertilized with slow-release synthetic and organic N sources.

The common perception that organic fertilizers are less harmful to the environment than synthetic fertilizers has led to an increasing use of organic amendments in turfgrass systems, including organic sources of N. Currently, synthetic fertilizers are the most commonly used N source for managed turfgrasses. As more people begin to switch to organic fertilizers, it is important to quantify and compare the greenhouse gas emissions from the soils of turf fertilized with organic and synthetic fertilizers.

Another common perception is that synthetic fertilizers are more harmful to beneficial microbial populations in the soil than organic fertilizers. Studying the differences in microbial populations between soils fertilized with organic and synthetic fertilizers will provide insight into how these inputs affect soil health. Solvita® & Woods End Laboratories provide two kits that easily allow for testing the biologically-active C and N fractions in soil organic matter: Soil CO_2-Burst (SCB) and Soil Labile Amino Nitrogen (SLAN) tests. These tests measure labile C and N, which are correlated to the soil microbial activity.

The objective of this study was to determine how synthetic and organic fertilizers influence greenhouse gas emissions and soil labile C and N concentrations of turfgrass lawns.

MATERIALS & METHODS

This field study was conducted during June through October 2019 at the Plant Science Research and Education Facility in Storrs, CT on an existing tall fescue (*Festuca arundinacea*) turf that was established in September 2007. The experiment was set out as a randomized complete block design with three replications. Plot size was 1 x 1 m. Plots were fertilized once in June and October with either a slow-release synthetic fertilizer (ProSeries 25-0-12) or an all-natural organic fertilizer (Suståne 5-2-4). A non-fertilized control plot was also included in this study. Plots have received the same treatments yearly since 2008 (with the exception of 2010). Fertilizers were applied at four rates (50, 100, 150, and 200 kg N ha^{-1}) in equal split applications in June and October. Plots were mowed to a 3-inch height twice a week during the growing season and clippings were returned. In May 2019, Barricade was applied to prevent the germination of grassy weeds and Acelepryn was applied to control white grubs.

CO_2, N_2O, and CH_4 emissions were measured once a month using the static chamber method (Livingston and Hutchinson, 1995) with a modification in chamber design as described by Morse et al. (2012). PVC collars were placed in the soil of each plot and remained there in order to minimize soil disturbance. On the day of sampling, PVC chambers were positioned into the soil collars and a gas sample was collected immediately, then again 30 and 60 minutes later. Gas samples were collected using a gas tight syringe through septa on the chambers. Gas samples were immediately injected into a 22 mL pre-evacuated gas vial after sampling. At the time of sampling, air temperature, barometric pressure, soil temperature and moisture at 10 cm, and chamber height were recorded.

Gas samples were taken to the laboratory and injected by a PerkinElmer TurboMatric 40 Trap headspace sampler into a PerkinElmer Clarus 580 gas chromatograph. The gas chromatograph uses a flame ionization detector and a Model Arnel methanizer to quantify CO_2 and CH_4 concentrations and an electron capture detector to measure N_2O. Concentrations of the gases were calculated in units of ppmv by comparing the chromatograph areas of samples to known standards.

Gas fluxes were calculated according to Helton et al. (2014) and Morse et al. (2012). Emissions for each gas were determined by calculating the slope of the regression between gas concentration and time over the one-hour incubation. Measurements of barometric pressure and temperature taken at the time of sampling were used with the ideal gas law to calculate in units of mass (mg m^{-3}) in R 3.6.1 (R Core Team 2014). The minimum detectable concentration difference (MDCD) was calculated for each gas (Yates et al., 2006) and all fluxes less than the MDCD were set equal to zero. The slope (mg m^{-3} hr^{-1}) was used to calculate emissions for any gas flux over the MDCD and had an $r^2 > 0.85$. One slope was non-linear with an $r^2 < 0.85$ so the third time point was dropped. Chamber heights were used to convert gas flux to units of mg m^{-2} hr^{-1}.

Soil samples were collected two weeks pre- and post-fertilizer applications in June and October. Ten samples, each 10 cm deep, were collected from each plot. Soil augers were washed and wiped down with 70% ethanol between sampling of each

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plot. Soil samples were placed into a −20˚C freezer. After passing samples through a 1-mm sieve, soil was analyzed with the SCB test for all dates and SLAN test for the two-week post-fertilization dates.

Greenhouse gas (CO_2, CH_4, and N_2O) gas flux (mg m^{-2} hr^{-1}) and soil SCB and SLAN concentration means were analyzed for treatment differences (treatment versus control, fertilizer type, fertilizer rate, and fertilizer type × fertilizer rate interaction) by using analysis of variance with Fisher's LSD for mean separation in the GLIMMIX procedure of SAS 9.4 (SAS Institute, Cary, NC).

RESULTS & DISCUSSION

Differences in greenhouse gas emissions for treatment versus control, fertilizer type, fertilizer rate, and fertilizer type × fertilizer rate interaction effects were not significant across the growing season ($P > 0.05$). CO_2 gas emissions were greatest in June and July and dropped throughout the season (Fig. 1). This is consistent with previous data showing higher concentrations of CO_2 emitted in turfgrass areas during warmer seasons (Groffman et al., 2006). The results from the 2019 growing season gas collection suggest that there is high variability within the data for CO_2 gas flux. Control plots with no fertilizer added to the turf showed high variability in CO_2 emissions relative to the treated plots between months (Fig. 1). The plots with organic fertilizer applications showed no statistical difference to plots that received slow-release synthetic fertilizer applications with respect to CO_2 emissions across all months. Most of the treatments had non-detectable concentrations of N_2O gas, with the exception of the first month of sampling (Fig. 2). CH_4 concentrations were also mostly non-detectable. The plots that did result in detectable concentrations showed a net intake of CH_4 by the soil (Fig. 3).

The results from this study also show that there is no significant difference between the fertilizer types or rates for either the SCB or SLAN tests ($P > 0.05$). There is a significant difference between the control and all treatments for the SCB June pre-fertilization date and the SLAN June post-fertilization date. There is also a significant fertilizer type × fertilizer rate interaction for the SCB October post-fertilization date and the SLAN June post-fertilization date (Table 1). The SCB and SLAN interactions indicate that there is no significant difference between the organic fertilizers for all rates, but there is a significant difference for the synthetic fertilizer between rates. However, these results are not consistent between all dates.

Overall, these results suggest that the addition of organic versus slow-release synthetic fertilizer to turfgrass lawn stands does not result in significantly different soil N and C mineralization or greenhouse gas emissions.

Table 1. Mean Solvita soil test concentrations in relation to treatments and analysis of variance *P* values.

	CO_2-Burst				SLAN	
	6/10/19	**6/26/19**	**10/8/19**	**10/22/19**	**6/26/19**	**10/22/19**
Fertilizer Type	mg kg^{-1}					
Control	43.1	78.7	59.5	83.3	112.5	159.1
Slow-release synthetic	66.2	88.9	71.8	95.8	147.0	154.9
Organic	65.6	74.9	69.4	84.1	136.8	167.9
Fertilizer Rate (kg N ha^{-1})						
0	43.1	78.7	59.5	83.3	112.5	159.1
50	64.2	72.1	66.6	83.8	147.0	169.5
100	64.3	92.5	74.7	103.8	146.5	147.3
150	74.0	87.9	68.8	85.8	128.0	168.7
200	62.7	75.0	71.9	84.6	142.9	162.5
Source of Variation	*P* values					
Treatments vs. Control	0.0143	0.8725	0.0880	0.7456	0.0208	0.3530
Fertilizer Type	0.8334	0.1175	0.3003	0.5876	0.4130	0.8547
Fertilizer Rate	0.4200	0.2568	0.1741	0.9257	0.2311	0.5743
Type × Rate	0.7965	0.3175	0.3048	0.0158	0.0088	0.5319

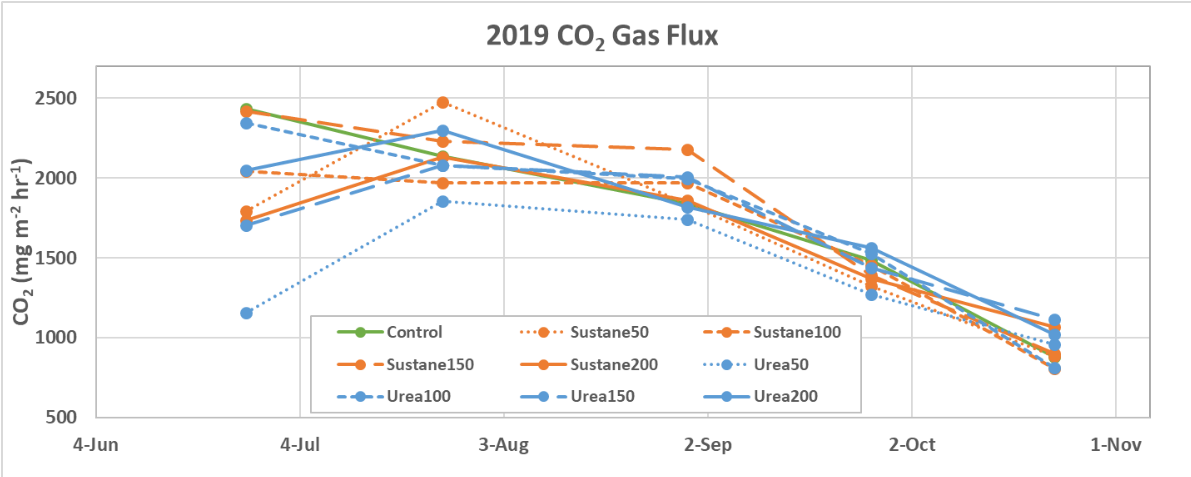

Figure 1. Responses of mean CO_2 gas emissions (mg m^{-2} hr^{-1}) for each fertilizer type (control, Suståne, and Urea) and rate (0, 50, 100, 150, and 200 kg N ha^{-1}) across the monthly sampling dates.

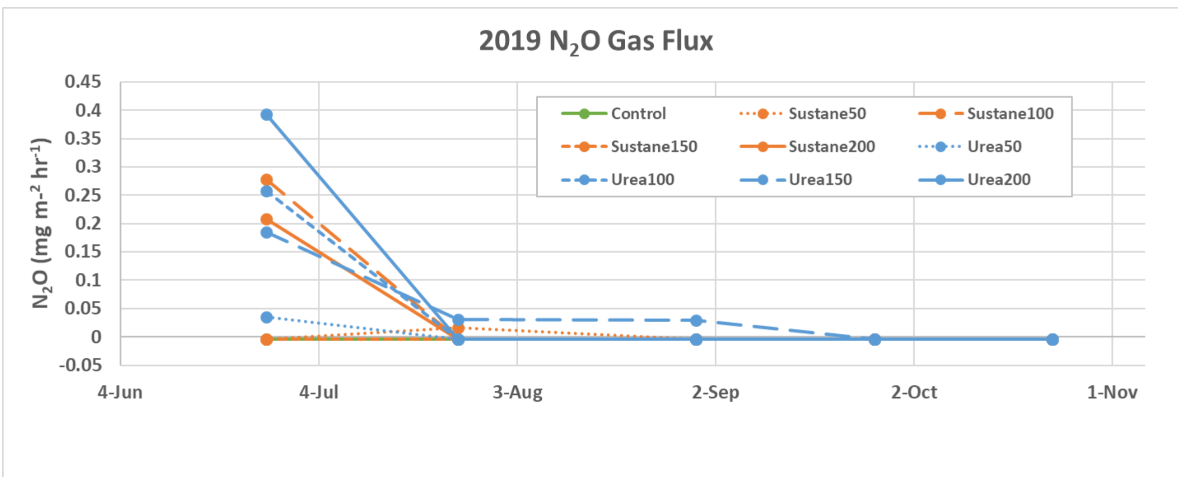

Figure 2. Responses of mean N_2O gas emissions (mg m^{-2} hr^{-1}) for each fertilizer type (control, Suståne, and Urea) and rate (0, 50, 100, 150, and 200 kg N ha^{-1}) across the monthly sampling dates.

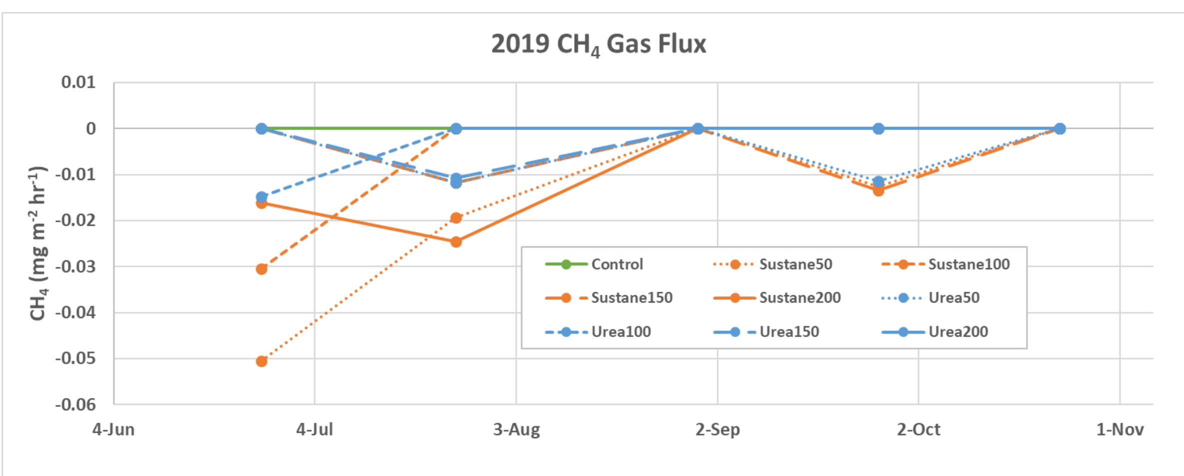

Figure 3. Responses of mean CH_4 gas emissions (mg m^{-2} hr^{-1}) for each fertilizer type (control, Suståne, and Urea) and rate (0, 50, 100, 150, and 200 kg N ha^{-1}) across the monthly sampling dates.

SUMMARY

Despite the perception by many that synthetic fertilizers are more harmful to the environment than organic fertilizers, the first year results of this study suggests that the greenhouse gas emissions and soil N and C mineralization are not significantly different between a tall fescue turf field fertilized with slow-release synthetic fertilizer and organic fertilizer. The data also suggests that the rate at which the fertilizer is applied does not produce significantly different gas flux or SCB and SLAN concentration results.

These results will provide some preliminary data to assist turf practitioners, as well as policy makers and regulators, on deciding what types of N fertilizers to use to help minimize greenhouse gas emissions and detrimental soil health practices.

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SOLVITA SOIL TEST KITS TO CATEGORIZE GOLF COURSE FAIRWAY RESPONSIVENESS TO NITROGEN FERTILIZATION - 2019

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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 grow-in period. Full implementation of the treatments and data collection commenced in 2018.

Beginning in the spring 2018, and continuing through 2019, 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 November from each plot. 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

Significant treatment effects are presented in Table 1. Traffic effects were significant for NDVI, visual quality, visual color, visual density, percentage green cover, DGCI, and clipping yields with higher values for the no traffic plots. Fertilizer treatment effects were significant for SLAN, SCB, NDVI, visual quality, color, and density, percentage green cover, DGCI, and clipping yields. Additionally, there was a significant traffic × rate interaction for SLAN and clippings yield. Generally, responses from the lower organic rates were significantly lower than the standard treatment for the visual measurements, whereas, visual ratings from four or five of the highest organic rates were not significantly different than the standard treatment. For SLAN and SCB, the zero control rate was significantly lower than the standard, while the five highest organic rates were significantly higher than the standard.

Across the 2019-growing season and for both traffic treatments, significant ($P > 0.05$) logistic regression responses for SLAN and SCB concentrations were observed for all variables except cover and DGCI for SLAN concentrations in the trafficked plots (Fig. 1). When all variables were combined, there were no differences in the probability curves generated from the traffic treatments (Fig. 2). For both Traffic and No-Traffic treatments combined, there was a ≥ 67% chance that the bentgrass responses across all variables would equal or exceed the response of the Standard fertilizer treatment when SLAN–N concentrations were ≥ 314 mg kg^{-1} and SCB–C concentrations were ≥ 163 mg L^{-1} (Fig. 2).

The results from 2019 suggest that the Solvita SLAN and SCB tests can be used to categorize the mineralization potential of creeping bentgrass fairway soils and, therefore, their expected response to N fertilization (Table 2 and Fig. 2). With these benchmark concentrations, generalized N fertilizer recommendations are proposed for creeping bentgrass fairways:

SLAN or SCB at $P < 0.33$, full Standard N rate.
SLAN or SCB at $P = 0.33 \leq 0.67$, ⅔ to ½ of Standard N rate.
SLAN or SCB at $P = 0.67 \leq 0.90$, ½ to ⅓ Standard N rate.
SLAN or SCB at $P > 0.90$, little to no N.

Table 1. Mean Solvita soil test concentrations and bentgrass quality and growth responses for 2019 growing season, with analysis of variance (AOV) *P* values.

	SLAN–N	SCB–C	NDVI	Visual Quality	Visual Color	Visual Density	Cover	DGCI	Sum Clippings yield
Traffic	mg kg^{-1}	mg kg^{-1}					% green		g m^{-2}
No	255.7	127.8	0.692	6.7	6.9	6.9	85	0.486	49.5
Yes	255.9	130.0	0.682	6.0	6.3	6.1	80	0.471	22.9
Treatment†									
0	226.8*	104.5*	0.660*	4.7*	5.3*	5.1*	73	0.461	21.1*
0.25	238.7	118.9	0.672*	5.1*	5.7*	5.5*	79	0.467	27.5
0.50	238.5	120.2	0.684	5.6*	6.0*	5.8*	82	0.473	31.2
0.75	246.6	123.8	0.685	6.0*	6.1*	6.2*	83	0.476	31.2
1.00	250.8	125.5	0.684	6.4*	6.4*	6.4*	83	0.476	31.1
1.25	256.0*	133.4*	0.692	6.4*	6.8*	6.6	84	0.482	41.3
1.50	261.0*	138.0*	0.692	6.6	6.7*	6.8	85	0.487	41.4
1.75	271.0*	140.8*	0.696	7.0	7.1	7.1	86	0.487	46.7*
2.00	282.5*	141.6*	0.698	7.3	7.3	7.3	86	0.488	44.4*
2.25	299.7*	149.2*	0.702	7.6	7.7	7.5	86	0.491*	48.9*
Standard	242.3	121.8	0.694	7.1	7.7	7.3	82	0.475	33.4
				AOV *P*-values					
Traffic	0.8389	0.3905	0.0294	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0023
Treatment	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0114	0.0001	<0.0001
T × T	0.0089	0.1578	0.4701	0.2794	0.9522	0.5262	0.2726	0.5704	0.0310

* 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 0.2 lbs N per 10000ft^2 every 21 days.

Table 2. Proposed categories of creeping bentgrass fairway soils in relation to SLAN-N and SCB-C concentrations and probability of response equaling or exceeding that of the Standard N fertilizer treatment response.

P Value	SLAN-N, mg kg^{-1}	SCB-C, mg L^{-1}	Category of response in relation to Standard fertilizer treatment
≤ 0.33	< 231	< 116	Very Low to Low
0.33 ≤ 0.67	231 ≤ 314	116 ≤ 163	Low to Moderate
0.67 ≤ 0.90	314 ≤ 402	163 ≤ 211	Moderate to High
> 0.90	> 402	> 211	High to Very High

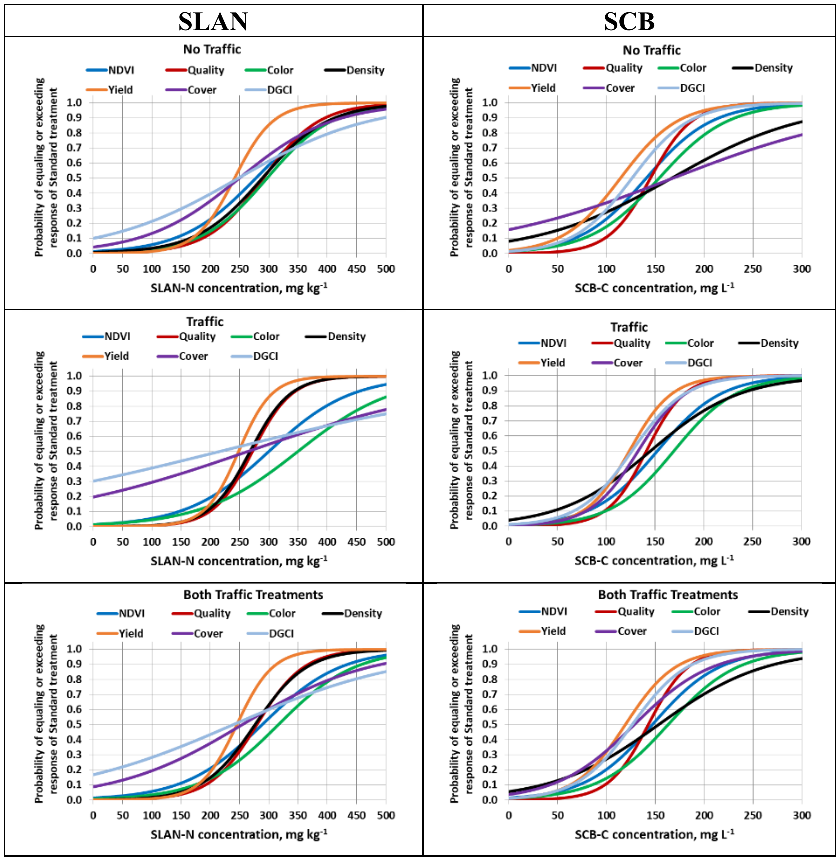

Fig. 1. Probability curves of equaling or exceeding the NDVI, visual quality, visual color, visual density, clippings yield, percent green cover, and DGCI response of the Standard fertilizer treatment in relation to the Solvita SLAN–N and SCB–C concentrations for the No-Traffic and Traffic plots, and when both traffic treatments are combined.

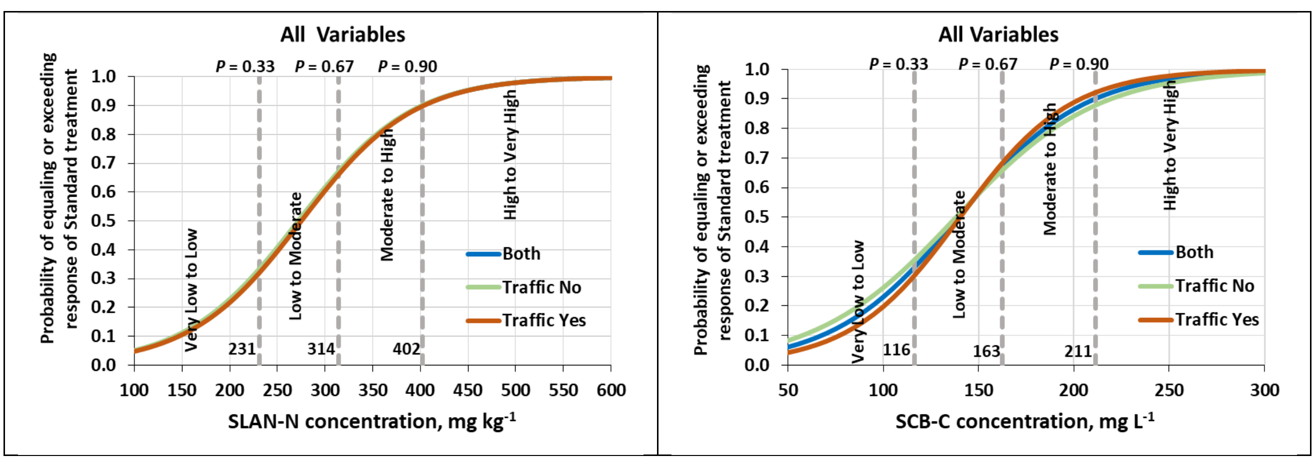

Fig. 2. Probability curves of equaling or exceeding the response of the Standard fertilizer treatment in relation to the Solvita SLAN–N and SCB–C concentrations for the No-Traffic and Traffic plots, and when all variables are combined across both traffic treatments.

SUMMARY

After the Second complete season of full treatments imposition in 2019, the results suggest that SLAN–N and SCB–C concentrations show promise in predicting bentgrass fairway quality and growth responses equally well for both no trafficked and trafficked plots. Fairway creeping bentgrass growth and quality responses are moderately to strongly correlated to SLAN–N and SCB–C test concentrations. Across all variables, there was little difference in the probability curves for trafficked and non-trafficked treatments, suggesting that these tests are reliable under varying traffic conditions in creeping bentgrass fairways. It is expected that differences should become even more apparent in the 3rd year of the study with more mineralization.

The 2019 results suggest that fairway creeping bentgrass soils can be categorized with Solvita tests as their probability of equaling or exceeding the response of a standard N treatment, and this can be used to guide N fertilization. We are also currently working on guidance tables that superintendents can use to adjust their standard N rates to creeping bentgrass fairways based on Solvita test results.

NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP) 2018 NATIONAL TALL FESCUE TEST – 2019 RESULTS

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INTRODUCTION

Turf-type tall fescue has become a significant turfgrass species of golf, sod, sports turf and landscape professionals. Characteristics that make turf-type tall fescue desirable are: improved wear tolerance, shade tolerance, improved dark green color, and lower fertility requirements compared to Kentucky bluegrass and perennial ryegrass. Turf-type tall fescue also exhibits excellent drought avoidance characteristics. When developing turfgrass seed mixtures that are more environmentally sustainable in order to reduce inputs such as fertilizer and water, turf-type tall fescue can be a good alternative.

The National Turfgrass Evaluation Program (NTEP) is sponsored by the Beltsville Agriculture Research Center and the National Turfgrass Federation Inc. NTEP works with turfgrass breeders and has designated evaluation sites throughout the United States to assess and rate turfgrass species and cultivars. Results from turfgrass evaluations can aid professionals in their selection of turfgrass species/cultivars that best meet their needs. Evaluation results also aid breeders and seed companies in the development, selection and marketing of new turfgrass cultivars. In 2018 NTEP selected eighteen standard testing sites and ten ancillary test locations for their 2018 Turf-type Tall Fescue Test. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected as a standard site for the 2018 Turf-type Tall Fescue Test. This NTEP trial will continue for five years. 2019 was the first year of the 2018 Turf-Type Tall Fescue test.

MATERIALS AND METHODS

One hundred thirty-two cultivars of Turf-type tall fescue were seeded on September 21, 2018 at the Plant Science Research and Education Facility in Storrs, CT. 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
Once established, all plots and cultivars received the same management protocol throughout the study. Management practices for 2019 were as follows:

<u>Mowing</u> - Plots were maintained at a mowing height of 2.75 inches and mowed two times per week. Clippings were returned.
<u>Irrigation</u> – In 2019, irrigation of this trial was applied as needed. Supplemental irrigation in the fall of 2018 during establishment was not needed.

On September 25, 2018, there was a 6" rain event in Storrs at the Plant Science Research Facility. Additional rain events delayed removal of the Remay fabric that covered the trial and subsequent maintenance of the plots. Once the cover was removed, seed migration was noted within each plot. Left over seed for each cultivar was weighed and equal amounts of seed for each entry were applied to the appropriate plots on April 24, 2019. The initial mowing of the trial did not occur until April 2019. The first Quality Rating occurred in June 2019. Therefore, no Spring Green up, Genetic Color Rating or Leaf Texture Rating occurred in 2019. Repeated applications of Tenacity were necessary to reduce *Poa annua* in the plot area.

Fertilizer and Pesticide Applications for 2019
Pre-emergent (Tenacity) was applied (6 times) during the growing season on 5/3/19, 5/24/19, 6/14/19, 7/5/19, 7/25/19, 8/8/19 - Rates were: 5 fl oz /A, 2 fl oz /A, 2 fl oz /A, 2 fl oz/A, 2 fl oz/A, 2 fl oz/A, respectively.
Broadleaf
9/13/19 – T Zone 1.3 fl oz/m

Fertilizer
4/19/19 - .25#N/m, Ammonium sulfate, sprayed with multi-pro
5/2/19 - 1# N /1,000 ft^2, 16-28-12, 30% SCU
6/5/19 – 1#N / 1,000 ft^2, 30-0-6, 50%SCU
8/28/19 – 1#N / 1,000 ft^2, 30-0-6, 50%SCU
10/1/19 – 1#N / 1,000 ft^2, 30-0-6, 50%SCU

2019 was the first year of recording data for the Turf-Type Tall Fescue Test. Ratings taken and recorded were:

Establishment Ratings
Plots were seeded on September 21, 2018. Establishment ratings were taken on October 19, 2018 and are referenced in Table 2.

Quality Ratings
Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2019 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 monthly quality ratings are provided in Table 2.

A few general observations noted were: mean quality values for overall quality continue to illustrate that there is little diversity between cultivars. PPG – TF-336, (Mountain View Seeds) had the highest mean quality ratings for the 2019 growing season. However, when comparing the mean values for overall quality, there were no significant differences between PPG-TF-336 and the next 53 cultivars. Kentucky 31 exhibited the poorest overall turf quality.

Table 1- Sponsors and Entries			
SPONSOR	**ENTRY**	**SPONSOR**	**ENTRY**
Allied Seed LLC	AST8118LM	DLF Pickseed USA	DLFPS-321/3702
Allied Seed LLC	AST8218LM	DLF Pickseed USA	DLFPS-321/3703
Allied Seed LLC	A-TF31	DLF Pickseed USA	DLFPS-321/3705
Barenbrug Research	BAR 9FE MAS	DLF Pickseed USA	DLFPS-321/3706
Barenbrug Research	BAR FA 8228	DLF Pickseed USA	DLFPS-321/3707
Barenbrug Research	BAR-TF-134	DLF Pickseed USA	DLFPS-321/3708
Barenbrug Research	BAR-FA8230	Grassland Oregon Seed	GO-RH20
Berger International	BGR-TF3	Grassland Oregon Seed	Burmingham
Brett Young	BY-TF-169	Grassland Oregon Seed	GO-AOMK
Brett Young	PST-5BYOB	Integra Turf, Inc.	PPG-TF 244
Brett Young Seeds	AH2	Integra Turf, Inc.	PPG-TF 305
Burlingham Seeds	Firehawk SLT	Integrated Seed Growers	ProGold
Burlingham Seeds	Bullseye LTZ	Integrated Seed Growers	Moondance
Burlingham Seeds	Turbo SS	Jacklin Seed by Simplot	JT-517
Burlingham Seeds	Dragster	Jacklin Seed by Simplot	JS-DTT
Carlton Seed Co.	Naturally Green	Jacklin Seed by Simplot	JT 233
Columbia Seeds	COL-TF-148	Jacklin Seed by Simplot	JT 268
Columbia Seeds	NAI-3N2	Lakeside Ag. Ventures	NAI-FQZ-17
Columbia Seeds	NAI-TUE	Landmark Turf & Native Seed	AH1
Columbia Seeds	PPG-TF-313	Landmark Turf & Native Seed	PPG-TF-249
Columbia Seeds	PPG-TF-323	Landmark Turf & Native Seed	PPG-TF-262
Columbia Seeds	PPG-TF-338	Landmark Turf & Native Seed	PPG-TF-267
Criadero El Concerro SA	FC15-01P	Landmark Turf & Native Seed	NAI-ROS4
DLF Pickseed USA	DLFPS-321/3693	Landmark Turf & Native Seed	NAI-ST5
DLF Pickseed USA	DLFPS-321/3694	Lebanon Seaboard Corp.	LTP-TF-122
DLF Pickseed USA	DLFPS-321/3695	Lebanon Seaboard Corp.	LTP-TF-111
DLF Pickseed USA	TMT1	Lewis Seed Co.	PPG-TF 316
DLF Pickseed USA	RS1	Mountain View Seeds	PPG-TF-238
DLF Pickseed USA	DLFPS-TF/3550	Mountain View Seeds	PPG-TF-254
DLF Pickseed USA	DLFPS-TF/3552	Mountain View Seeds	PPG-TF-308
DLF Pickseed USA	DLFPS-TF/3553	Mountain View Seeds	PPG-TF-255
DLF Pickseed USA	DLFPS-321/3679	Mountain View Seeds	PPG-TF-312
DLF Pickseed USA	DLFPS-321/3696	Mountain View Seeds	PPG-TF-315
DLF Pickseed USA	DLFPS-321/3699	Mountain View Seeds	PPG-TF-336
DLF Pickseed USA	Grande 3	Mountain View Seeds	PPG-TF-337
DLF Pickseed USA	DLFPS-321/3701	Oregro Seed	Palomar

Table 1 *(continued)* - Sponsors and Entries			
SPONSOR	**ENTRY**	**SPONSOR**	**ENTRY**
Oregro Seed	Escalade	Scotts Co.	K18-NSE
Oregro Seed	OG-WALK	Semillas Dalmau	RHF
Peak Plant Genetics LLC	PPG-TF-320	Semillas Fito	RC4
Peak Plant Genetics LLC	PPG-TF-231	Semillas Fito	RHL2
Peak Plant Genetics LLC	PPG-TF-306	Semillas Fito	Estrena
Peak Plant Genetics LLC	PPG-TF-318	Site One Land. Supply	Tango
Pennington Seed	ATF2116	Site One Land. Supply	3N1
Pennington Seed	NT-3	Site One Land. Supply	Bandit
Pennington Seed	ATF 1768	Site One Land. Supply	Copious TF
Pennington Seed	TD2	Site One Land. Supply	Padre 2
ProSeeds Marketing, Inc.	3B2	Site One Land. Supply	Bravo 2
ProSeeds Marketing, Inc.	RH1	Smith Seed Services	TF445
ProSeeds Marketing, Inc.	RH3	Smith Seed Services	TF456
Pure Seed (Rose Agri)	Lifeguard	Smith Seed Services, LLC	SE5302
Pure Seed (Rose Agri)	PST-5DART	Smith Seed Services, LLC	SE5STAR
Pure Seed (Rose Agri)	PST-5DC24	Smith Seed Services, LLC	SE5CR1
Pure Seed Testing	5LSS	Smith Seed Services, LLC	SETF104
Pure Seed Testing	PST-5TRN	Smith Seed Services, LLC	SETFM2
Pure Seed Testing	PST-5GQ	Smith Seed Services, LLC	SETFM3
Pure Seed Testing	PST-5MCMO	Standard	Paramount
Pure Seed Testing	PST-5E6	Standard	Fayette
Pure Seed Testing	PST-5THM	Standard	Bullseye
Pure Seed Testing	PST-5MINK	Standard	Hemi
Pure Seed Testing	PST-5SQB	Standard	Raptor III
Pure Seed Testing	PST-5DZM	Standard	Kentucky-31
Pure Seed Testing	PST-5GLBS	The Scotts Miracle Gro Co	K18-RS6
Radix Research	RAD--TF105	The Scotts Miracle Gro Co	K18-WB1
Radix Research	RAD-TF0.0	Tualatin Valley Seeds	LBF
Rutgers University	RDC	Vista Seed Partners	PPG-TF-257
Scotts Co.	K18-ROE	Z Seeds	ZRC1

Figure 1 – 2019 Turf-Type Tall Fescue NTEP Trial, University of Connecticut (photo-October 2019)

Table 2. Tall Fescue NTEP results 2019 for percent establishment and turfgrass quality (rating 1-9, where 9 equals the highest turf quality). Table is listed with highest mean quality cultivars listed first.

Entry Num.	Entry	% Fall Establishment	Quality						
		10/19/18	06/27/19	07/19/19	08/14/19	09/16/19	10/16/19	11/06/19	Mean
87	PPG-TF-336	50.0	5.3	6.7	6.7	7.0	7.3	7.0	**6.7**
15	DLFPS-TF/3553	40.0	6.0	6.3	6.7	6.7	7.0	7.0	**6.6**
86	PPG-TF-315	46.7	6.0	6.3	6.7	7.0	6.7	6.7	**6.6**
103	NAI-ROS4	53.3	5.7	6.7	6.7	6.7	6.7	7.0	**6.6**
11	BGR-TF3	53.3	6.0	6.3	6.3	6.7	7.0	6.7	**6.5**
67	PPG-TF-262	46.7	5.7	6.0	6.3	6.3	7.3	7.3	**6.5**
109	SETF104	46.7	5.7	6.3	6.7	7.0	7.0	6.3	**6.5**
3	DLFPS-321/3693	53.3	5.7	6.0	6.3	6.3	6.7	7.3	**6.4**
66	PPG-TF-249	46.7	5.7	6.3	6.0	6.7	7.0	7.0	**6.4**
69	AH2	63.3	5.3	6.3	6.3	6.7	6.7	7.0	**6.4**
2	Paramount	50.0	5.3	5.7	6.3	6.7	7.0	6.7	**6.3**
17	LBF	40.0	5.3	6.0	6.3	6.7	6.7	7.0	**6.3**
18	TD2	46.7	5.3	6.0	6.0	6.7	6.7	7.0	**6.3**
19	DLFPS-321/3696	43.3	5.0	6.0	6.0	6.3	7.0	7.3	**6.3**
21	Grande 3	53.3	5.7	6.3	6.7	6.3	6.3	6.7	**6.3**
28	COL-TF-148	40.0	5.3	5.7	6.7	6.3	7.0	7.0	**6.3**
68	PPG-TF-267	46.7	5.0	6.0	6.3	6.3	7.0	7.0	**6.3**
89	ZRC1	50.0	5.3	6.0	6.0	6.3	7.0	7.0	**6.3**
90	PPG-TF-231	53.3	5.3	6.0	6.3	6.0	7.0	7.0	**6.3**
99	GO-RH20	56.7	5.7	6.0	6.0	6.3	7.0	7.0	**6.3**
121	PPG-TF-338	43.3	5.7	6.0	6.0	6.3	6.7	7.0	**6.3**
8	NT-3	46.7	5.3	6.0	6.3	6.0	6.7	7.0	**6.2**
12	ATF 1768	46.7	5.7	5.7	6.0	6.3	7.0	6.3	**6.2**
25	RDC	53.3	6.0	5.7	6.0	6.3	6.7	6.7	**6.2**
59	DLFPS-321/3705	40.0	5.3	5.7	5.3	6.7	7.0	7.0	**6.2**
65	AH1	53.3	5.3	5.7	5.7	6.3	7.0	7.0	**6.2**
81	PPG-TF-238	40.0	5.3	6.3	6.0	5.7	7.0	7.0	**6.2**
85	PPG-TF-312	43.3	5.3	5.7	5.7	6.3	7.0	7.0	**6.2**
93	Bullseye	43.3	5.3	6.0	6.0	6.3	6.7	6.7	**6.2**
111	SETFM3	43.3	5.3	6.0	6.0	6.3	6.3	7.0	**6.2**
117	RHF	46.7	5.3	6.0	6.0	6.0	6.7	7.0	**6.2**
4	DLFPS-321/3694	46.7	5.0	5.7	6.0	6.0	6.7	7.0	**6.1**
10	5LSS	50.0	5.3	5.7	5.7	6.7	6.3	6.7	**6.1**
24	JS-DTT	46.7	5.3	6.0	5.7	6.0	6.7	7.0	**6.1**
31	K18-ROE	46.7	5.3	6.3	6.0	6.0	6.3	6.3	**6.1**
34	DLFPS-321/3701	50.0	5.3	5.7	5.7	6.3	6.3	7.0	**6.1**
37	PST-5TRN	40.0	5.7	6.3	6.0	6.7	6.0	6.0	**6.1**
78	PPG-TF 316	43.3	5.3	6.3	6.0	6.3	6.3	6.3	**6.1**
80	PPG-TF-257	40.0	5.3	6.0	6.0	6.0	6.3	6.7	**6.1**
84	PPG-TF-255	43.3	5.0	6.0	6.3	6.3	6.7	6.3	**6.1**
92	PPG-TF-318	46.7	5.3	5.7	6.0	6.0	6.7	6.7	**6.1**
113	RAD--TF105	50.0	5.3	6.0	6.0	6.0	6.3	6.7	**6.1**
115	RHL2	46.7	5.0	5.7	6.0	5.7	7.0	7.0	**6.1**
119	PPG-TF-320	36.7	5.0	6.0	6.3	6.0	6.7	6.7	**6.1**
9	RS1	46.7	5.0	5.3	6.0	6.0	6.7	7.0	**6.0**
13	DLFPS-TF/3550	43.3	5.0	5.7	5.7	6.0	6.7	7.0	**6.0**
40	ProGold	46.7	5.3	5.3	6.7	6.0	6.7	6.0	**6.0**
43	PST-5BYOB	56.7	5.3	6.0	6.0	6.0	6.3	6.3	**6.0**

46	Moondance	50.0	5.3	5.3	6.0	6.0	6.7	6.7	**6.0**
62	DLFPS-321/3708	36.7	5.3	6.0	5.3	6.0	6.7	6.7	**6.0**
70	K18-RS6	46.7	5.0	5.7	5.7	6.3	7.0	6.3	**6.0**
71	K18-WB1	40.0	5.0	5.7	5.7	6.3	6.7	6.7	**6.0**
122	Estrena	43.3	5.3	5.7	5.7	6.3	6.7	6.3	**6.0**
14	DLFPS-TF/3552	33.3	5.3	6.0	5.7	5.7	6.3	6.7	**5.9**
16	DLFPS-321/3679	40.0	5.3	6.0	5.7	5.7	6.3	6.7	**5.9**
20	DLFPS-321/3699	40.0	5.3	5.3	5.7	6.0	6.3	7.0	**5.9**
22	Fayette	46.7	5.0	5.3	5.7	6.0	6.7	6.7	**5.9**
23	JT-517	46.7	5.0	5.7	6.0	5.7	6.7	6.7	**5.9**
29	LTP-TF-122	36.7	5.0	5.3	6.0	5.7	6.3	7.0	**5.9**
39	PST-5MCMO	43.3	5.0	5.3	6.3	6.0	6.7	6.3	**5.9**
41	PST-5E6	43.3	5.3	5.7	5.7	6.3	6.3	6.3	**5.9**
42	PST-5THM	50.0	5.0	6.0	6.0	6.0	6.7	5.7	**5.9**
45	PST-5MINK	46.7	5.0	5.7	5.3	6.3	6.3	6.7	**5.9**
51	PST-5DC24	46.7	5.3	5.7	6.0	5.7	6.3	6.3	**5.9**
55	Copious TF	43.3	5.3	5.7	6.0	5.7	6.3	6.7	**5.9**
56	Padre 2	40.0	5.3	5.7	5.7	5.7	6.3	6.7	**5.9**
61	DLFPS-321/3707	36.7	5.0	6.3	5.3	5.7	6.3	6.7	**5.9**
72	RH1	50.0	5.0	5.3	5.7	6.0	6.7	7.0	**5.9**
73	RH3	40.0	5.0	5.7	5.3	6.3	6.7	6.7	**5.9**
76	PPG-TF 244	43.3	5.3	5.7	6.0	5.3	6.3	6.7	**5.9**
82	PPG-TF-254	46.7	5.3	5.3	5.7	6.0	6.3	6.7	**5.9**
98	Dragster	36.7	5.0	5.3	5.7	6.0	6.7	6.7	**5.9**
102	NAI-3N2	40.0	5.3	5.7	5.7	5.7	6.7	6.3	**5.9**
105	NAI-ST5	46.7	5.0	5.3	5.7	6.0	6.7	7.0	**5.9**
106	SE5302	40.0	5.3	6.0	5.7	5.7	6.3	6.3	**5.9**
127	Escalade	46.7	5.3	5.3	6.0	6.0	6.3	6.7	**5.9**
129	TF445	43.3	5.0	6.0	5.7	5.7	6.7	6.7	**5.9**
130	TF456	33.3	5.3	5.3	6.0	5.3	6.7	6.7	**5.9**
1	Naturally Green	46.7	5.3	5.7	5.7	6.0	6.0	6.3	**5.8**
5	DLFPS-321/3695	50.0	5.0	5.7	5.3	6.0	6.7	6.0	**5.8**
27	BAR FA 8228	46.7	5.3	5.7	5.7	5.7	6.0	6.3	**5.8**
30	LTP-TF-111	40.0	5.0	5.3	5.7	5.7	6.7	6.3	**5.8**
32	K18-NSE	43.3	5.0	5.3	6.0	5.7	6.0	6.7	**5.8**
33	BY-TF-169	43.3	5.0	5.7	5.3	6.0	6.3	6.7	**5.8**
44	Lifeguard	46.7	5.3	5.3	5.7	6.0	6.3	6.0	**5.8**
49	PST-5GLBS	43.3	5.0	5.7	5.7	6.0	6.3	6.0	**5.8**
50	PST-5DART	50.0	5.3	5.7	5.7	5.3	6.3	6.3	**5.8**
54	Bandit	36.7	5.0	5.7	5.7	6.0	6.3	6.3	**5.8**
57	Bravo 2	43.3	5.0	5.7	5.7	6.0	6.3	6.3	**5.8**
60	DLFPS-321/3706	40.0	5.0	5.3	5.7	6.0	6.3	6.7	**5.8**
63	BAR-TF-134	30.0	5.3	5.7	5.0	5.7	6.3	7.0	**5.8**
64	BAR-FA8230	43.3	5.3	6.0	5.3	6.0	6.3	6.0	**5.8**
74	JT 233	43.3	5.0	5.0	5.7	6.0	6.3	7.0	**5.8**
77	PPG-TF 305	46.7	5.0	5.7	5.7	5.7	6.7	6.0	**5.8**
83	PPG-TF-308	40.0	5.3	5.7	5.7	6.0	6.0	6.3	**5.8**
88	PPG-TF-337	46.7	5.7	5.3	5.7	5.3	6.3	6.7	**5.8**
94	Firehawk SLT	36.7	5.0	5.3	5.3	6.0	6.7	6.7	**5.8**
96	Bullseye LTZ	46.7	5.0	5.0	5.3	6.0	6.7	6.7	**5.8**
100	Burmingham	40.0	5.0	5.7	6.0	6.0	6.0	6.0	**5.8**
104	NAI-TUE	46.7	5.3	6.0	5.3	5.7	6.3	6.3	**5.8**
112	3B2	43.3	5.0	5.7	5.7	5.7	6.3	6.7	**5.8**
118	PPG-TF-313	36.7	5.0	5.7	5.3	5.7	6.7	6.7	**5.8**

125	A-TF31	40.0	5.0	5.7	5.7	5.7	6.3	6.7	**5.8**
6	TMT1	50.0	5.3	5.0	5.3	5.7	6.3	6.3	**5.7**
36	DLFPS-321/3703	36.7	5.0	5.3	5.7	5.3	6.3	6.3	**5.7**
52	Tango	46.7	5.0	6.0	5.7	5.3	6.0	6.0	**5.7**
58	NAI-FQZ-17	36.7	5.0	5.0	5.7	5.7	6.3	6.3	**5.7**
75	JT 268	43.3	5.0	5.3	5.7	6.0	6.3	6.0	**5.7**
91	PPG-TF-306	43.3	5.3	5.0	5.0	6.0	6.7	6.0	**5.7**
95	Hemi	43.3	5.0	5.0	5.3	6.0	6.3	6.3	**5.7**
97	Turbo SS	46.7	5.0	5.7	5.3	6.0	6.0	6.0	**5.7**
107	SE5STAR	43.3	5.0	5.3	5.3	6.3	6.0	6.3	**5.7**
108	SE5CR1	40.0	5.0	5.0	5.3	5.7	6.7	6.3	**5.7**
110	SETFM2	33.3	5.0	5.7	5.7	5.3	6.3	6.3	**5.7**
116	Raptor III	33.3	5.0	5.3	5.3	5.3	6.3	6.7	**5.7**
120	PPG-TF-323	40.0	5.0	5.0	5.3	5.7	6.3	6.7	**5.7**
126	Palomar	40.0	5.3	5.7	5.3	6.0	6.0	6.0	**5.7**
128	OG-WALK	36.7	5.0	5.3	5.3	6.0	6.3	6.3	**5.7**
131	FC15-01P	36.7	5.3	5.3	5.7	5.7	6.3	5.7	**5.7**
7	ATF2116	40.0	5.0	5.0	6.0	5.3	6.0	6.0	**5.6**
35	DLFPS-321/3702	33.3	4.7	5.3	5.0	5.3	6.3	6.7	**5.6**
47	PST-5SQB	43.3	5.0	5.3	5.7	5.3	6.3	6.0	**5.6**
48	PST-5DZM	43.3	5.0	5.3	5.3	5.3	6.3	6.0	**5.6**
53	3N1	40.0	5.0	5.3	5.3	5.7	6.3	6.0	**5.6**
79	RC4	40.0	5.0	5.0	5.3	5.7	6.0	6.3	**5.6**
123	AST8118LM	43.3	5.0	5.3	5.3	5.3	6.0	6.3	**5.6**
124	AST8218LM	40.0	5.0	5.3	5.3	5.0	6.3	6.3	**5.6**
26	BAR 9FE MAS	53.3	5.0	5.3	5.0	5.7	6.0	6.0	**5.5**
38	PST-5GQ	40.0	5.0	5.3	5.3	5.3	6.0	6.0	**5.5**
114	RAD-TF0.0	43.3	5.0	5.3	4.7	5.0	6.3	6.7	**5.5**
101	GO-AOMK	36.7	5.0	5.0	5.0	5.3	6.3	6.0	**5.4**
132	Kentucky-31	56.7	4.3	4.7	4.3	4.0	4.3	5.3	**4.5**
	$LSD_{0.05}$	**13.62**	**0.69**	**1.06**	**1.05**	**1.06**	**0.86**	**0.76**	**0.64**
	CV%	**19.2**	**8.3**	**11.6**	**11.3**	**11.0**	**8.2**	**7.3**	**6.7**

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NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2014 NATIONAL FINELEAF FESCUE ANCILLARY TEST – 2019 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 three 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 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 2019, traffic was initiated on plots beginning on 5/1/19 and continued throughout the season and concluded at the end of September 2019. This five-year study concluded in November of 2019.

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

Fertilizer and pesticide applications
5/3/19 - Pre-emergent 0.54 oz. /1,000 ft^2 Prodiamine®.
5/3/19 - Acelepryn®, .367 fl. Oz. /1,000 ft^2
5/9/19 - 25-0-12 60% SCU at rate of 1.25 #N/1,000 sq.'
6/28/19 - Secure® fungicide 0.5 oz. /1,000 ft^2 (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 three times throughout the 2019 growing season.

DATA COLLECTION
Spring green-up ratings were taken and recorded (Table 2 non-trafficked and Table 3 trafficked) on April 16, 2019. Green-up measures the transition from winter dormancy to active spring growth. Ratings were based on a scale of 1-9, with one equaling brown turf and nine equaling dark green turf.

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2019 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. Turf plots rated with a score of less than six are deemed unacceptable. 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 25th, July 15th and October 10th. Percent living cover ratings are provided in Table 2 for non-trafficked plots and Table 3 for trafficked plots.

Percent Red Thread ratings were taken in May and noted in Tables 2 and 3.

RESULTS & DISCUSSION

In 2014, the University of Connecticut was chosen as a site for the Fineleaf Fescue Ancillary trial. Results (2019) 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.

2019 marked the final year of this fine fescue trial. The overall turfgrass quality for 2019 was much lower than the previous four 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 decreases in quality carried over from 2018, which was a very wet year. While all three factors combined may have led to a decrease in turfgrass quality, I believe that the high soil moisture of 2018 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 and 2019 a fungicide application was made 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, in addition, 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.

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. Six 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 2018 results. Chewings, slender, and creeping red fescues exhibited higher quality ratings when compared to the hard fescues. Results from 2019 simulated golf cart traffic trial indicate, from the mean quality values, that seven of the top 10 species for quality were chewings fescues. Radar (chewings) Bar VV-VP3-CT (chewings), and Bolster (C14-OS3) (strong creeping red) illustrated the highest quality ratings under simulated golf cart traffic. One hard fescue DLFPS-FRC/3060 and one sheep fescue (Quatro) scored in the top ten for both quality and percent density. It should be noted that at the conclusion of the study for all entries, in the trafficked plots, mean turfgrass quality for fairway turf was unacceptable. All ratings were less than 6 (table 3). Lower turf quality ratings were likely impacted by the lower mowing heights and traffic treatments. This is evident by the fact that in the non-trafficked study, seven cultivars were considered acceptable (rated above 6) at the conclusion of the study (Table 2)

The results of the first three years of this study were promising. There were cultivars and species that exhibited quality turf even when subjected to traffic, reduced irrigation and reduced fertilizer. However, in 2018 and 2019 (fourth and fifth years of study) overall turfgrass quality began to decline for all entries. While a few entries were acceptable under non-trafficked conditions (Table 2) 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	Barpearl (BAR FRT 5002)	Slender Creeping Red
Barenbrug USA	BAR VV-VP3-CT	Chewings
Barenbrug USA	Sandrine (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 2019 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, percent red thread in May, 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				Percent Red Thread	Quality						
Entry	04/16/19	05/25	07/15	10/05	Mean	05/05	05/25	06/28	07/29	08/21	09/18	10/05	Mean
Radar	7.3	88.3	92.7	94.7	91.9	4.0	7.3	7.3	6.0	6.0	7.7	7.3	6.9
DLFPS-FRC/3060	6.7	95.0	95.0	93.3	94.4	4.7	6.7	6.7	5.7	6.3	7.0	7.0	6.6
Compass II (PPG-FRC 113)	6.7	88.3	95.0	93.3	92.2	2.3	6.7	6.7	6.0	6.0	6.3	6.7	6.4
DLF-FRC 3338	6.7	86.7	89.7	86.7	87.7	2.0	7.3	7.0	5.0	5.7	6.7	6.3	6.3
Momentum (PPG-FRC-114)	6.7	88.3	86.3	88.3	87.7	3.0	7.3	6.7	5.3	5.7	6.3	6.0	6.2
DLFPS-FRC/3057	6.3	88.3	80.0	86.7	85.0	3.3	6.7	6.7	5.7	6.0	6.3	6.0	6.2
Bolster (C14-OS3)	6.3	83.3	89.7	88.3	87.1	1.0	7.0	7.0	5.3	5.7	6.0	6.0	6.2
BAR VV-VP3-CT	6.7	88.3	81.7	76.7	82.2	2.7	7.0	6.3	4.7	5.7	6.0	5.7	5.9
MNHD-14	4.7	83.3	83.0	76.7	81.0	0.0	6.3	6.0	6.0	5.3	5.3	5.7	5.8
SeaMist (PPG-FRT-101)	6.7	88.3	86.7	83.3	86.1	1.7	6.7	6.3	4.7	5.3	6.0	5.7	5.8
7C34	5.7	90.0	83.3	76.7	83.3	5.7	6.0	5.3	5.3	5.7	5.0	5.0	5.4
RAD-FR33R	5.7	90.0	86.7	80.0	85.6	2.0	6.0	5.7	5.0	5.3	4.3	5.3	5.3
Cascade	6.0	78.3	71.3	76.7	75.4	1.3	6.0	5.3	4.7	5.0	5.0	5.7	5.3
Castle (RAD-FC32)	5.7	86.7	75.0	66.7	76.1	1.3	6.3	6.3	4.3	4.7	4.7	4.3	5.1
DLF-FRR-6162	5.7	90.0	83.3	78.3	83.9	2.0	6.3	5.7	4.7	4.0	5.0	5.0	5.1
DLFPS-FL/3060	4.7	80.0	63.3	76.7	73.3	0.0	5.7	5.3	4.7	4.7	5.0	5.0	5.1
Quatro	5.0	80.0	75.0	85.0	80.0	0.0	5.7	4.7	5.3	5.0	5.0	4.7	5.1
Marvel	5.7	85.0	76.7	73.3	78.3	5.3	6.0	4.7	4.7	4.3	5.3	5.0	5.0
Jetty (PPG-FL-106)	5.0	83.3	78.3	70.0	77.2	0.0	5.7	5.3	5.0	5.0	4.3	4.7	5.0
RAD-FC44	6.3	88.3	76.7	73.3	79.4	0.3	7.0	5.7	4.3	4.0	4.3	4.7	5.0
Cardinal (PPG-FRC-111)	5.7	85.0	80.0	73.3	79.4	1.7	6.3	5.3	4.0	5.3	4.0	4.7	4.9
RAD-FR47	5.7	91.7	68.3	46.7	68.9	1.0	6.0	5.3	4.0	4.7	4.0	4.7	4.8
Gladiator (TH456)	4.3	65.0	68.3	70.0	67.8	0.3	5.3	5.0	4.3	4.7	4.3	4.7	4.7
PST-4BEN	5.7	78.3	61.7	66.7	68.9	4.0	5.7	4.7	4.3	4.3	4.7	4.7	4.7
Minimus	4.0	60.0	51.7	36.7	49.4	1.7	5.3	4.0	4.7	4.7	4.0	4.3	4.5
DLFPS-FRR/3068	5.3	85.0	51.7	48.3	61.7	3.0	5.7	4.7	4.3	4.7	3.7	4.0	4.5
DLFPS-FL/3066	4.3	75.0	70.0	68.3	71.1	0.0	5.3	4.7	4.0	4.3	4.0	4.0	4.4
Bar Pearl (BAR FRT 5002)	4.0	71.7	68.3	66.7	68.9	1.3	5.0	4.7	4.0	4.0	4.0	4.7	4.4

DLFPS-FRR/3069	5.3	68.3	46.7	56.7	57.2	1.3	5.3	4.0	3.7	4.0	4.0	4.3	4.2
Boreal	5.7	85.0	61.7	41.7	62.8	3.0	5.0	4.3	3.7	4.0	4.0	4.3	4.2
Resolute (7H7)	5.0	73.3	50.0	45.0	56.1	0.0	5.0	5.0	4.0	4.0	3.3	4.0	4.2
PST-4DR4	5.3	78.3	66.7	56.7	67.2	5.0	5.3	4.7	3.7	3.7	3.7	4.3	4.2
Navigator II	5.3	70.0	40.0	25.0	45.0	2.0	4.7	4.7	3.7	4.3	3.7	3.7	4.1
Kent	5.3	70.0	30.0	31.7	43.9	1.0	5.3	4.3	3.7	4.0	3.7	3.7	4.1
PST-4ED4	5.0	75.0	56.7	53.3	61.7	2.3	5.0	4.0	4.3	3.7	4.0	3.7	4.1
Sword	5.0	58.3	45.0	58.3	53.9	1.3	4.3	4.7	3.7	3.7	4.0	4.0	4.1
Sandrine (BAR 6FR 126)	4.7	66.7	51.7	28.3	48.9	1.0	5.0	4.7	3.7	3.3	3.7	4.0	4.1
Beacon	4.3	75.0	35.0	28.3	46.1	0.7	4.3	4.3	3.3	4.7	4.0	3.3	4.0
PST-4RUE	5.7	66.7	60.0	48.3	58.3	4.3	5.3	4.0	3.3	4.0	3.0	4.0	3.9
Beudin	4.3	81.7	55.0	41.7	59.4	0.7	4.7	4.3	3.3	3.3	3.0	3.3	3.7
Seabreeze GT	5.3	68.3	45.0	41.7	51.7	3.0	4.7	4.0	2.7	3.3	3.0	3.7	3.6
PST-4BND	2.7	28.3	25.0	31.7	28.3	0.7	3.0	2.7	3.0	2.7	3.0	2.3	2.8
$LSD_{0.05}$	1.16	22.35	27.97	28.69	22.12	4.32	1.36	1.64	1.44	1.46	1.49	1.42	1.12
CV%	13.2	17.5	25.5	27.6	19.4	136.3	14.6	19.3	20.0	19.3	19.9	18.4	14.1

Table 3. 2019 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, percent red thread in May, 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				Percent Red Thread	Quality						
Entry	04/16	05/25	07/15	10/05	Mean	05/05	05/25	06/28	07/29	08/21	09/18/	10/05	Mean
Radar	7.3	83.3	76.7	76.7	78.9	2.0	6.0	5.0	5.3	5.0	5.0	5.3	5.3
BAR VV-VP3-CT	6.7	78.3	66.7	70.0	71.7	0.3	5.3	3.7	4.7	5.0	4.7	5.0	4.7
Bolster (C14-OS3)	6.3	66.7	55.0	33.3	51.7	0.3	4.7	4.3	4.0	4.0	4.3	4.7	4.3
DLFPS-FRC/3057	6.3	76.7	50.0	48.3	58.3	0.0	4.3	4.3	4.3	4.7	4.0	4.0	4.3
Momentum (PPG-FRC-114)	6.7	66.7	66.7	33.3	55.6	1.3	4.7	4.0	4.0	3.3	3.7	4.0	3.9
Cascade	6.0	46.7	53.3	30.0	43.3	2.7	5.0	3.0	3.7	3.3	4.0	4.3	3.9
7C34	5.7	78.3	51.7	43.3	57.8	1.7	4.7	3.3	3.7	3.3	4.0	3.7	3.8
DLF-FRC 3338	6.7	45.0	53.3	34.3	44.2	0.3	5.0	4.0	4.0	3.0	3.0	3.3	3.7
Quatro	5.0	60.0	41.7	36.7	46.1	1.3	3.3	3.0	3.7	4.0	3.7	4.3	3.7
DLFPS-FRC/3060	6.7	63.3	53.3	30.0	48.9	0.7	5.0	3.3	4.0	3.0	3.0	3.3	3.6
SeaMist (PPG-FRT-101)	6.7	58.3	48.3	26.7	44.4	0.0	3.7	3.7	3.3	3.0	2.7	3.7	3.3
Marvel	5.7	53.3	38.3	20.0	37.2	0.3	4.0	2.7	3.0	3.3	3.0	3.3	3.2
Compas II (PPG-FRC 113)	6.7	65.0	55.0	30.7	50.2	0.0	3.7	3.7	3.3	3.0	2.7	3.0	3.2
RAD-FR33R	5.7	51.7	26.7	14.0	30.8	1.3	3.3	2.7	3.3	2.3	2.7	2.7	2.8
Navigator II	5.3	38.3	30.0	11.7	26.7	0.0	3.3	3.3	2.7	2.7	2.3	2.3	2.8
PST-4BEN	5.7	43.3	25.0	21.7	30.0	1.7	3.3	1.7	2.7	3.0	2.7	3.0	2.7
Castle (RAD-FC32)	5.7	28.3	33.3	18.7	26.8	0.0	3.0	2.7	3.0	2.0	2.0	3.0	2.6
DLF-FRR-6162	5.7	43.3	26.7	7.3	25.8	1.7	3.3	2.3	3.0	1.7	2.3	2.7	2.6
Kent	5.3	40.0	21.7	7.7	23.1	0.0	3.3	2.0	3.0	2.0	2.0	2.3	2.4
RAD-FR47	5.7	41.7	8.3	14.3	21.4	0.0	3.7	2.0	2.7	2.0	2.0	2.3	2.4
PST-4RUE	5.7	41.7	13.7	22.0	25.8	0.0	3.3	2.0	2.3	2.3	2.0	2.7	2.4
DLFPS-FRR/3068	5.3	33.3	13.3	7.0	17.9	0.3	3.0	2.3	2.7	1.7	2.0	2.7	2.4
Boreal	5.7	20.0	27.7	7.0	18.2	0.3	3.3	2.3	3.0	2.0	1.3	2.3	2.4
Jetty (PPG-FL-106)	5.0	21.7	16.7	17.0	18.4	0.0	2.3	2.0	2.7	2.3	2.3	2.7	2.4
RAD-FC44	6.3	31.7	29.3	16.0	25.7	0.7	2.7	2.3	3.0	2.0	2.3	2.0	2.4
MNHD-14	4.7	26.7	13.3	17.7	19.2	0.0	3.0	1.7	2.7	2.3	2.0	2.3	2.3
Sword	5.0	20.0	10.0	10.0	13.3	0.3	3.0	1.3	2.3	2.0	2.7	2.7	2.3
Cardinal II (PPG-FRC-111)	5.7	36.7	30.0	8.7	25.1	0.3	2.7	2.7	2.3	2.0	1.7	2.3	2.3
PST-4DR4	5.3	33.3	22.7	8.7	21.6	1.3	2.7	2.0	2.3	2.0	2.0	2.7	2.3
PST-4ED4	5.0	20.0	10.0	6.7	12.2	1.0	3.7	2.3	2.3	1.7	1.7	2.0	2.3
Minimus	4.0	16.7	11.3	4.3	10.8	0.0	3.3	1.7	2.3	2.0	1.7	2.3	2.2
DLFPS-FL/3060	4.7	16.7	8.3	7.7	10.9	0.0	2.7	1.7	2.7	1.7	2.3	2.3	2.2

Beacon	4.3	25.0	7.0	5.3	12.4	0.0	2.7	1.7	2.3	2.0	1.7	2.3	2.1
DLFPS-FRR/3069	5.3	20.0	14.0	4.7	12.9	0.0	2.3	1.7	2.0	1.7	2.3	2.0	2.0
Gladiator (TH456)	4.3	13.3	8.7	5.3	9.1	0.7	2.3	1.3	2.0	2.0	1.7	2.0	1.9
Seabreeze GT	5.3	21.7	21.7	5.0	16.1	0.3	3.0	1.7	2.3	1.3	1.3	1.7	1.9
Barpearl (BAR FRT 5002)	4.0	26.7	16.7	5.3	16.2	0.0	2.0	1.3	2.3	2.0	1.3	1.7	1.8
DLFPS-FL/3066	4.3	16.7	6.0	4.0	8.9	0.0	2.0	1.7	2.0	1.7	1.0	2.0	1.7
Resolute (7H7)	5.0	23.3	7.0	5.3	11.9	0.0	2.3	1.3	2.0	1.7	1.3	1.7	1.7
PST-4BND	2.7	10.0	3.7	3.7	5.8	0.0	2.3	1.0	2.0	1.3	1.3	1.7	1.6
Sandrine (BAR 6FR 126)	4.7	13.3	6.0	4.7	8.0	2.0	2.3	1.3	2.0	1.3	1.0	1.3	1.6
Beudin	4.3	8.3	3.7	2.7	4.9	0.0	2.3	1.3	1.7	1.0	1.0	1.3	1.4
$LSD_{0.05}$	1.16	25.68	21.41	20.14	17.70	1.95	1.39	1.33	1.26	1.03	1.39	1.35	0.93
CV%	13.2	40.9	46.8	66.1	38.2	219.5	25.3	33.2	26.5	25.7	35.4	29.9	20.8

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NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2017 KENTUCKY BLUEGRASS TEST – 2019 RESULTS

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INTRODUCTION

Kentucky bluegrass is among the most widely utilized cool season turfgrasses. It is used in home lawns, sports turf, parks, and golf courses. Kentucky bluegrass is strongly rhizomatous. It produces a high-density turfgrass stand that is capable of spreading and quickly filling in voids. Other characteristics that make Kentucky bluegrass desirable are color, rapid recovery rate, good drought tolerance, and leaf texture. Limiting factors with Kentucky bluegrass are its lack of good shade tolerance, and its slow germination and establishment rate.
Maintenance requirements (water, fertility) are medium to medium high. Mowing heights can range from 0.5 inches (cultivar dependent) to 3 inches. Irrigation is required to avoid dormancy. However, when Kentucky bluegrass does go into dormancy, it is quick to recover once watering or rainfall resumes.

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 2017 NTEP selected fourteen standard testing sites and seven ancillary test locations for the 2017 National Kentucky bluegrass test. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected as a standard site for the 2017 Kentucky bluegrass test. NTEP trials typically run for five years, The 2017 Kentucky bluegrass trial will run through the 2022 growing season.

MATERIALS AND METHODS

Eighty-nine Kentucky bluegrass cultivars were seeded on August 25, 2017 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:

<u>Mowing</u> - Plots were maintained at a mowing height of 2.0 inches and mowed two times per week. Clippings are returned.

<u>Irrigation</u> – Supplemental irrigation is applied to prevent stress or dormancy.

<u>Fertilizer and pesticide applications for 2019</u>
May 3, 2019 Prodiamine @ .55 fl oz/m
May 3, 2019 Acelepryn @ .365 fl oz/m.
May 9, 2019 - 1#N/m using 30-0-6 (50% SCU).
May 29, 2019 Tenacity (Mesotrione 4 fl oz/A)
June 14, 2019 Tenacity (Mesotrione 2 fl oz/A)
June 24, 2019 - 1 #N/m using 25-0-12 (60% SCU)
July 5, 2019 - Tenacity (Mesotrione 2 fl oz/A)
July 25, 2019 - Tenacity (Mesotrione 2 fl oz/A)
Aug. 8, 2019 - Tenacity (Mesotrione 2 fl oz/A)
Aug. 27, 2019 - Tenacity (Mesotrione 2 fl oz/A)
Sept. 4, 2019 -1#N/m was applied using 30-0-6 (50% SCU).
Sept. 5, 2019- SpeedZone at a rate of 1.8 fl oz/m.
Nov. 4, 2019 - 1 #N/m using 25-0-12 (60% SCU)

DATA COLLECTION

<u>Genetic Color Ratings</u> - Genetic color ratings (Table 2) were taken in the late spring (June 5, 2019) 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).

<u>Leaf Texture Ratings</u> - Visual leaf texture ratings were taken in the late spring June 5, 2019) while the grass was actively growing and not under stress conditions. Texture ratings were made using a visual scale with 1 equaling coarse turf and 9 equaling fine (Table 2).

<u>Quality Ratings</u> - Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2019 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. Turf plots rated with a score of less than six are deemed unacceptable. Monthly quality and mean quality ratings are provided in table 2.

RESULTS & DISCUSSION

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

During the establishment phase and in the early spring of 2018 small amounts of poa annua was present in several plots. Applications of Tenacity® and Prograss® were applied throughout the spring and fall in order to reduce poa annua encroachment and to remove existing poa from the study (see management practices). Applications of Tenacity® were continued in 2019. Reductions of Poa annua populations were noted.

Most of the cultivars (55) had acceptable quality scores of 6 or greater for mean overall quality rankings. The three cultivars receiving the highest ratings for overall mean quality in 2019 were After Midnight (7.8), PPG-KB 1131 (7.7) and, J-3510 (7.6). However, there was no significant difference between the top 17 cultivars listed in table 2. The two cultivars that had the lowest overall ratings were MVS-130 and Kenblue.

Table 1- Sponsors and Entries			
ENTRY	**SPONSOR**	**ENTRY**	**SPONSOR**
A11-40	Landmark Turf & Native	GO-22B23	Grassland Oregon
A13-1	Landmark Turf & Native	GO-2628	Grassland Oregon
A99-2897	Turf Merchants, Inc	GO-2425	Grassland Oregon
LTP-11-41	Lebanon Seedboard.	DLFPS-340/3364	DLF Pickseed
Blue Knight	Ledeboer Plant Breeding	DLFPS-340/3446	DLF Pickseed
Rad 553	Seeds Inc.	DLFPS-340/3556	DLF Pickseed
Selway	Seeds Inc.	DLFPS-340/3553	DLF Pickseed
Babe	Seeds Inc.	DLFPS-340/3494	DLF Pickseed
AKB3128	Pennington	DLFPS-340/3500	DLF Pickseed
AKB 3179	Pennington	DLFPS-340/3438	DLF Pickseed
AKB3241	Pennington	DLFPS-340/3549	DLF Pickseed
NK-1	Pennington	DLFPS-340/3548	DLF Pickseed
KH3492	Pennington Seed	DLFPS-340/3444	DLF Pickseed
Yellowstone (A12-7)	Landmark Turf &Native	DLFPS-340/3455	DLF Pickseed
After Midnight	Jacklin Seed by Simplot	DLFPS-340/3550	DLF Pickseed
J-1138	Jacklin Seed by Simplot	DLFPS-340/3551	DLF Pickseed
J-1319	Jacklin Seed by Simplot	DLFPS-340/3552	DLF Pickseed
J-2726	Jacklin Seed by Simplot	MVS-130	Mountain View
J-3510	Jacklin Seed by Simplot	A16-1	Mountain View
Bar PP 71213	Barenbrug	A16-7	Mountain View
Bar PP 7309V	Barenbrug	A12-34	Mountain View
Bar PP 79366	Barenbrug	A11-26	Mountain View
Barvette HGT	Standard	PPG-KB-1320	Mountain View
BAR PP 7K426	Barenbrug	A11-38	Peak Plant Genetics
BAR PP 7236V	Barenbrug	PPG-KB 1131	Mountain View
BAR PP 79494	Barenbrug	A10-280	Mountain View
Barserati (BAR PP 110358)	Barenbrug	Shamrock	Standard.
RAD-1776	Barenbrug	A16-2	Scotts
NAI-A16-3	Novel AG Inc.	PPG-KB 1304	ProSeeds
NAI-13-132	SiteOne Landscape	A15-6	Peak Plant Genetics
NAI-15-80	SiteOne Landscape	A16-17	Peak Plant Genetics.
NAI-13-9	Columbia River	Prosperity	Blue Mt.
NAI-13-14	Columbia River	A06-8	Blue Mt.
NAI-14-122	Columbia River	Kenblue	Standard
Orion (PST-K13-143)	Pure Seed Testing	PST-K13-139	Pure-Seed Testing
NAI-14-128	Columbia River	PST-K13-141	Pure-Seed Testing
NAI-14-132	Columbia River	PST-K11-118	Pure-Seed Testing
NAI-14-133	Columbia River	PST-K15-157	Pure-Seed Testing
NAI-14-176	Columbia River	PST-K11-7	DLF Pickseed
NAI-14-178	Columbia River	PST-K15-167	Pure-Seed Testing
NAI-14-187	Columbia River	PST-K15-177	Pure-Seed Testing
NAI-15-84	Columbia River	PST-K15-172	Pure-Seed Testing
Pivot	Columbia River	Midnight	Standard.
Blue Devil	Columbia Seeds	PST—T14-39	Pure-Seed Testing
Skye	Standard		

Figure 1 – 2017 NTEP National Kentucky Bluegrass Test, University of Connecticut (photo- July 2018)

Table 2. Kentucky Bluegrass NTEP results 2019 for genetic color (ratings 1-9, where 9 equals darker green), leaf texture (rating 1-9, where 9 equals the finest texture leaf blade), turfgrass quality (rating 1-9, where 9 equals the highest turf quality). Table is listed with highest mean quality cultivars listed first.

	Spring Green up	Genetic color	Texture	Density	Quality						
Entry	04/16	06/05	06/05	09/19	05/25	06/28	07/29	08/21	09/18	10/18	mean
After Midnight	4.7	8.7	4.3	8.0	7.3	7.3	8.7	8.0	8.3	7.3	7.8
PPG-KB 1131	4.7	8.0	3.3	8.0	6.7	7.7	8.0	7.7	8.0	8.0	7.7
J-3510	3.3	7.7	3.7	7.7	7.7	7.7	7.7	7.3	8.0	7.3	7.6
NAI-13-9	4.3	8.7	4.0	7.7	7.0	7.7	7.3	7.7	7.7	7.3	7.4
Prosperity	4.3	9.0	3.7	7.0	6.7	7.7	7.7	7.3	8.0	7.3	7.4
NAI-13-132	4.3	8.7	3.3	7.7	6.7	8.3	8.3	7.0	7.3	7.0	7.4
Midnight	4.0	8.3	3.0	7.3	6.3	7.0	8.3	7.3	8.0	7.3	7.4
J-2726	5.0	8.0	4.3	7.3	6.7	7.0	8.7	7.0	7.7	7.3	7.4
J-1319	4.3	9.0	5.7	7.7	6.3	7.3	7.7	7.3	8.3	7.0	7.3
NAI-13-14	4.7	8.3	3.7	7.7	7.0	7.3	8.0	7.3	7.7	6.7	7.3
A16-7	5.3	7.0	3.7	6.3	7.3	7.3	7.3	7.7	7.0	7.0	7.3
GO-2425	6.0	6.7	2.7	8.0	7.0	7.0	7.7	7.3	7.0	7.0	7.2
PST-11-7	5.3	7.0	4.3	8.3	8.0	7.0	7.7	6.3	7.0	7.0	7.2
Blue Devil	4.7	8.0	3.3	7.7	6.3	6.7	7.7	7.3	7.3	7.3	7.1
BAR PP 79494	5.0	8.7	4.0	7.0	6.7	7.0	8.0	6.7	7.3	7.0	7.1
DLFPS-340/3556	5.7	7.0	4.3	6.3	8.0	7.0	6.7	6.7	7.0	7.0	7.1
J-1138	4.3	7.7	3.3	7.3	6.0	7.3	6.7	7.3	7.0	7.7	7.0
DLFPS-340/3550	5.7	7.0	4.0	6.7	7.7	8.3	5.7	6.7	6.7	6.7	6.9
PPG-KB 1304	7.7	6.0	3.0	7.0	6.7	6.3	7.0	7.0	7.3	7.0	6.9
NAI-14-178	7.0	6.0	2.3	8.3	6.7	7.0	6.0	7.0	7.3	7.0	6.8
A99-2897	5.3	7.3	4.3	7.0	7.0	6.3	7.3	6.7	7.0	6.7	6.8
A16-2	7.3	6.0	2.7	8.0	6.7	5.7	7.0	7.0	7.0	7.3	6.8
NAI-A16-3	6.7	6.3	3.0	7.7	7.0	6.7	6.7	6.3	7.3	6.7	6.8
Skye	6.3	7.0	3.3	7.7	6.7	7.0	6.7	6.0	7.3	7.0	6.8
KH3492	7.3	6.7	2.7	8.0	6.7	6.7	6.3	7.0	7.3	6.3	6.7
GO-2628	6.0	6.7	2.7	8.0	7.0	5.3	7.0	6.7	6.7	7.7	6.7
PST-K15-177	5.7	7.3	3.3	7.0	7.0	6.7	6.3	6.7	6.7	7.0	6.7
A11-26	5.3	7.7	3.3	7.0	7.3	6.3	7.0	6.3	6.7	6.7	6.7
DLFPS-340/3552	4.3	7.0	3.3	8.0	7.7	6.3	6.7	6.0	7.0	6.7	6.7
BAR PP 79366	5.0	6.3	3.3	6.7	7.7	6.7	7.3	5.7	6.3	6.7	6.7
DLFPS-340/3553	7.3	5.7	3.0	7.3	7.0	5.3	6.7	7.0	7.0	7.0	6.7
DLFPS-340/3494	4.7	7.3	4.3	6.3	7.0	6.7	7.7	6.7	6.3	5.7	6.7
NAI-15-84	5.7	8.0	3.7	6.3	6.0	6.3	6.7	7.0	6.3	7.3	6.6
DLFPS-340/3500	4.3	6.0	3.3	7.3	7.0	6.3	7.0	6.3	6.7	6.3	6.6
DLFPS-340/3444	6.7	5.7	3.3	6.3	5.7	7.0	6.3	6.3	7.0	7.0	6.6
PPG-KB 1320	5.0	8.7	4.0	7.3	5.7	6.7	7.3	6.3	6.7	6.7	6.6
GO-22B23	5.3	6.7	2.7	7.3	6.0	7.0	6.7	6.0	6.3	7.3	6.6
Blue Knight	4.7	8.0	3.7	7.7	6.0	6.7	6.3	6.3	6.7	7.0	6.5

Babe	6.7	6.0	4.3	6.7	6.3	7.0	6.7	6.7	5.0	7.0	6.4
RAD-1776	6.0	5.3	2.7	7.0	5.3	6.3	6.7	6.7	6.7	7.0	6.4
LTP-11-41	6.0	6.7	2.0	7.0	7.0	5.3	6.0	6.0	6.7	7.7	6.4
PST-K11-118	6.7	6.0	3.0	7.3	6.0	6.3	6.3	7.0	6.0	6.3	6.3
A11-40	7.3	5.0	3.0	7.3	5.7	5.7	6.3	6.7	6.3	7.0	6.3
Yellowstone (A12-7)	6.7	5.7	3.3	7.0	6.3	5.3	6.3	6.0	6.7	7.0	6.3
A16-17	7.3	5.0	2.3	7.0	6.7	6.0	6.3	6.0	6.0	6.7	6.3
A13-1	6.0	7.3	4.3	5.7	7.3	6.3	5.7	6.3	6.0	5.7	6.2
NK-1	4.7	7.0	4.0	5.3	7.3	5.7	5.7	6.0	6.3	6.3	6.2
DLFPS-340/3551	5.7	6.7	4.0	7.7	6.7	6.0	5.7	6.0	6.7	6.3	6.2
PST-K15-172	5.0	6.3	3.7	6.7	6.7	6.0	6.0	5.7	6.7	6.3	6.2
Barserati (BAR PP 110358)	6.3	5.0	3.0	7.3	6.0	6.0	6.7	6.3	6.0	6.0	6.2
A16-1	7.3	5.7	3.3	5.7	5.7	5.7	7.0	6.0	6.0	6.7	6.2
A10-280	6.0	6.7	4.3	7.0	6.0	6.3	5.7	5.7	7.0	6.3	6.2
A15-6	5.7	6.0	3.7	5.7	6.3	6.3	6.0	6.0	5.7	6.3	6.1
A06-8	6.3	6.7	4.0	6.3	7.0	6.7	5.3	5.7	5.3	6.3	6.1
A12-34	5.0	7.0	3.3	5.7	6.7	5.3	6.0	5.3	6.3	6.7	6.1
Shamrock	6.7	7.0	3.0	6.7	5.0	6.0	7.0	5.0	6.3	7.0	6.1
BAR PP 7309V	6.7	5.0	3.7	7.7	6.3	5.3	5.3	6.0	6.7	6.0	5.9
AKB3241	4.7	7.3	3.3	6.7	6.7	5.3	6.0	5.7	5.7	6.3	5.9
BAR PP 71213	6.0	4.7	3.7	8.0	5.7	6.7	6.3	5.3	6.0	5.7	5.9
A11-38	6.3	5.0	2.3	5.7	5.7	5.0	6.3	5.3	6.7	6.7	5.9
DLFPS-340/3549	5.0	5.3	3.3	6.7	7.0	5.7	5.7	5.7	5.7	5.7	5.9
PST-T14-39	5.0	6.7	2.7	7.7	6.7	4.0	6.7	5.3	6.0	6.7	5.9
DLFPS-340/3548	6.7	5.7	3.3	6.3	5.0	4.7	6.7	6.7	6.0	6.0	5.8
AKB3128	7.0	7.0	3.3	6.0	5.7	6.0	5.7	6.3	5.3	6.0	5.8
DLFPS-340/3364	5.7	7.3	4.7	6.0	5.7	5.7	5.7	6.0	5.7	6.3	5.8
PST-K13-141	6.3	6.0	3.0	5.3	6.3	5.7	5.3	6.0	5.7	6.0	5.8
PST-K13-139	5.0	7.3	4.0	6.3	6.3	5.7	5.3	5.7	5.7	6.3	5.8
DLFPS-340/3455	5.7	5.0	3.0	6.0	5.3	6.0	5.7	5.7	6.0	6.0	5.8
PST-K15-157	6.7	6.7	3.0	6.7	5.7	5.3	5.3	5.7	6.3	6.3	5.8
Orion (PST-K13-143)	5.7	6.7	2.7	7.0	5.7	5.3	5.0	6.0	6.0	6.3	5.7
BAR PP 7K426	6.3	4.7	3.3	6.3	6.7	5.3	5.0	5.7	5.7	6.0	5.7
BAR PP 7236V	6.7	4.7	3.0	7.7	5.3	5.0	6.7	5.7	5.3	6.3	5.7
AKB3179	4.3	6.3	3.3	5.7	6.3	5.7	5.7	5.3	5.0	6.3	5.7
NAI-15-80	5.7	6.3	2.7	8.3	5.3	5.0	5.0	5.3	6.3	7.3	5.7
DLFPS-340/3438	5.0	6.0	3.7	6.3	6.3	5.3	5.3	5.3	6.0	6.0	5.7
DLFPS-340/3446	6.0	5.7	4.0	6.7	6.0	5.3	5.0	5.7	5.7	6.3	5.7
Selway	6.7	5.7	2.0	7.3	5.3	4.3	5.7	5.7	6.3	6.3	5.6
PST-K15-167	4.3	7.7	4.7	6.0	5.3	5.0	5.0	5.7	6.0	6.3	5.6
NAI-14-132	5.0	7.7	3.0	6.0	7.0	4.0	4.7	4.7	6.0	7.0	5.6
Pivot	5.7	8.3	3.3	6.3	4.7	4.7	5.0	6.0	6.0	6.7	5.5

NAI-14-187	4.0	8.0	4.0	5.7	6.0	4.7	4.3	5.0	6.3	6.7	5.5
NAI-14-122	4.3	7.7	2.7	6.0	6.7	5.3	4.0	4.7	6.3	6.0	5.5
Barvette HGT®	7.7	5.7	2.3	9.0	5.0	5.0	5.7	5.3	5.7	6.0	5.4
NAI-14-128	4.0	8.0	3.7	5.7	7.3	4.7	4.3	4.3	6.3	5.3	5.4
NAI-14-133	5.3	8.0	3.7	5.0	6.3	4.7	4.0	4.7	6.7	5.7	5.3
RAD 553	5.7	5.0	2.3	6.3	5.3	5.0	5.0	5.3	5.3	5.3	5.2
NAI-14-176	5.0	6.7	3.7	5.3	7.0	4.3	4.0	5.0	5.3	5.0	5.1
MVS-130	5.3	7.3	3.0	5.0	6.3	4.0	3.7	4.3	5.0	6.0	4.9
Kenblue	7.0	4.3	2.0	5.7	4.3	3.7	6.0	5.0	4.7	4.7	4.7
$LSD_{0.05}$	1.39	1.18	1.03	1.30	1.27	1.26	1.34	1.15	1.21	1.07	0.64
CV%	15.3	10.9	18.9	11.8	12.3	13.0	13.3	11.5	11.6	10.1	6.3

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NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2015 STANDARD AND ANCILLARY LOW INPUT COOL SEASON TEST – 2019 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. Plots rated with a score of less than six are deemed unacceptable (Table 2 standard test and Table 3 ancillary test).

Percent Living Ground Cover of the Planted Species- Percent living cover ratings were taken after the growing season on September 18, 2019. (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 2019, ratings were done on July 8th and October 18th. (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 three entries for both the standard and ancillary studies were CRS Mix #3, DLFPS-TFAM, and DLFPS TFAStC. 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 (Table 1). While Yaak (100% a western yarrow) performed well in previous years, over all quality wasn't as good in 2019. For the third year in a row (2017, 2018 and 2019) 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) have been minimal since the study was established in 2015.

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 and 2019 there has been an extremely high level of weed encroachment in many of the plots. Clover is 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 and 2019 seasons has been 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.

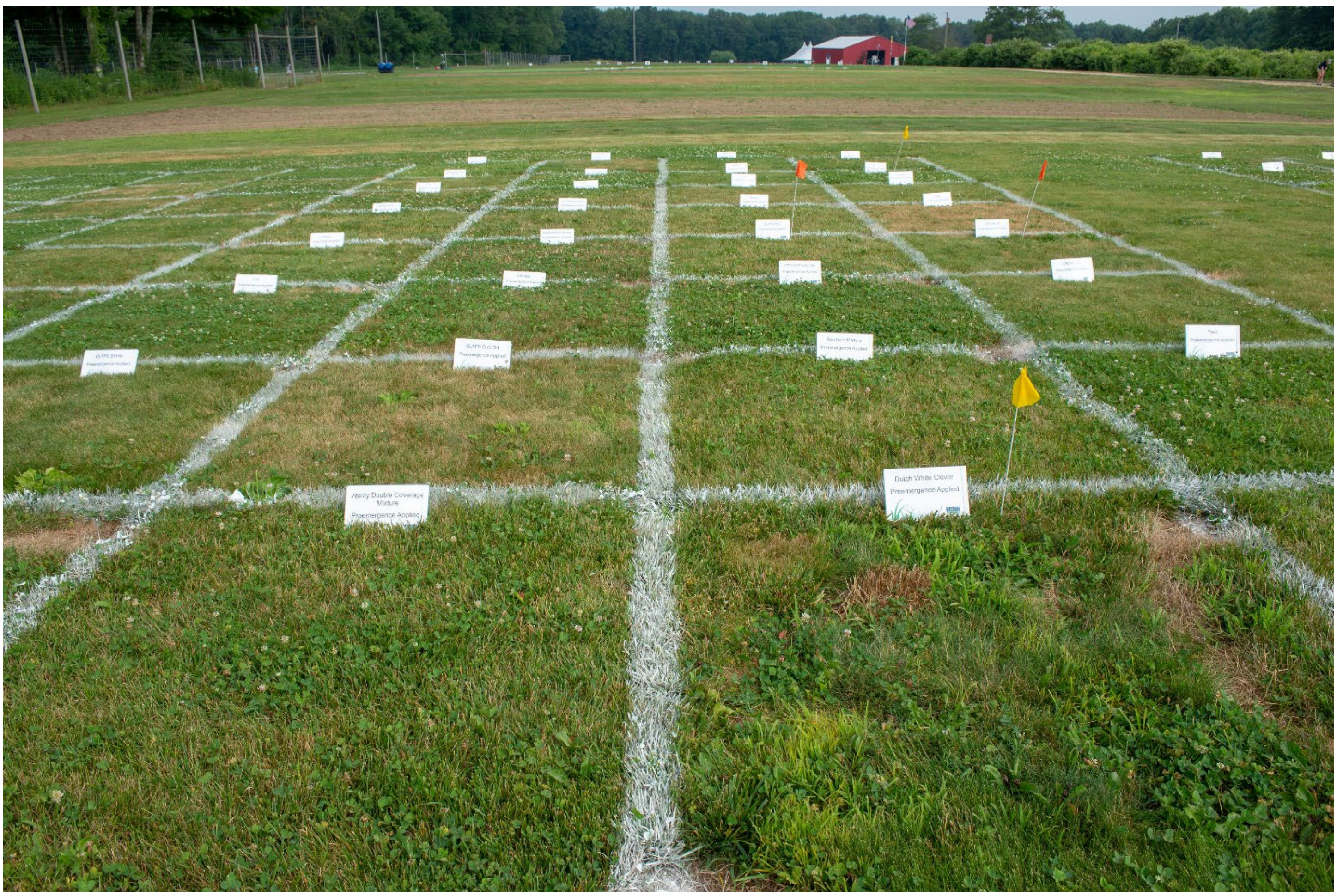

Figure 1- 2015 NTEP Low Input Cool Season Trials University of Connecticut
Photo taken July 2018

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	Resolute (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 2019 spring green-up, percent Living cover for fall, percent weed coverage for summer 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	04/16	09/18	07/08	10/18	Mean	05/25	06/28	07/31	08/21	09/18	10/18	Mean
CRS Mix #3	3.0	86.7	4.0	11.7	7.8	7.0	6.7	6.3	6.3	6.7	7.0	6.7
DLFPS-TFAM	6.3	83.3	35.0	7.7	21.3	7.0	5.7	6.3	6.0	6.3	6.3	6.3
DLFPS TFAStC	5.3	81.7	9.3	10.0	9.7	6.7	6.3	6.0	5.7	6.0	6.0	6.1
DLFPS-ChCrM	4.7	80.0	21.7	25.0	23.3	6.3	5.7	5.3	4.0	6.3	5.7	5.6
CRS Mix #1	3.3	76.7	16.7	20.0	18.3	6.0	5.3	5.3	5.0	6.0	5.7	5.6
Bullseye	5.7	55.0	51.7	18.3	35.0	6.0	4.0	5.0	5.0	5.7	6.0	5.3
CRS Mix #2	3.7	53.3	55.0	45.0	50.0	5.3	5.0	5.0	5.3	5.0	5.0	5.1
MNHD-15	3.0	56.7	36.7	48.3	42.5	5.3	4.7	5.0	5.0	5.3	5.0	5.1
BGR-TF3	6.0	68.3	26.7	25.0	25.8	6.3	5.0	4.3	3.7	5.0	5.7	5.0
Vitality Low Maintenance Mix	4.0	63.3	31.7	41.7	36.7	5.3	5.0	5.0	4.3	5.0	5.0	4.9
DTT Tall Fescue Mix	6.0	63.3	58.3	26.7	42.5	6.0	5.3	4.3	3.3	4.7	5.3	4.8
DTTHO TF/KBG Mix	5.3	50.0	35.0	51.7	43.3	5.7	4.3	4.3	4.7	5.3	4.7	4.8
Kingdom	4.7	58.3	38.3	45.0	41.7	5.3	4.7	5.0	4.0	5.0	5.0	4.8
Resolute (7H7)	4.0	63.3	48.3	40.0	44.2	5.7	5.0	5.0	4.0	4.7	4.7	4.8
DLFPS TF-A	5.0	48.3	36.7	25.0	30.8	6.7	4.7	4.3	3.0	5.0	5.0	4.8
Vitality Double Coverage Mix	5.7	48.3	45.0	31.7	38.3	5.7	4.7	5.0	4.0	4.0	5.3	4.8
DLFPS ChCrSH	5.7	70.0	36.7	30.0	33.3	5.7	5.7	4.3	3.0	5.3	4.7	4.8

A-SFT	5.7	48.3	60.0	28.3	44.2	5.7	4.0	5.0	3.7	4.7	5.3	4.7
DLFPS-ShHM	3.3	61.7	25.0	55.0	40.0	6.7	5.7	3.7	2.7	5.0	3.7	4.6
CS Mix	2.7	60.0	43.3	50.0	46.7	5.3	4.7	4.7	3.3	4.7	4.3	4.5
Radar	6.3	41.7	25.0	35.0	30.0	5.3	5.3	4.3	3.0	4.0	5.0	4.5
Southern Mixture	5.3	43.3	33.3	33.3	33.3	6.7	4.7	3.3	2.7	4.3	5.0	4.4
Ky-31 E+	4.7	36.7	26.7	40.0	33.3	5.3	5.3	5.0	2.7	2.7	4.7	4.3
Chantilly	6.3	45.0	51.7	68.3	60.0	5.7	4.0	4.3	3.3	4.0	3.3	4.1
Spartan II	3.7	53.3	51.7	56.7	54.2	5.0	4.0	4.3	3.0	3.7	3.7	3.9
Yaak	4.7	65.0	50.0	53.3	51.7	3.3	2.0	4.3	3.0	4.7	4.3	3.6
Northern Mixture	5.7	36.7	70.0	56.7	63.3	5.3	3.0	3.3	2.0	4.0	3.7	3.6
Bewitched	4.7	33.3	61.7	71.7	66.7	3.0	3.3	4.3	3.0	3.3	3.7	3.4
Quatro	3.3	38.3	63.3	85.0	74.2	4.7	4.0	4.7	1.7	3.3	2.3	3.4
Natural Knit®PRG Mix	5.3	35.0	81.7	45.0	63.3	4.7	3.3	4.0	1.7	2.7	3.3	3.3
Dutch White Clover	2.3	28.3	70.0	86.7	78.3	2.3	2.0	3.0	2.3	3.0	1.0	2.3
Kenblue	5.0	13.3	91.7	90.0	90.8	2.7	2.7	3.0	1.3	2.0	2.0	2.3
$LSD_{0.05}$	1.57	29.31	42.45	29.00	29.90	1.40	1.47	1.35	1.71	1.70	1.29	0.94
CV%	20.5	32.9	59.8	41.9	42.6	15.8	19.8	17.9	29.0	22.6	17.1	12.6

Table 3. NTEP Low Input Ancillary Test results 2019. Ratings for spring green-up, percent living cover for fall, percent weed coverage for summer 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	04/16	09/18	07/08	10/18	Mean	05/25	06/28	07/31	08/21	09/18	10/18	Mean
DLFPS TFAStC	5.3	81.7	10.0	11.7	10.8	8.0	6.3	6.7	6.0	6.3	6.7	6.7
CRS Mix #3	2.3	80.0	3.7	9.3	6.5	7.3	7.0	6.7	6.3	5.7	6.3	6.6
DLFPS-TFAM	4.7	80.0	8.3	8.3	8.3	8.0	6.7	6.7	5.7	6.3	5.3	6.4
Vitality Double Coverage Mix	5.7	53.3	26.7	15.0	20.8	6.3	6.0	6.3	5.3	5.3	6.0	5.9
DLFPS-ChCrM	5.0	75.0	10.0	8.3	9.2	6.3	6.3	6.3	4.0	6.0	6.0	5.8
CRS Mix #1	4.7	75.0	41.0	18.3	29.7	5.7	5.0	5.3	5.0	5.7	5.7	5.4
DTTHO TF/KBG Mix	5.3	61.7	58.3	40.0	49.2	5.7	6.7	5.3	4.7	4.7	5.3	5.4
Vitality Low Maintenance Mix	3.0	53.3	31.7	31.7	31.7	5.7	5.3	5.7	4.7	5.0	5.7	5.3
BGR-TF3	5.3	76.7	30.0	25.0	27.5	5.7	5.3	4.7	4.3	5.7	6.0	5.3
Bullseye	5.0	71.7	18.3	28.3	23.3	6.3	6.0	4.3	4.0	5.0	5.7	5.2
DLFPS TF-A	5.3	75.0	36.7	25.0	30.8	5.7	5.3	5.0	4.3	5.3	5.3	5.2
CRS Mix #2	3.3	76.7	26.7	26.7	26.7	5.0	4.7	5.0	4.7	5.7	5.7	5.1
MNHD-15	3.3	65.0	31.7	33.3	32.5	5.7	5.0	5.3	4.7	5.0	4.7	5.1
DLFPS-ShHM	3.0	61.7	17.0	41.7	29.3	6.3	6.0	5.3	4.0	4.0	4.3	5.0
CS Mix	4.3	50.0	23.3	35.0	29.2	6.3	5.7	4.7	3.7	4.7	4.7	4.9

Radar	4.0	58.3	28.3	28.3	28.3	6.0	4.7	5.0	3.7	5.0	4.7	4.8
Spartan II	3.0	50.0	31.7	35.0	33.3	5.3	4.7	4.7	3.7	4.7	4.7	4.6
Kingdom	4.7	50.0	48.3	40.0	44.2	5.7	4.7	5.0	3.3	4.3	4.7	4.6
DLFPS ChCrSH	4.3	66.7	35.0	40.0	37.5	6.0	5.0	4.0	3.0	4.7	4.7	4.6
A-SFT	5.0	51.7	50.0	60.0	55.0	5.3	4.3	4.0	3.7	4.7	5.0	4.5
DTT Tall Fescue Mix	5.0	51.7	35.0	56.7	45.8	5.3	5.0	4.0	3.0	4.0	4.3	4.3
Chantilly	5.7	50.0	58.3	63.3	60.8	5.7	4.7	4.3	3.0	3.7	4.0	4.2
Ky-31 E+	5.7	65.0	53.3	43.3	48.3	5.0	3.0	4.7	3.7	4.3	4.3	4.2
Southern Mixture	4.7	41.7	58.3	35.0	46.7	6.0	3.7	3.7	3.7	4.0	4.0	4.2
Resolute (7H7)	4.7	48.3	46.7	56.7	51.7	4.3	4.0	4.7	3.3	3.0	4.0	3.9
Northern Mixture	5.3	43.3	60.0	61.7	60.8	5.7	3.0	4.3	2.7	3.7	3.7	3.8
Natural Knit®PRG Mix	5.0	25.0	63.3	75.0	69.2	4.3	3.7	3.3	3.0	4.0	3.0	3.6
Bewitched	4.7	21.7	75.0	73.3	74.2	3.0	4.0	4.3	2.7	3.7	3.7	3.6
Yaak	3.3	38.3	83.3	66.7	75.0	2.0	2.3	3.0	3.0	4.0	4.0	3.1
Quatro	3.3	23.3	63.3	80.0	71.7	4.3	3.3	2.7	2.0	3.0	2.3	2.9
Kenblue	5.0	10.0	83.3	93.3	88.3	2.3	1.7	2.0	1.0	2.0	1.7	1.8
Dutch White Clover	2.0	8.3	90.0	91.7	90.8	1.0	2.0	1.7	1.0	2.0	1.7	1.6
$LSD_{0.05}$	1.51	19.62	26.25	20.75	17.87	1.09	1.35	1.09	1.51	1.36	1.11	1.11
CV%	21.0	22.1	38.5	30.0	26.0	12.5	17.5	14.4	24.6	18.3	14.8	10.1

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NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2016 PERENNIAL RYEGRASS TEST – 2019 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 that 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 2019 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 2019
5/3/19 - 0.54 oz. /1,000 ft^2 Prodiamine®. 65 WDG,
5/3/19 - Acelepryn®, .367 fl. Oz. /1,000 ft^2
5/9/19 - 1#N/m using 30-0-6 (50% SCU)
5/29/19 - Tenacity (Mesotrione 4 fl oz/A)
6/14/19 - Tenacity (Mesotrione 2 fl oz/A)
6/24/19 - 1 #N/m using 25-0-12 (60% SCU)
7/5/19 - Tenacity (Mesotrione 2 fl oz/A)
7/25/19 - Tenacity (Mesotrione 2 fl oz/A)
8/8/19 - Tenacity (Mesotrione 2 fl oz/A)
8/27/19 - Tenacity (Mesotrione 2 fl oz/A)
9/4/19 - 1#N/m using 30-0-6 (50% SCU).
11/4/19 - 1#N/m using 30-0-6 (50% SCU).

DATA COLLECTION
Spring Green-up Ratings - Spring green-up ratings were taken and recorded (Table 2) on April 16, 2019. 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 5, 2019) 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 2019 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 2019 growing season were: mean quality values for overall quality continue to illustrate that there is little diversity between cultivars. DLFPS-236/3543 had the highest mean quality rating at 7.5. However, there was no significant difference noted when comparing the top 49 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 six times in 2019 with mesotrione (Tenacity®) (see management practices)

Table 1- Sponsors and Entries 2016 NTEP Perennial Ryegrass Trial			
ENTRY	**SPONSOR**	**ENTRY**	**SPONSOR**
021	Scotts Miracle-GRO	GO-143	Grassland Oregon
Hatrick (BSP-17)	Bailey Seed and Grain	APR2612	ProSeeds Marketing
Fireball (BWH)	Bailey Seed and Grain	APR3060	Pennington
Tee-Me-Up (BSP-25)	Bailey Seed and Grain	Green Supreme+ (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	Paragon 2 GLR (FP2)	Turf Merchants
DLFPS-236/3540	DLF Pickseed USA	02BS2	Brett Young Seeds
DLFPS-236/3542	DLF Pickseed USA	Alloy (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	Paradox GLR (PPG-PR 331)	Turf Merchants
Spike GLS (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

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ASP0218 (A-6D)	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
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

Table 2. Perennial Ryegrass NTEP results 2019 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	04/16/19	06/05/19	05/25/19	06/28/19	07/29/19	8/22/209	09/18/19	10/18/19	mean
DLFPS-236/3543	6.3	7.3	7.7	6.7	8.0	7.3	7.7	7.7	7.5
APPLE 3GL (PPG-PR 339)	7.0	7.3	8.0	7.3	7.3	6.7	7.7	7.3	7.4
Homerun LS (PPG-PR 419)	6.7	6.7	8.0	7.0	7.3	7.7	7.0	7.3	7.4
PPG-PR 424	7.3	6.3	7.7	6.3	8.0	7.0	7.7	7.7	7.4
Pharaoh	7.7	7.7	7.7	6.7	8.0	7.0	7.3	7.7	7.4
Alloy (RRT	6.7	7.3	7.3	6.7	7.3	7.0	8.0	7.7	7.3
DLFPS-236-3546	7.0	7.0	7.3	6.7	7.7	7.3	7.7	7.0	7.3
DLFPS-236/3554	6.0	7.0	7.7	7.3	7.3	6.7	7.7	7.0	7.3
DLFPS-236-3547	6.7	6.0	7.7	7.0	6.7	7.3	7.0	7.7	7.2
DLFPS-236-3552	6.3	7.7	8.0	6.7	7.7	7.3	7.3	6.3	7.2
PPG-PR 421	7.0	8.0	7.3	7.0	7.3	7.3	7.3	7.0	7.2
NP-3	7.7	7.3	6.3	6.7	7.7	7.3	8.0	7.0	7.2
DLFPS-236-3550	6.7	7.0	8.0	6.7	7.7	6.7	7.0	6.7	7.1
PPG-PR 370	6.3	7.3	7.7	6.0	7.0	7.3	7.7	7.0	7.1
PPG-PR 423	7.3	7.3	7.7	7.0	6.0	7.7	7.3	7.0	7.1
PST-2FOXY	7.0	7.0	8.3	6.3	7.0	7.0	6.3	7.7	7.1
PST-2BDT	7.3	7.7	8.0	7.3	6.3	6.7	7.3	7.0	7.1
JR-197	6.7	7.0	7.7	7.0	7.0	6.7	6.7	7.7	7.1
Slugger 3GL (PPG-PR 343)	7.3	7.0	7.7	6.7	6.7	6.3	7.7	7.3	7.1
PPG-PR 420	6.3	7.3	7.3	6.7	7.0	7.3	7.0	7.0	7.1
DLFPS-236/3545	7.3	7.0	7.7	6.3	7.3	6.3	7.0	7.3	7.0
PPG-PR 422	6.7	7.3	7.7	6.7	6.7	6.3	7.0	7.7	7.0
DLFPS-236-3548	6.3	7.3	7.3	6.3	7.3	7.0	7.0	6.7	6.9
PPG-PR 360	7.0	7.7	7.7	6.7	7.3	6.7	6.3	7.0	6.9
DLFPS-236/3538	6.0	7.0	7.0	6.7	7.0	6.7	7.7	6.7	6.9
Grand Slam GLD	6.7	6.7	7.0	7.0	6.7	6.0	7.3	7.7	6.9
PST-2GTD	6.7	7.7	7.3	7.3	6.7	7.0	6.7	6.7	6.9
CPN	6.0	6.7	7.0	6.3	7.0	6.7	7.3	7.3	6.9
DLFPS-236/3542	7.0	7.3	8.0	6.7	6.3	5.7	7.7	7.0	6.9
PL2	6.7	7.7	7.7	5.7	6.3	6.7	7.7	7.3	6.9
Shield (02BS4)	6.7	7.3	7.3	6.7	6.3	6.7	7.3	7.0	6.9
PPG-PR 371	6.7	6.7	8.0	7.0	6.0	7.0	6.7	6.7	6.9
DLFPS-236/3544	7.0	7.0	7.0	5.7	7.3	6.7	7.3	7.0	6.8
Signet	7.3	6.0	7.7	6.3	7.0	6.3	7.3	6.3	6.8
PST-2A2	6.0	6.3	7.3	6.3	6.7	6.3	7.3	7.0	6.8
DLFPS-236/3541	6.0	7.7	7.3	7.0	6.3	6.3	6.7	7.0	6.8

Slider SL (PPG-PR 241)	6.7	7.7	7.7	6.7	6.7	6.0	6.7	7.0	6.8
Overdrive 5G	6.3	7.0	7.7	6.0	6.3	6.0	8.0	6.7	6.8
02BS2	7.3	6.0	6.7	6.7	6.3	6.7	7.0	7.0	6.7
Paradox GLR (PPG-PR 331)	7.0	6.7	6.3	6.3	6.7	6.7	7.0	7.3	6.7
PPG-PR 367	7.7	7.3	7.0	6.7	6.0	7.0	6.7	7.0	6.7
UMPQUA	6.3	7.0	6.7	6.0	6.3	6.0	7.7	7.7	6.7
Seabisquit	7.7	6.0	7.3	6.3	6.3	6.0	7.7	6.7	6.7
Xcelerator	7.3	7.3	7.7	6.0	6.7	6.0	7.0	6.7	6.7
ASPO118GL (A-4G)	6.0	8.0	8.0	6.7	6.7	5.7	6.7	6.3	6.7
APR2616	6.0	7.3	7.3	7.3	6.0	6.3	7.7	5.3	6.7
PR-6-15	6.7	6.7	7.3	6.3	6.0	6.7	6.7	7.0	6.7
PPG-PR 372	7.3	6.7	7.3	6.7	6.7	5.7	6.3	7.3	6.7
Furlong (LTP-FCB)	6.3	7.0	7.3	7.3	6.0	6.0	6.3	7.0	6.7
Gray Wolf (PST-2GAL)	7.0	7.0	7.7	6.7	6.0	5.7	7.3	6.7	6.7
DLFPS-236/3540	7.7	7.0	6.7	6.7	7.0	5.7	7.0	6.7	6.6
JR-123	6.7	6.7	7.3	7.0	6.7	5.7	6.3	6.7	6.6
PST-2MAY	7.0	6.7	7.3	5.7	6.7	6.0	7.3	6.7	6.6
Spike GLS (UF3)	6.0	6.3	8.0	6.3	6.0	5.7	6.7	6.7	6.6
Man O"War	6.0	6.7	7.3	6.3	5.0	6.3	7.0	7.3	6.6
Intense	7.0	7.3	7.0	7.0	5.7	6.3	6.3	6.7	6.5
Fasstball 3GL (PPG-PR 329)	7.0	7.0	7.3	6.7	6.0	6.0	6.3	6.7	6.5
PR-5-16	6.7	6.7	7.3	5.7	6.7	6.0	6.7	6.7	6.5
21	6.3	7.0	7.3	6.7	6.0	6.0	6.3	6.3	6.4
Derby Xtreme	6.0	7.7	8.0	6.3	5.0	5.7	6.3	7.3	6.4
PPG-PR 385	5.7	6.7	7.3	6.3	6.3	6.3	6.7	5.7	6.4
SR4650	6.0	6.0	7.3	5.7	6.0	6.7	6.7	6.3	6.4
PST-2EGAD	6.7	7.3	7.3	6.7	5.7	6.0	6.3	6.7	6.4
Allstar III	7.3	6.7	7.7	6.3	6.3	5.3	6.7	6.3	6.4
LPB-SD-102	5.0	6.3	7.0	5.3	6.7	5.7	7.0	6.7	6.4
DLFPS-236-3556	6.7	7.0	6.3	6.7	6.3	5.3	7.0	6.7	6.4
GO-142	6.0	8.0	8.0	5.7	5.7	6.0	6.7	6.3	6.4
23	7.0	6.7	6.7	6.0	6.7	6.0	7.0	6.0	6.4
Karma	6.0	6.7	7.3	6.7	6.3	6.0	6.3	5.7	6.4
ASP0218 (A-6D)	6.7	8.0	7.0	6.0	6.3	5.7	6.3	6.7	6.3
NP-2	7.0	7.0	7.3	7.3	6.3	5.0	5.3	6.7	6.3
GO-141	6.7	7.7	7.7	5.7	5.7	6.0	7.0	6.0	6.3
LPB-SD-101	5.3	6.3	7.0	5.7	6.7	5.0	7.3	6.0	6.3
Evolve	6.7	6.7	7.7	6.0	6.0	5.7	6.3	6.0	6.3

BAR LP 6164	7.3	7.0	7.3	5.3	6.0	6.3	6.7	6.0	6.3
02BS1	7.0	7.0	7.3	5.7	6.3	5.0	6.7	6.7	6.3
Mensa	5.3	7.0	6.7	6.0	6.0	4.7	7.3	6.3	6.2
Paragon 2 GLR (FP2)	7.0	7.0	7.0	5.3	6.0	5.7	6.3	6.7	6.2
BAR LP 6117	5.7	6.7	7.3	6.0	5.3	6.3	6.3	5.7	6.2
ASPO 117 (A-PR15)	7.0	7.3	7.0	5.7	5.7	5.7	6.7	6.0	6.1
Silver Sport (PST-2CRP)	6.3	7.7	7.7	6.7	4.7	5.0	6.3	6.3	6.1
Gray Hawk (PST-2FIND)	6.3	6.3	7.0	5.3	5.7	5.7	6.7	6.3	6.1
DLFPS-236/3553	5.7	6.7	6.7	5.7	6.0	5.7	6.0	6.7	6.1
APR3060	6.7	7.3	7.3	7.0	5.7	5.3	5.7	5.3	6.1
PST-2PDA	7.3	6.3	7.0	6.0	5.0	5.7	6.3	6.3	6.1
Savant	5.3	6.3	7.3	5.7	6.3	4.7	6.0	6.0	6.0
GO-143	6.0	7.7	7.3	6.3	5.3	5.0	6.0	6.0	6.0
Green Supreme+ (AMP-R1)	7.3	8.0	7.3	5.3	6.0	6.3	5.0	6.0	6.0
BAR LP 6233	6.3	6.3	6.0	6.0	6.3	6.0	6.0	5.7	6.0
Pepper II (RAD-PR-103)	6.7	8.7	7.3	6.7	5.0	5.3	5.7	6.0	6.0
Hatrick (BSP-17)	6.3	9.0	7.3	5.0	6.0	6.0	5.7	5.7	5.9
Saguaro	6.3	6.3	7.3	6.0	5.0	5.0	6.0	6.3	5.9
MRSL-PR15	6.3	8.0	7.3	6.0	5.3	5.0	6.0	6.0	5.9
CS-6	6.0	7.7	6.7	5.7	5.0	5.7	6.3	6.3	5.9
APR2612	6.0	8.0	7.3	5.7	5.3	5.3	6.0	6.0	5.9
BAR LP 6159	6.0	7.0	7.3	6.0	5.7	5.0	6.3	5.3	5.9
LPB-SD-104	5.0	7.7	7.0	5.3	6.3	4.7	6.3	5.7	5.9
LPB-SD-103	6.7	7.0	7.0	5.3	5.7	4.3	6.7	6.3	5.9
JR-747	5.0	7.0	6.7	6.0	6.0	4.7	6.3	5.7	5.9
ASP0116EXT	6.0	9.0	7.0	6.0	5.0	5.0	6.0	6.0	5.8
BAR LP 6131	5.7	6.0	7.7	5.3	4.7	6.0	6.0	5.3	5.8
Fireball (BWH)	6.7	9.0	7.7	5.7	4.7	5.0	5.3	6.3	5.8
BAR LP 6158	6.7	6.3	6.7	6.0	5.0	5.0	6.3	5.7	5.8
DLFPS-238/3014	5.7	6.0	7.3	6.7	5.7	5.0	5.3	4.7	5.8
JR-888	6.3	6.0	7.3	6.7	5.3	3.7	5.3	6.0	5.7
BAR LP 6162	4.7	8.0	7.3	6.3	5.7	4.7	5.0	5.3	5.7
Tee-Me-Up (BSP-25)	5.3	9.0	7.3	6.0	5.3	5.0	5.3	5.0	5.7
RAD-PR-112	5.3	8.3	7.0	5.3	4.7	5.0	5.3	6.3	5.6
Brightstar SLT	6.0	5.7	7.3	5.3	5.0	5.3	5.7	5.0	5.6
LPB-SD-105	4.7	6.3	6.0	5.3	6.3	4.3	5.3	5.7	5.5
MRSL-PR16	6.3	7.0	6.7	4.7	5.0	5.0	5.3	6.3	5.5
SNX	6.0	8.0	6.3	5.0	4.7	5.0	6.3	5.7	5.5

BAR LP 6165	6.0	5.0	6.0	5.0	5.3	4.7	5.0	5.0	5.2
Linn	5.3	2.0	4.0	4.0	3.0	3.3	4.0	4.0	3.7
$LSD_{0.05}$	1.22	1.22	1.09	1.18	1.62	1.39	1.30	1.16	0.75
CV%	11.7	10.8	9.3	11.7	16.3	14.5	12.1	11.1	7.2

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2019 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, Lebanon Turf Products, Landmark Turf & Native Seed, and DLF Pickseed USA. 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 9, 2019 and received 1#N/1,000 ft^2 of a 50% slow 30-0-6, applied in 2 directions. Prodiamine was applied on 5/3/2019 at the rate of .55 fl oz/m. Supplemental irrigation was applied as needed during establishment in 2017 and in the spring of 2018. No supplemental irrigation was needed in 2019.

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 quality and green cover ratings are provided in Tables 2 and 3.
Additionally, digital image analysis (DIA) was captured **8** times during the growing season (4/24/19, 5/22/19, 6/27/19, 7/19/19, 8/14/19, 9/16/19, 10/16/19, 11/6/19) 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 2019 Kentucky bluegrass ALIST test ranged from 6.6 – 5.2 with LSD of .45.

Little diversity in turf quality was evident between the cultivars of the top statistical group, which included 5321, Martha (A06-46), LTP-11-41, SRX-2758, Fullback, A11-38, Merlot, SRX-466, A11-40 and Zinfandel**.** Bordeaux exhibited the poorest turf quality.

The top statistical group of cultivars with the highest mean percent green cover included Martha (A06-46), SRX-2758, Zinfandel, A11-40, 5321, SRX-466, Bluebank, Fullback, A12-34, Merlot, and Legend. MVS-130 exhibited the poorest mean for percent green cover.

Table 1. Kentucky Bluegrass, Cultivars and Sponsors

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	

Table 2. Kentucky Bluegrass ALIST Results 2019 (Sorted by Highest Quality)

		Quality								
Entry no.	Entry	04/24	05/22	06/27	07/19	08/14	09/16	10/16	11/06	Mean Quality
12	5321	5.8	6.0	6.3	7.5	6.8	6.5	7.0	6.8	**6.6**
17	LTP-11-41	6.0	6.8	6.5	7.5	6.5	6.3	6.5	6.0	**6.5**
23	Martha (A06-46)	6.0	6.3	7.0	7.5	6.5	5.8	6.3	6.3	**6.4**
8	SRX-2758	6.0	6.3	7.0	6.5	6.0	6.3	6.5	6.8	**6.4**
10	Fullback	6.0	6.5	6.8	6.5	6.0	6.3	6.0	6.0	**6.3**
11	A11-38	6.0	7.0	7.3	7.0	5.8	5.3	5.5	6.0	**6.2**
13	Merlot	5.8	5.5	6.3	7.0	6.3	6.5	6.0	6.3	**6.2**
20	SRX-466	6.3	6.5	6.8	6.8	5.8	5.8	6.0	5.8	**6.2**
21	A11-40	6.3	7.0	7.0	6.8	5.8	5.3	5.5	6.0	**6.2**
9	Zinfandel	5.0	5.3	6.3	7.0	6.5	6.5	6.5	6.3	**6.2**
18	A12-7	6.0	6.5	6.5	6.3	5.3	6.3	6.0	6.3	**6.1**
19	PPG-KB 1320	5.0	5.0	6.3	6.5	5.5	6.0	6.5	6.3	**5.9**
16	Jackrabbit	6.5	6.5	6.5	6.3	4.8	4.8	5.8	5.5	**5.8**
2	Hampton	6.0	6.3	6.5	6.8	5.5	5.0	5.0	5.3	**5.8**
22	Legend	5.5	5.3	6.3	6.5	5.5	5.5	5.8	5.8	**5.8**
3	PPG-KB 1131	5.0	5.0	6.0	6.3	5.0	6.0	6.3	6.3	**5.7**
4	Keeneland	5.8	5.5	6.3	6.0	5.3	5.0	5.8	6.0	**5.7**
7	A12-34	5.3	5.0	6.5	6.0	5.8	6.0	5.5	5.5	**5.7**
1	Champagne	6.0	6.3	6.0	5.8	5.0	5.0	5.5	5.5	**5.6**
14	NAI-13-14	5.0	5.0	5.5	5.5	4.8	5.8	6.5	6.5	**5.6**
15	MVS-130	5.0	5.8	5.8	5.8	5.0	5.3	6.0	6.0	**5.6**
6	Bluebank	5.0	5.0	5.5	5.8	5.0	5.5	6.3	6.3	**5.5**
5	Bordeaux	5.0	5.3	5.8	5.8	5.0	4.8	4.5	5.3	**5.2**
	$LSD_{0.05}$	**0.43**	**0.70**	**0.78**	**0.97**	**0.87**	**0.73**	**0.84**	**0.90**	**0.45**
	CV%	**5.4**	**8.4**	**8.7**	**10.6**	**11.0**	**9.1**	**10.0**	**10.6**	**5.3**

Acknowledgements: This project is funded by the Alliance for Low Input Sustainable Turf (ALIST).

Table 3. Kentucky Bluegrass ALIST Results 2019 (Sorted by Percent Green Cover)

		Percent Green Cover								
Entry no.	Entry	04/24	05/22	06/27	07/19	08/14	09/16	10/16	11/06	**Mean Green Cover**
23	Martha (A06-46)	50.4	97.4	86.8	73.8	64.0	70.0	72.2	62.0	**72.1**
8	SRX-2758	63.0	95.4	80.5	71.6	61.5	74.2	68.1	60.2	**71.8**
9	Zinfandel	52.3	96.9	86.2	70.8	70.6	78.3	66.7	51.4	**71.6**
21	A11-40	66.0	97.8	82.5	70.4	58.0	73.1	68.2	56.2	**71.5**
12	5321	44.0	95.8	80.8	74.4	74.2	75.5	67.6	52.8	**70.6**
20	SRX-466	63.9	96.3	79.4	67.7	59.4	69.3	67.7	54.5	**69.8**
6	Bluebank	56.0	95.7	82.9	66.0	61.5	76.2	63.4	50.1	**69.0**
10	Fullback	62.9	96.3	78.9	69.8	58.7	67.0	64.2	53.8	**68.9**
7	A12-34	56.6	95.7	77.4	64.2	59.5	71.0	67.2	59.5	**68.9**
13	Merlot	52.3	96.3	81.3	70.5	63.1	73.4	62.5	48.8	**68.5**
22	Legend	52.5	96.5	81.2	66.5	63.0	71.8	60.1	50.4	**67.7**
3	PPG-KB 1131	52.9	97.0	84.1	63.7	53.0	74.8	60.4	50.7	**67.1**
14	NAI-13-14	56.9	97.1	81.9	57.2	51.8	78.4	59.7	51.7	**66.8**
19	PPG-KB 1320	43.7	93.5	80.4	64.8	54.9	69.6	66.6	58.0	**66.4**
4	Keeneland	59.9	97.0	80.8	60.7	48.9	64.8	63.4	52.5	**66.0**
1	Champagne	67.1	94.9	69.6	55.9	47.8	68.7	63.2	52.7	**65.0**
17	LTP-11-41	55.6	97.4	73.7	63.1	55.8	66.5	59.2	45.7	**64.6**
2	Hampton	53.4	95.8	81.2	64.9	50.5	70.4	52.7	41.7	**63.8**
5	Bordeaux	56.7	97.0	77.3	59.0	55.7	69.2	47.9	43.6	**63.3**
11	A11-38	52.3	96.1	74.5	68.6	56.4	62.5	53.6	41.0	**63.1**
18	A12-7	58.6	95.7	72.3	57.7	48.9	57.4	59.3	52.5	**62.8**
16	Jackrabbit	62.9	94.5	74.4	58.0	46.4	57.5	58.8	49.7	**62.8**
15	MVS-130	50.4	92.9	73.2	51.9	36.0	56.6	57.0	50.4	**58.5**
	$LSD_{0.05}$	**8.97**	**2.30**	**5.43**	**9.65**	**12.57**	**7.57**	**10.25**	**10.83**	**4.79**
	CV%	**11.3**	**1.7**	**4.9**	**10.5**	**10.5**	**7.7**	**11.7**	**14.8**	**5.1**

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DEVELOPMENT OF CROWN RUST RESISTANT PERENNIAL RYEGRASS USING MUTATION BREEDING

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ABSTRACT

Perennial ryegrass (*Lolium perenne* L.*)* is an important cool-season turfgrass species, which is widely cultivated around the world. Crown rust caused by *Puccinia coronata* f. sp. *lolii*, is one of the destructive species in perennial ryegrass for both turfgrass and pasture. Fungicide application is one of the effective methods to control crown rust in perennial ryegrass, but this approach is pollutive and expensive. Therefore, breeding crown rust resistant cultivars of perennial ryegrass may provide a better solution. The dwarf perennial mutant was isolated from a mutagenized M1 seedling population, derived from FN radiated seeds and named as FNA3. Under field conditions, the dwarf mutant was found crown rust resistant compare to wild type and named as FNA3-RR. Backcross 1 (BC1) and Backcross 2 (BC2) populations were developed, by crossing with wild type plants one and two times respectively, to confirm crown rust resistance in the next generations and study genetic analysis. Crown rust resistance was observed in BC1 and BC2 generations as well, which suggests crown rust resistance is heritable in the FNA3-RR mutant. It was also observed that crown rust is not associated with dwarfism in the FNA3-RR mutant. FNA3-RR mutant may provide valuable resources for understanding the genetic basis of crown rust resistance and breeding crown rust resistant perennial ryegrass cultivar.

INTRODUCTION

Perennial ryegrass (*Lolium perenne* L.) is one of the most popular and important bunch type cool-season turfgrass species (Jiang and Huang 2001; Grinberg et al., 2016). Because of its quick establishment, attractiveness, and good leafy appearance, it is grown in many diverse areas such as residential lawns, national parks, athletic fields, and golf course fairways. In addition, perennial ryegrass germinates quickly, establishing a lawn prior to the germination of other turf species. At present, perennial ryegrass has been introduced to all parts of the world (Thorogood, 2003). However, the grass is only moderately resistant to heat, cold, fungal diseases, drought, salt, and sulfur dioxide stresses (Beard and Beard, 2005).

Rust diseases caused by *Puccinia* species are among the most economically important diseases of wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), oat (*Avena sativa*), and some turfgrass species (Bockus et al., 2010). Crown rust caused by *Puccinia coronata* f. sp. *lolii*, is one of the destructive species in perennial ryegrass. Perennial ryegrass crown rust symptoms typically appear as circular orange or yellow-colored pustules on the leaves. *Puccinia coronata* is a heteroecious macrocyclic fungus that requires an alternate host, the common barberry (*Berberis vulgaris*), to complete the life cycle.
Crown rust infection on the perennial ryegrass makes it very unattractive and unhealthy, as a result, it becomes unacceptable to those who use these plants. If infected plants do not get chemical treatment, crown rust can eventually lead to stunting and thinning of the turfgrass plant (Smiley et al. 2005). As a consequence, crown rust is not only harmful to perennial ryegrass, but also seed production and pasture industries. Chemical treatment increases the cost of turfgrass maintenances and residues pollute the environment. In addition, chemical applications are restricted in some parts of the world. Therefore, the most efficient, cost-effective and environmentally friendly method to protect perennial ryegrass from crown rust diseases is by creating resistant cultivars.

Mutation breeding have been very helpful to create new traits in perennial ryegrass. Using the mutation breeding method, prostrate growth, dwarf, and shade tolerant perennial grass cultivars have been developed (Chen et al., 2016, Li et al., 2017). Furthermore, dwarf plants have been developed in centipedegrass (Dickens et al., 1981), bermudagrass (Lu et al., 2009, Baharun et al., 2016) and St. Augustinegrass (Li et al., 2010, Cakir et al., 2017) through mutation breeding. Baharun et al., (2016) successfully developed dwarf slow growing bermudagrass using gamma radiations. They isolated other turfgrass quality mutants with desired traits such as narrow leaf blades, dark green color, and high-density mutants. Mutlu and Djapo, (2016) also developed dwarf and narrow leaf blade cultivars in St. Augustinegrass through gamma radiation.

Dwarf perennial ryegrass mutant (FNA3) was isolated from the fast-neutron (FN) mutagenized M1 perennial ryegrass population. This mutant was found crown rust resistant under field conditions which was named FNA3-RR. Crown rust resistant perennial ryegrass could be very useful for the turfgrass industry. Dwarf perennial ryegrass could reduce mowing frequencies as well. Perennial ryegrass cultivars with possessing these two traits together will be tremendously economical for the US turf industry from the perspective of the maintenance cost, and time.

MATERIALS & METHODS

Fast-neutron mutagenesis

The perennial ryegrass mutation breeding program was started in our lab using one of the best perennial ryegrass cultivar ‘Fiesta 4’. ‘Fiesta 4’ perennial ryegrass wet seeds were irradiated with 1.0 kr of FN. The irradiated seeds (M0) were air-dried for 12 h and stored at 4°C. FN treated M1 seeds were sown in the farm at a density of 1.5 kg per 100 square meters with broadcast spreader machine and grown to maturity at the University of Connecticut, Plant Science Research and Education Facility in Storrs, CT, USA. Fields were watered and fertilized as needed and seeds (M1) were harvested at the end of seed maturity. They were air-dried at room temperature and were stored at 4 °C for the next experiments.

Identification of dwarf mutants

A total of 300,000 M1 seeds were evaluated in the 30 X 60 cm shallow black germination trays, containing Promix potting soil. Before germinating mutagenized seeds in the trays, seeds were soaked with 300 µM gibberellic acid (GA3) solution to obtain uniform germination. After 10 h soaking, GA3 solution was removed and seeds were kept at 4 ºC for 14 days to make uniform germination. Cold-treated seeds were germinated and grown on moist paper towels at 25°C under a 16 h light cycle (35–45 $\mu mol \cdot m^{-2} \cdot s^{-1}$) for two weeks. When plants reached the three-leaf stage, dwarf mutant plants were identified. Putative dwarf plants were transferred to plug trays (28 X 56 cm and 7.62 cm deep) containing Promix potting soil and allowed to grow in the greenhouse at 20 - 25°C under natural light. Plants were given fertilizer every 14 days with a 0.12% 20-20-20 (N-P-K) solution and irrigation as needed. After five weeks of growth, the putative dwarf mutant was confirmed.

Observation of crown rust resistance in M1 FNA3-RR mutant and population development

The dwarf mutant was planted on the field with 6 replications along with wild type. During our field experiment, we observed the mutant was crown rust resistant compare to wild under natural conditions in 2017 which was named FNA3-RR. Dwarf phenotype in the FNA3 mutant was named as FNA3-D. FNA3-RR mutant was backcrossed with wild type one and two times to develop backcross 1 (BC1) and backcross 2 (BC2) respectively, to confirm crown rust resistance in subsequent generations. BC1 and BC2 crosses were made in 2018 and 2019 on the field.

Crown rust screening of BC1 and BC2 populations

Twenty BC1 plants along with 6 each wild type and FNA3-RR mutant were planted on the field in 2018 for crown rust reaction evaluation. In 2019, 211 BC2 progenies along with 24 wild type and 6 FNA3-RR mutants were planted for crown rust screening. Crown rust resistance reactions were categorized into two category resistance and susceptible. Plants with no visible crown rust symptoms or very small pustules categorized resistant and plants having with medium and large-sized pustules covering a large part of the leaves categorized as susceptible.

RESULTS

Crown rust resistance transmitted to the next generation

To confirm the transmissibility of crown rust resistance in FNA3-RR mutant, BC1 and BC2 progenies were evaluated on the field under natural conditions in 2019. In the BC1 progenies, out of 20 plants, 9 were resistant and 11 susceptible (Table1). Chi square test confirms that this ratio fits to be expected 1:1 Mendelian genetic ratio. In the 211 BC2 progenies, 60 plants were resistant and 151 susceptible (Table-2). In BC2 as well, Chi square test confirms that this ratio fits to be expected 1:3 Mendelian genetic BC2 ratio. FNA3-RR mutant showed resistance, while wild type susceptibility. These results indicate that crown rust resistance is transmissible to the next generations and genetically controlled by a dominant gene (Figure-1).

Table-1: List of crown rust responses of WT, FNA3-RR, and BC1 progenies: WT, FNA3-RR, and BC1 progenies were planted on the field for natural crown rust infections in 2019. Disease responses were recorded in September 2019.

Crown Rust Responses	WT	M1 FNA3-RR	FNA3-RR BC1 Progenies
Resistant	0	6	9
Susceptible	6	0	11
Total	6	6	20

Table-2: List of crown rust responses of WT, FNA3-RR, and BC2 progenies: WT, FNA3-RR, and BC2 progenies were planted on the field for natural crown rust infections in 2019. Disease responses were recorded in September 2019.

Crown Rust Responses	WT	M1 FNA3-RR	FNA3-RR BC2 Progenies
Resistant	0	6	60
Susceptible	24	0	151
Total	24	6	211

Dwarfism and crown rust resistance are not genetically linked

Phenotypic analysis of BC2 progenies was done to understand the relationship between dwarfism and crown rust resistance. Out of 60 crown rust resistant mutants, 33 were dwarf and 27 plants had wild type height, meaning dwarfism and crown rust resistance are not linked together in FNA3-RR mutant (Table-3). These results suggest that dwarfism and crown rust resistance segregate independently, which means they are controlled by separate genes.

Table-3: List of the 60 BC2 crown rust resistant plants for their height: Plants height were measured of the 60 BC2 crown rust resistant plants on the field in 2019.

Rust Responses	Number of WT normal height plants	Number of FNA3-D dwarf height plants	Total
Resistant	27	33	60

WT (Susceptible) M1 FNA3-RR (Resistant)

Susceptible BC2 Progeny Resistant BC2 Progeny

Figure 1: Crown rust phenotype on the field: BC2 progenies, WT, and M1 FNA3-RR mutant were planted on the field in May 2019. Crown rust responses were recorded in September 2019. Wild type plants were susceptible to crown rust, whereas, M1 FNA3-RR mutant plants showed resistance. In FNA3-RR BC2 progenies, 60 plants had resistance and 151 were susceptible.

CONCLUSIONS

Breeding perennial ryegrasses with crown rust resistance is one of the most important objectives in the breeding programme. Crown rust is one of the most damaging foliar diseases of the perennial ryegrasses which deteriorate turf quality. In the present experiment, using the mutation breeding method, we developed crown rust resistant perennial ryegrass. Our crown rust resistant mutant could be very useful to protect perennial ryegrass from this disease. *Puccinia coronata* fungus evolves very fast due to the high rate of mutations, as results, resistant cultivars become susceptible to this disease (Dracatos et al., 2010). New crown rust resistant cultivar could be useful if a new race of *Puccinia coronata* fungus breaks the resistance of other cultivars. In addition, the FNA3-RR mutant has very strong rust resistance which could be more useful than exiting resistance available in the cultivars. Our results also confirmed that dwarfism and crown rust resistance are not linked together in the FNA3-RR mutant. There, it is possible that FN mutagenesis have induced another dominant mutation in the crown rust controlling gene which have made FNA3-RR mutant rust resistant. Crown rust resistant perennial ryegrass will be helpful to reduce chemical applications that could save money and protect the environment. In addition, dwarfism in the perennial ryegrass mutant could reduce mowing frequencies, fertilizer applications, and water use.

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CORRELATIONS BETWEEN TWO ALKALI EXTRACTABLE AMINO-NITROGEN TESTS AND RESPONSE TO ORGANIC FERTILIZER IN TURFGRASS SOILS

Moore, D.B., K. Guillard, X. Geng, T.F. Morris, and W.F. Brinton. 2019. Correlations between two alkali extractable amino-nitrogen tests and response to organic fertilizer in turfgrass soils. Soil Sci. Soc. Am. J. 83:791–799. doi:10.2136/sssaj2018.10.0371

ABSTRACT

The Illinois soil nitrogen (N) test (ISNT) and the Solvita Labile Amino-Nitrogen (SLAN) test are chemical analyses that estimate the concentrations of soil labile N. The SLAN uses the same reagent as the ISNT but is a relatively new test with limited field data available. This study was conducted across 6 yr (2008–2013) to determine if concentrations of SLAN–N and ISNT–N are correlated in soils under predominantly Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.) lawn turf and to compare the response of SLAN–N and ISNT–N concentrations in relation to varying organic fertilizer rates. Separate randomized complete block field experiments were established in Connecticut on the two species with varying rates of an organic fertilizer to create a wide range of labile soil N concentrations. Soil samples were collected in the spring of each year and analyzed for concentrations of ISNT–N and SLAN–N. For all years and each species, and for pooled years and species, SLAN–N concentrations were positively and significantly ($p < 0.05$) correlated with ISNT–N concentrations. Correlations were strongest ($r > 0.80$) at Year 6 of the study. Furthermore, SLAN–N and ISNT–N concentrations increased linearly ($p < 0.05$) in response to organic fertilizer rate, but the rate of change was greater for ISNT–N. The data suggest that the SLAN test is generally well correlated with the ISNT and may offer an easy and rapid soil analysis to guide N fertilization.

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PREDICTING COOL-SEASON TURFGRASS RESPONSE WITH SOLVITA SOIL TESTS, PART 1: LABILE AMINO-NITROGEN CONCENTRATIONS

Moore, D.B., K. Guillard, X. Geng, T.F. Morris, and W.F. Brinton. 2019. Predicting cool-season turfgrass response with Solvita soil tests, Part 1: Labile amino-nitrogen concentrations. Crop Sci. 59:1779–1788. doi:10.2135/cropsci2018.11.0706

ABSTRACT

Current turfgrass fertilizer recommendations do not account for potential mineralizable N in the soil. The Solvita Soil Labile Amino-Nitrogen (SLAN) test measures a labile fraction of soil N. This study was conducted across 9 yr (2008–2016) in Connecticut to determine if responses from predominately Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.) lawns are correlated to SLAN–N concentrations, and to determine the probability of turfgrass responses equaling or exceeding the response from benchmark urea rates in relation to SLAN–N concentrations. Randomized complete block design field experiments were set out with 23 rates of an organic fertilizer (0–2000 kg N ha^{-1} yr^{-1}) and four different rates of urea (50, 100, 150, and 200 kg N ha^{-1} yr^{-1}). Yearly spring soil samples were analyzed for SLAN–N concentrations, and turfgrass growth and quality responses were collected during the growing seasons. Turfgrass responded positively and linearly ($P < 0.001$) to SLAN–N concentrations, but correlations were relatively weak to moderate. When spring soil SLAN–N concentrations were ≥158, 165, 198, and 217 mg kg^{-1}, there was a ≥90% probability that overall combined responses across species and measured variables would be equal to or greater than responses obtained from 50, 100, 150, and 200 kg urea N ha^{-1} yr^{-1}, respectively. The SLAN test has promise as an objective soil test to categorize the N fertilization response potential of turfgrass soils, and this would be helpful in guiding N fertilization.

PREDICTING COOL-SEASON TURFGRASS RESPONSE WITH SOLVITA SOIL TESTS, PART 2: CO_2-BURST CARBON CONCENTRATIONS

Moore, D.B., K. Guillard, T.F. Morris, and W.F. Brinton. 2019. Predicting cool-season turfgrass response with Solvita soil tests, Part 2: CO_2-burst carbon concentrations. Crop Sci. 59:2237–2248. doi:10.2135/cropsci2018.11.0707

ABSTRACT

Current turfgrass fertilizer recommendations do not account for plant-available soil N mineralized from labile C fractions. The Solvita Soil CO_2–Burst (SSCB) test can measure mineralizable C via soil CO_2 respiration. This study was conducted across 3 yr (2014–2016) in Connecticut to determine: (i) if SSCB–C concentrations are correlated to responses from predominately Kentucky bluegrass (*Poa pratensis* L.) and tall fescue [*Schedonorus arundinaceus* (Schreb.) Dumort.] lawns, and (ii) the probability of turfgrass responses being equal or greater than responses from common urea rates in relation to SSCB–C concentrations. Randomized complete block design field experiments were set out with 23 rates of organic fertilizer (0–2000 kg N ha^{-1} yr^{-1}) and four different rates of urea (50, 100, 150, and 200 kg N ha^{-1} yr^{-1}). Yearly spring soil samples were analyzed for SSCB–C concentrations and correlated with turfgrass responses. Growth and quality responded positively and linearly ($P < 0.001$) to SSCB–C concentrations, but variability was high and correlations were relatively weak. When spring soil SSCB–C concentrations were □91, 113, 166, and 211 mg kg^{-1} there was a ≥90% probability that overall combined responses across species and variables would be equal to or greater than responses obtained from urea rates of 50, 100, 150, and 200 kg N ha^{-1} yr^{-1}, respectively. The SSCB test has promise for predicting the probability of soils supporting turfgrass whose performance equals or exceeds benchmark values. This would be helpful in guiding N fertilization, but high variability within the test may limit its predictive ability.

CORRELATION BETWEEN SOLVITA LABILE AMINO-NITROGEN AND CO_2-BURST SOIL HEALTH TESTS AND RESPONSE TO ORGANIC FERTILIZER IN A TURFGRASS SOIL

Moore, D.B., K. Guillard, T.F. Morris, and W.F. Brinton. 2019. Correlation between Solvita labile amino-nitrogen and CO_2-burst soil health tests and response to organic fertilizer in a turfgrass soil. Commun. Soil Sci. Plant Anal. 50:2948–2959. doi:10.1080/00103624.2019.1689258

ABSTRACT

The Solvita Soil Labile Amino-Nitrogen (SLAN) and Soil CO_2-Burst (SSCB) tests are used in soil health assessments. Field experiments were conducted from 2014–2016 in Connecticut, USA to: (1) determine if SLAN and SSCB concentrations are correlated for a sandy loam soil under predominately Kentucky bluegrass (*Poa pratensis* L.) and tall fescue [*Schedonorus arundinaceus* (Schreb.) Dumort.] turfgrass lawns, and (2) compare the response of SSCB–C and SLAN–N concentrations in relation to varying rates of an organic fertilizer. Concentrations of SLAN–N were positively and significantly ($P < 0.001$) correlated with concentrations of SSCB–C for all years, both species, and combinations of years and species ($r = 0.477$ to 0.754). The response of SSCB–C and SLAN–N concentrations to organic fertilizer rates were positively linear and significant ($P < 0.01$) in all cases but one (2014 tall fescue SSCB–C concentrations). Rates of change across fertilizer rates were generally greater for SLAN–N concentrations. There was greater variation within the SSCB test than within the SLAN test. The results suggest that the SLAN and SSCB tests are well-correlated and both may be able to provide an estimate of a turfgrass soil's N mineralization potential.

OPTIMIZING PRE-GERMINATION TECHNIQUES FOR KENTUCKY BLUEGRASS AND PERENNIAL RYEGRASS

Campbell, J.H., J.J. Henderson, J.C. Inguagiato, V.H. Wallace, and A. Minniti. 2019. Optimizing pre-germination techniques for Kentucky bluegrass and perennial ryegrass. J. Environ. Hort. 37:19–23. doi/pdf/10.24266/0738-2898-37.1.19

ABSTRACT

Many intensively trafficked areas such as athletic fields and golf courses require constant overseeding to maintain suitable turfgrass cover. Rapid seed germination and development are critical to managing these high wear areas. The objectives of this research were to determine the effect of water aeration, seed soaking duration, and water temperature on mean germination time (MGT) and final germination percentage (FGP) of Kentucky bluegrass (Poa pratensis L., KBG) and perennial ryegrass (Lolium perenne L., PRG). Two separate controlled environment studies were conducted. PRG soaked in aerated water from 8 to 48 h had a 20% decrease in MGT compared to an untreated control, while treated KBG decreased MGT by only 10% compared to an untreated control. Soaking duration and water temperature had significant effects on KBG. KBG MGT was optimized at 20 C (68 F) water temperature with a soaking duration of 24 h. MGT of PRG was optimized when soaked for 8 h while water was aerated. There was no significant difference in FGP for any of the treatments tested.