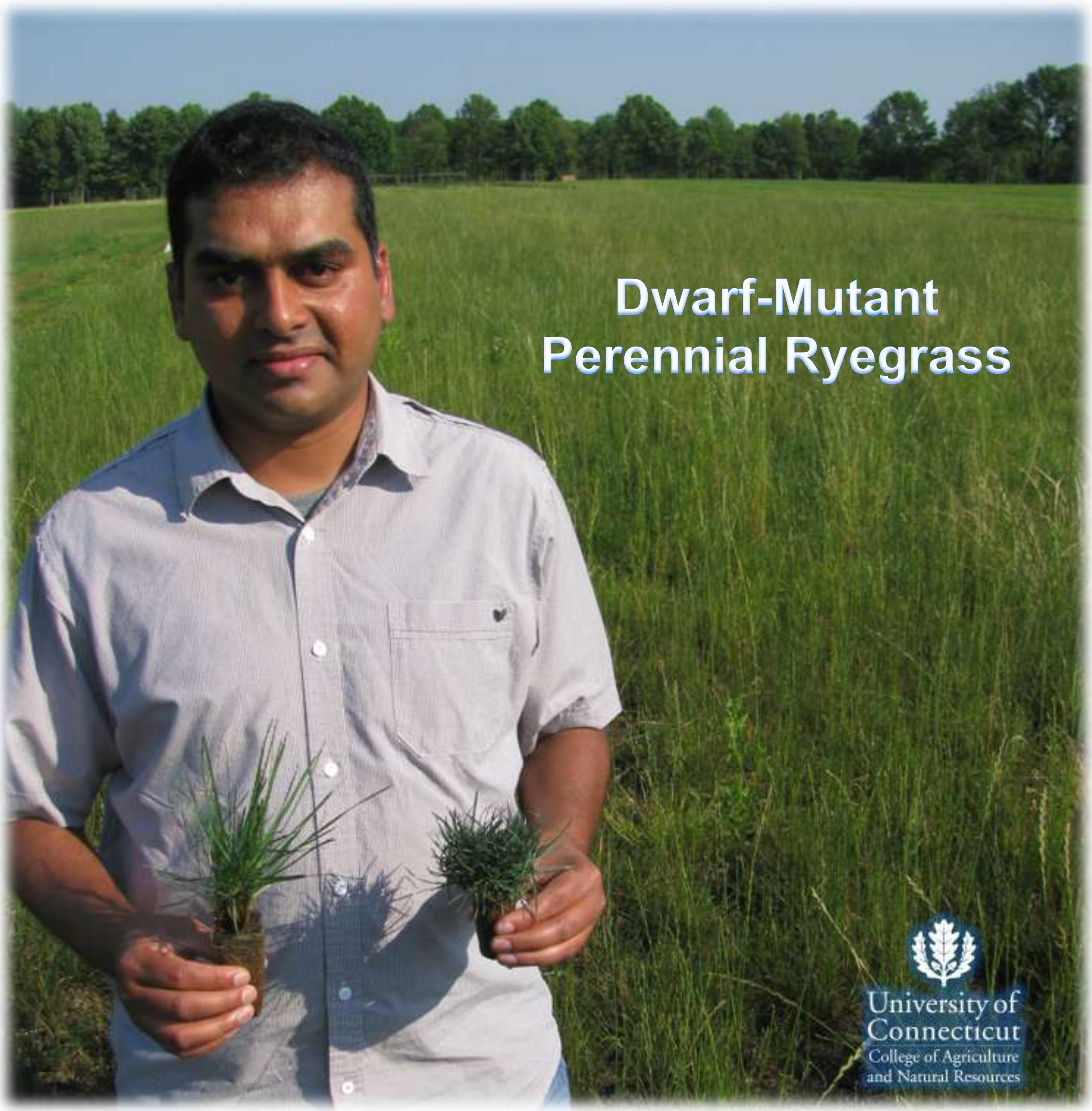
# University of Connecticut

## *College of Agriculture & Natural Resources*

## 2011 Annual Turfgrass Research Report



Cover photo: Dr. Chandra Thammina (Post-Doctoral Fellow in Dr. Yi Li's Biotechnology Research Group) comparing dwarf-mutant perennial ryegrass (on the right) with the wild-type commercial perennial ryegrass (on the left). The dwarf-mutant perennial ryegass has potential to reduce the mowing frequency needed to maintain turf areas while retaining turf quality. (Read more about this research beginning on page 75)



University of Connecticut • Department of Plant Science and Landscape Architecture

# 2011 Annual Turfgrass Research Report Summary

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

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

This report is divided into various sections and includes original research results in the fields of pest control (pathology and entomology), athletic field and golf turf maintenance, cultivar improvement, fertility, and nutrient management. Additionally, abstracts and citations of scientific publications and presentations published in 2011 by University of Connecticut turfgrass researchers are included. This information is presented in the hopes of providing current information on relevant research topics for use by members of the turfgrass industry.

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

Dr. Karl Guillard, Editor

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# 2011 Financial Support

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

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*The University of Connecticut Turf Group*

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**PREVENTATIVE ANTHRACNOSE CONTROL WITH VARIOUS FUNGICIDES IN AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2011**

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University of Connecticut, Storrs

## INTRODUCTION

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


## MATERIALS AND METHODS

A field study was conducted on an annual bluegrass (*Poa annua*) putting green turf grown on a Paxton fine sandy loam at the Plant Science Research Facility in Storrs, CT. The field was established in 2009 from aerification cores containing annual bluegrass seed from Wethersfield Country Club and cores indigenous to the site. Turf was mowed five days $wk^{-1}$ at a height of 0.130-inches. The site was irrigated as necessary to avoid drought stress. A total of 1.2 lbs of nitrogen was applied throughout the study to produce conditions favorable for anthracnose development.

Treatments consisted of currently available and experimental fungicides applied individually, in combination, or in rotational programs. Initial applications were made on 25 May prior to disease development. Subsequent applications were made on 14 d intervals (dates listed in Tables 1-4) until 17 August. All treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal per $1000ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose was assessed as the percent area blighted by *C. cereale* within each plot when disease was present from 9 July until 17 August. Dollar spot incidence (*Sclerotinia homoeocarpa*) was determined by counting disease foci within each plot between 24 June and 19 August. Turf quality was visually assessed on a 1-9 scale; where 9 represented the best quality and 6 was the minimum acceptable level. Phytotoxicity was visually assessed on a 0-5 scale; where 0 represented no turf injury and 2 was the maximum acceptable level. Relative chlorophyll index was measured with the Field Scout CM1000 (Spectrum Technologies, Inc) chlorophyll meter. Higher values represented darker green foliage reflectance. Ten readings were taken per plot with the mean used for data analysis. Algae was assessed on a 1-9 scale; where 1 represented minimal algal development and 3 represented the maximum acceptable level. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

## RESULTS

*Anthracnose*

Anthracnose developed naturally in early-July and increased rapidly, reaching 76% plot area blighted in untreated turf by mid-July (Table 1). All treatments reduced anthracnose severity compared to untreated turf, with most providing good control (i.e., $\leq$ 5%) early in the epidemic (Table 1). However, QP TM, Heritage TL, and UC11-13 failed to provide acceptable anthracnose control at this time, or throughout the remainder of the study. By late-July, efficacy of Velista (0.3 oz), UC11-6 alternated with UC11-4, Banner MAXX, and Daconil Ultrex, was also reduced. Treatments providing good anthracnose control throughout the study included Tourney, Velista + Daconil Ultrex, Velista + Chipco Signature, DuPont Program 1, and Velista (0.5 oz). Syngenta Programs 1 and 2 provided near complete anthracnose control throughout the study.

*Dollar Spot*

Dollar spot developed throughout the study area during favorable conditions on 24 June and became severe during the month of August (Table 2). No treatment differences were observed initially on 24 June. By 10 July, dollar spot had increased throughout the study with 40 foci in untreated plots. Most treatments reduced dollar spot compared to untreated turf on this date. Treatment UC11-13 had the fewest dollar spot foci (0.5 per plot), although remaining treatments were not significantly different. Turf treated with QP TM did not reduce dollar spot compared to untreated, and Heritage TL and the alternation of UC11-6 and UC11-4 provided only slight disease reductions. On 19 August no treatment provided acceptable dollar spot control except UC11-13

*Turf quality, Phytotoxicity, Algae and Chlorophyll*

Turf quality was generally good among all treatments prior to disease development (Table 3), except plots treated with Syngenta Program 2 on 1 and 10 June. An unacceptable level of phytotoxicity was associated with initial applications of this treatment on these dates (Table 4). However, quality improved by 24 June, and remained high until dollar spot increased on 19 August. Repeat applications of Tourney and Banner MAXX also reduced turf quality due to phytotoxicity on 24 June and 15 July. Later in the season, treatments providing poor anthracnose control resulted in unacceptable turf quality by 15 July. Dollar spot development also contributed to unacceptable turf quality on 19 August in all treatments, except Syngenta Program 1 and the combination of Velista and Daconil Ultrex. Turf treated with Syngenta Program 1 consistently had the highest turf quality and chlorophyll reflectance values (Table 5) throughout the study.

Algae developed in the study area on 24 June. All treatments reduced algae except Tourney, Velista (0.5 oz), UC11-13, and QP TM which were no different than untreated (Table 3).

Chlorophyll reflectance values were comparable to turf quality ratings throughout the study.

## DISCUSSION

Severe anthracnose pressure provided for a rigorous assessment of treatment efficacy. Rotational programs generally provided the best anthracnose control; however, Tourney and the high rate of Velista (0.5 oz) applied alone also provided season-long anthracnose control. Low rate applications of Velista (0.3 oz) tank mixed with Daconil Ultrex or Chipco Signature also provided good control; reducing disease more than either fungicide applied alone. UC11-13 failed to control anthracnose, but provided excellent dollar spot control in this trial. Strobilurin and benzamidazole fungicides have been shown to effectively control anthracnose at some locations; however resistance to these fungicides is known to occur. Based on field performance, resistance appears to have developed at the Storrs site to these classes of fungicides.

Turf quality was generally good in all treatments prior to disease development, with the exception of programs containing increased rates (0.2 fl oz) of Primo MAXX or repeat applications of DMI fungicides resulting in phytotoxicity. No phytoxicity was observed in Syngenta Program 1 which contained the same rate of Primo MAXX as Syngenta Program 2 plus a material containing a green pigment which likely masked discoloration at that time. Initial phytotoxicity in Syngenta Program 2 subsided approximately 24 days after initial treatment, and quality of Primo MAXX treated turf was very high thereafter.

Table 1. Anthracnose severity in an annual bluegrass putting green turf treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| | | | Anthracnose Severity | | | |
|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 $ft^{-2}$ | Int.[z] | 9 Jul | 15 Jul | 29 Jul | 17 Aug |
| | | | --------------------% plot area blighted-------------------- | | | |
| Tourney……………… | 0.28 oz | 14 d | 0.3 c[u] | 0.8 d | 1.3 e | 2.8 g |
| Velista………………… | 0.3 oz | 14 d | 0.0 c | 0.8 d | 5.3 de | 2.8 g |
| + Daconil Ultrex……. | 3.25 oz | | | | | |
| Velista………………… | 0.3 oz | 14 d | 0.0 c | 2.0 d | 3.8 de | 3.5 fg |
| + Chipco Signature…… | 4.0 oz | | | | | |
| DuPont Program 1 | | Pgm[y] | 0.0 c | 0.5 d | 1.5 e | 3.3 g |
| Chipco Signature…...… | 4.0 oz | | | | | |
| - Banner MAXX…… | 1.0 fl oz | | | | | |
| - Velista……………..…… | 0.5 oz | | | | | |
| - Daconil Ultrex ……. | 3.25 oz | | | | | |
| Velista………………… | 0.3 oz | 14 d | 0.8 c | 8.5 d | 17.3 cd | 13.8 ef |
| Velista………………… | 0.5 oz | 14 d | 0.3 c | 1.0 d | 1.8 e | 2.3 g |
| UC11-6...………… | 0.494 fl oz | 14 d[x] | 3.5 c | 6.5 d | 27.5 c | 36.8 c |
| - UC11-4…..... | 3.6 fl oz | | | | | |
| UC11-13..…………... | 0.5 fl oz | 14 d | 16.8 b | 36.3 c | 56.3 b | 62.5 b |
| Syngenta Program 1 | | Pgm[w] | 0.0 c | 0.0 d | 0.0 e | 0.0 g |
| - UC11-17……..…… | 4.0 fl oz | | | | | |
| - Primo MAXX……... | 0.2 fl oz | | | | | |
| - Daconil Action…..... | 3.6 fl oz | | | | | |
| - Renown…………….. | 4.5fl oz | | | | | |
| - UC11-6………...….. | 0.5 fl oz | | | | | |
| Syngenta Program 2 | | Pgm[v] | 0.0 c | 0.0 d | 1.1 e | 0.0 g |
| - Daconil Action…… | 3.6 fl oz | | | | | |
| - Primo MAXX…….. | 0.2 fl oz | | | | | |
| - UC11-8...………..… | 1.6 fl oz | | | | | |
| - UC11-18………... | 1.26 fl oz | | | | | |
| Heritage TL………... | 1.0 fl oz | 14 d | 21.8 b | 55.0 b | 80.0 a | 81.3 a |
| Banner MAXX……... | 1.0 fl oz | 14 d | 2.3 c | 6.8 d | 18.5 cd | 25.0 d |
| QP TM……………… | 2.0 fl oz | 14 d | 22.5 b | 56.3 b | 67.0 ab | 68.8 b |
| Daconil Ultrex………. | 3.25 oz | 14 d | 1.3 c | 6.8 d | 25.8 c | 16.8 de |
| Untreated | | -- | 30.8 a | 75.8 a | 66.3 ab | 72.5 ab |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | | 2 | 8 | 9 | 14 |

[z] Initial application was made on 25 May.

[y] Applications were made every 14d. Banner MAXX was applied on 25 May. Velista and Daconil Ultrex were applied in rotation on 8 Jun, 7 Jul and 3 Aug and 23 Jun, 20 Jul, and 17 Aug, respectively. Chipco Signature was applied in combination with each treatment on all dates.

[x] UC11-6 and UC11-4 were applied in rotation every 14d; UC11-6 was applied on 25 May, 23 Jun, 20 July and 17 Aug. UC11-4 was applied on 8 Jun, 7 Jul, and 3 Aug.

[w] Applications were made every 14d. Renown was applied on 25 May, 23 Jun, 20 Jul, and 17 Aug; Daconil Action and UC11-6 were applied on 8 Jun, 7 Jul, and 3 Aug. Primo MAXX and UC11-17 were applied on all dates.

[v] UC11-8 and UC11-18 were alternated every 14d, beginning with UC11-8 on 25 May. Daconil Action and Primo MAXX were applied on all dates.

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

Table 2. Dollar spot foci on an annual bluegrass putting green turf treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment Rate per 1000 $ft^{-2}$ | Int.[z] | Dollar Spot Incidence | | |
|---|---|---|---|---|
| | | 24 Jun | 10 Jul | 19 Aug |
| | | ------------number of foci per 18 $ft^2$------------- | | |
| Tourney………………0.28 oz | 14 d | 0.0 | 1.5 d[u] | 86.8 b-e |
| Velista…………………0.3 oz<br>+ Daconil Ultrex…….3.25 oz | 14 d | 0.3 | 2.5 d | 47.5 def |
| Velista…………………0.3 oz<br>+ Chipco Signature……4.0 oz | 14 d | 1.0 | 6.0 cd | 119.3 bc |
| DuPont Program 1<br>Chipco Signature…...…4.0 oz<br>- Banner MAXX……1.0 fl oz<br>- Velista……………..……0.5 oz<br>- Daconil Ultrex …….3.25 oz | Pgm[y] | 1.3 | 3.5 d | 70.3 cde |
| Velista…………………0.3 oz | 14 d | 2.8 | 9.3 cd | 103.5 bc |
| Velista…………………0.5 oz | 14 d | 0.3 | 1.3 d | 82.0 b-e |
| UC11-6..…………0.494 fl oz<br>- UC11-4….....3.6 fl oz | 14 d[x] | 2.5 | 15.3 bc | 96.5 bcd |
| UC11-13..…………...0.5 fl oz | 14 d | 0.0 | 0.5 d | 5.5 f |
| Syngenta Program 1<br>- UC11-17……..……4.0 fl oz<br>- Primo MAXX……...0.2 fl oz<br>- Daconil Action…....3.6 fl oz<br>- Renown……………..4.5fl oz<br>- UC11-6………...…..0.5 fl oz | Pgm[w] | 0.3 | 1.3 d | 39.3 ef |
| Syngenta Program 2<br>- Daconil Action……3.6 fl oz<br>- Primo MAXX……..0.2 fl oz<br>- UC11-8...………..…1.6 fl oz<br>- UC11-18………...1.26 fl oz | Pgm[v] | 2.0 | 3.3 d | 86.8 b-e |
| Heritage TL………...1.0 fl oz | 14 d | 9.5 | 24.5 b | 120.3 b |
| Banner MAXX……...1.0 fl oz | 14 d | 1.0 | 8.0 cd | 54.3 def |
| QP TM………………2.0 fl oz | 14 d | 9.0 | 46.0 a | 208.3 a |
| Daconil Ultrex……….3.25 oz | 14 d | 0.3 | 6.3 cd | 86.0 b-e |
| Untreated | -- | 2.8 | 40.3 a | 235.0 a |
| ANOVA: Treatment (P > F) | | 0.0677 | 0.0001 | 0.0001 |
| Days after treatment | | 1 | 3 | 2 |

[z] Initial application was made on 25 May.

[y] Applications were made every 14d. Banner MAXX was applied on 25 May. Velista and Daconil Ultrex were applied in rotation on 8 Jun, 7 Jul and 3 Aug and 23 Jun, 20 Jul, and 17 Aug, respectively. Chipco Signature was applied in combination with each treatment on all dates.

[x] UC11-6 and UC11-4 were applied in rotation every 14d; UC11-6 was applied on 25 May, 23 Jun, 20 July and 17 Aug. UC11-4 was applied on 8 Jun, 7 Jul, and 3 Aug.

[w] Applications were made every 14d. Renown was applied on 25 May, 23 Jun, 20 Jul, and 17 Aug; Daconil Action and UC11-6 were applied on 8 Jun, 7 Jul, and 3 Aug. Primo MAXX and UC11-17 were applied on all dates.

[v] UC11-8 and UC11-18 were alternated every 14d, beginning with UC11-8 on 25 May. Daconil Action and Primo MAXX were applied on all dates.

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

Table 3. Turf quality of annual bluegrass putting green turf treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment Rate per 1000 $ft^{-2}$ | Int.[z] | Turf quality 1 Jun | 10 Jun | 24 Jun | 15 Jul | 19 Aug | Algae 24 Jun |
|---|---|---|---|---|---|---|---|
| | | ------------------1-9; 6=min acceptable------------------ | | | | | --1-9-- |
| Tourney……………….0.28 oz | 14 d | 7.3 abc[u] | 6.5 cde | 5.3 f | 5.8 ef | 4.3 de | 2.5 a-d |
| Velista…………………0.3 oz + Daconil Ultrex…….3.25 oz | 14 d | 7.0 abc | 6.5 cde | 7.3 bc | 7.0 bcd | 6.0 b | 1.0 e |
| Velista…………………0.3 oz + Chipco Signature……4.0 oz | 14 d | 7.8 a | 6.8 bcd | 7.5 b | 6.8 cde | 4.8 cd | 1.5 cde |
| DuPont Program 1 Chipco Signature…...…4.0 oz - Banner MAXX……1.0 fl oz - Velista………….……0.5 oz - Daconil Ultrex …….3.25 oz | Pgm[y] | 6.8 bc | 6.3 de | 7.3 bc | 7.5 abc | 4.8 cd | 1.3 de |
| Velista…………………0.3 oz | 14 d | 7.0 abc | 6.8 bcd | 6.8 bcd | 5.8 ef | 3.8 e | 2.3 b-e |
| Velista…………………0.5 oz | 14 d | 7.3 abc | 7.3 ab | 7.0 bc | 7.3 bc | 4.8 cd | 2.8 abc |
| UC11-6...…………0.494 fl oz - UC11-4…......3.6 fl oz | 14 d[x] | 7.3 abc | 6.3 de | 7.3 bc | 5.8 ef | 2.8 f | 2.0 cde |
| UC11-13..…………...0.5 fl oz | 14 d | 7.0 abc | 6.0 ef | 5.8 ef | 3.8 g | 1.3 g | 3.5 ab |
| Syngenta Program 1 - UC11-17……..…….4.0 fl oz - Primo MAXX……...0.2 fl oz - Daconil Action…....3.6 fl oz - Renown……………..4.5fl oz - UC11-6………...…..0.5 fl oz | Pgm[w] | 7.5 ab | 7.8 a | 9.0 a | 8.5 a | 7.0 a | 2.0 cde |
| Syngenta Program 2 - Daconil Action……3.6 fl oz - Primo MAXX……..0.2 fl oz - UC11-8...………..…1.6 fl oz - UC11-18.………...1.26 fl oz | Pgm[v] | 5.3 d | 5.5 f | 7.5 b | 8.0 ab | 5.3 bc | 1.0 e |
| Heritage TL………...1.0 fl oz | 14 d | 7.3 abc | 7.0 bc | 6.0 def | 2.8 gh | 1.0 g | 2.0 cde |
| Banner MAXX……...1.0 fl oz | 14 d | 6.5 c | 6.3 de | 5.8 ef | 5.5 f | 3.5 ef | 1.3 de |
| QP TM………………2.0 fl oz | 14 d | 7.5 ab | 7.3 ab | 6.8 bcd | 2.8 gh | 1.3 g | 2.5 a-d |
| Daconil Ultrex……….3.25 oz | 14 d | 7.0 abc | 6.0 ef | 6.5 cde | 6.0 def | 3.8 e | 1.3 de |
| Untreated | -- | 6.8 bc | 6.0 ef | 5.8 ef | 2.3 h | 1.5 g | 3.8 a |
| ANOVA: Treatment (P > F) | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0051 |
| Days after treatment | | 7 | 2 | 1 | 8 | 2 | 1 |

[z] Initial application was made on 25 May.

[y] Applications were made every 14d. Banner MAXX was applied on 25 May. Velista and Daconil Ultrex were applied in rotation on 8 Jun, 7 Jul and 3 Aug and 23 Jun, 20 Jul, and 17 Aug, respectively. Chipco Signature was applied in combination with each treatment on all dates.

[x] UC11-6 and UC11-4 were applied in rotation every 14d; UC11-6 was applied on 25 May, 23 Jun, 20 July and 17 Aug. UC11-4 was applied on 8 Jun, 7 Jul, and 3 Aug.

[w] Applications were made every 14d. Renown was applied on 25 May, 23 Jun, 20 Jul, and 17 Aug; Daconil Action and UC11-6 were applied on 8 Jun, 7 Jul, and 3 Aug. Primo MAXX and UC11-17 were applied on all dates.

[v] UC11-8 and UC11-18 were alternated every 14d, beginning with UC11-8 on 25 May. Daconil Action and Primo MAXX were applied on all dates.

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

Table 4. Phytotoxicity of annual bluegrass putting green turf treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment Rate per 1000 ft$^{-2}$ | Int.[z] | Phytotoxicity | | | | |
|---|---|---|---|---|---|---|
| | | 1 Jun | 10 Jun | 24 Jun | 15 Jul | 19 Aug |
| | | ----------------0-5; 2=max acceptable--------------- | | | | |
| Tourney………………0.28 oz | 14 d | 0.0 b[u] | 0.3 c | 2.8 a | 1.8 a | 0.3 |
| Velista…………………0.3 oz + Daconil Ultrex…….3.25 oz | 14 d | 0.3 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| Velista…………………0.3 oz + Chipco Signature……4.0 oz | 14 d | 0.8 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| DuPont Program 1 Chipco Signature…...…4.0 oz - Banner MAXX……1.0 fl oz - Velista…………….……0.5 oz - Daconil Ultrex …….3.25 oz | Pgm[y] | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| Velista…………………0.3 oz | 14 d | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| Velista…………………0.5 oz | 14 d | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| UC11-6...…………0.494 fl oz - UC11-4…......3.6 fl oz | 14 d[x] | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| UC11-13..…………...0.5 fl oz | 14 d | 0.3 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| Syngenta Program 1 - UC11-17……..…….4.0 fl oz - Primo MAXX……...0.2 fl oz - Daconil Action…....3.6 fl oz - Renown……………..4.5fl oz - UC11-6………...…..0.5 fl oz | Pgm[w] | 0.8 b | 1.0 b | 0.0 c | 0.0 b | 0.0 |
| Syngenta Program 2 - Daconil Action……3.6 fl oz - Primo MAXX……..0.2 fl oz - UC11-8...………..…1.6 fl oz - UC11-18.………...1.26 fl oz | Pgm[v] | 2.3 a | 2.5 a | 0.3 c | 0.3 b | 0.0 |
| Heritage TL………...1.0 fl oz | 14 d | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.3 |
| Banner MAXX……...1.0 fl oz | 14 d | 0.0 b | 0.3 c | 1.0 b | 0.3 b | 0.0 |
| QP TM………………2.0 fl oz | 14 d | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| Daconil Ultrex……….3.25 oz | 14 d | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| Untreated | -- | 0.0 b | 0.0 c | 0.0 c | 0.0 b | 0.0 |
| ANOVA: Treatment (P > F) | | 0.0003 | 0.0001 | 0.0001 | 0.0001 | 0.5582 |
| Days after treatment | | 7 | 2 | 1 | 8 | 2 |

[z] Initial application was made on 25 May.

[y] Applications were made every 14d. Banner MAXX was applied on 25 May. Velista and Daconil Ultrex were applied in rotation on 8 Jun, 7 Jul and 3 Aug and 23 Jun, 20 Jul, and 17 Aug, respectively. Chipco Signature was applied in combination with each treatment on all dates.

[x] UC11-6 and UC11-4 were applied in rotation every 14d; UC11-6 was applied on 25 May, 23 Jun, 20 July and 17 Aug. UC11-4 was applied on 8 Jun, 7 Jul, and 3 Aug.

[w] Applications were made every 14d. Renown was applied on 25 May, 23 Jun, 20 Jul, and 17 Aug; Daconil Action and UC11-6 were applied on 8 Jun, 7 Jul, and 3 Aug. Primo MAXX and UC11-17 were applied on all dates.

[v] UC11-8 and UC11-18 were alternated every 14d, beginning with UC11-8 on 25 May. Daconil Action and Primo MAXX were applied on all dates.

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

Table 5. Chlorophyll reflective index of annual bluegrass putting green turf treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment Rate per 1000 ft$^{-2}$ | Int.[z] | Chlorophyll Reflectance 16 Jun | 13 Jul | 27 Jul | 5 Aug | 18 Aug |
|---|---|---|---|---|---|---|
| | | ----------------------------chlorophyll index---------------------------- | | | | |
| Tourney……………….0.28 oz | 14 d | 228.0 def [u] | 226.8 cd | 228.3 cd | 287.5 bc | 261.0 ab |
| Velista…………………0.3 oz + Daconil Ultrex…….3.25 oz | 14 d | 242.3 bc | 237.5 bcd | 231.3 cd | 280.0 bc | 224.5 cd |
| Velista…………………0.3 oz + Chipco Signature……4.0 oz | 14 d | 241.3 bc | 233.3 bcd | 235.3 bcd | 260.5 cd | 222.3 cd |
| DuPont Program 1<br>Chipco Signature…..…4.0 oz<br>- Banner MAXX……1.0 fl oz<br>- Velista……………..……0.5 oz<br>- Daconil Ultrex …….3.25 oz | Pgm[y] | 238.5 bcd | 248.5 bc | 238.5 bcd | 281.5 bc | 219.0 d |
| Velista…………………0.3 oz | 14 d | 240.0 bc | 229.5 cd | 223.5 de | 260.8 cd | 216.0 d |
| Velista…………………0.5 oz | 14 d | 239.0 bc | 248.0 bc | 254.3 b | 283.8 bc | 244.0 bc |
| UC11-6...…………0.494 fl oz<br>- UC11-4…......3.6 fl oz | 14 d[x] | 236.5 bcd | 224.5 d | 199.0 f | 217.5 ef | 179.8 efg |
| UC11-13..…………...0.5 fl oz | 14 d | 232.0 cde | 200.5 ef | 175.3 g | 200.8 f | 173.5 fg |
| Syngenta Program 1<br>- UC11-17……..……4.0 fl oz<br>- Primo MAXX……...0.2 fl oz<br>- Daconil Action…....3.6 fl oz<br>- Renown……………..4.5fl oz<br>- UC11-6………...…..0.5 fl oz | Pgm[w] | 275.5 a | 278.8 a | 284.3 a | 328.5 a | 269.0 a |
| Syngenta Program 2<br>- Daconil Action……3.6 fl oz<br>- Primo MAXX……..0.2 fl oz<br>- UC11-8...……….…1.6 fl oz<br>- UC11-18………...1.26 fl oz | Pgm[v] | 243.5 b | 252.3 b | 249.0 bc | 297.8 b | 244.8 bc |
| Heritage TL………...1.0 fl oz | 14 d | 239.0 bc | 179.0 fg | 150.8 h | 157.5 g | 143.8 h |
| Banner MAXX……...1.0 fl oz | 14 d | 237.0 bcd | 232.5 bcd | 206.0 ef | 234.8 de | 202.3 de |
| QP TM………………2.0 fl oz | 14 d | 243.3 b | 185.8 fg | 156.0 gh | 165.3 g | 140.5 h |
| Daconil Ultrex……….3.25 oz | 14 d | 225.5 ef | 217.0 de | 201.8 f | 215.5 ef | 190.3 ef |
| Untreated | -- | 221.3 f | 176.5 g | 161.0 gh | 162.8 g | 160.3 gh |
| ANOVA: Treatment (P > F) | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 8 | 6 | 7 | 2 | 1 |

[z] Initial application was made on 25 May.

[y] Applications were made every 14d. Banner MAXX was applied on 25 May. Velista and Daconil Ultrex were applied in rotation on 8 Jun, 7 Jul and 3 Aug and 23 Jun, 20 Jul, and 17 Aug, respectively. Chipco Signature was applied in combination with each treatment on all dates.

[x] UC11-6 and UC11-4 were applied in rotation every 14d; UC11-6 was applied on 25 May, 23 Jun, 20 July and 17 Aug. UC11-4 was applied on 8 Jun, 7 Jul, and 3 Aug.

[w] Applications were made every 14d. Renown was applied on 25 May, 23 Jun, 20 Jul, and 17 Aug; Daconil Action and UC11-6 were applied on 8 Jun, 7 Jul, and 3 Aug. Primo MAXX and UC11-17 were applied on all dates.

[v] UC11-8 and UC11-18 were alternated every 14d, beginning with UC11-8 on 25 May. Daconil Action and Primo MAXX were applied on all dates.

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

# PREVENTIVE BROWN PATCH CONTROL ON COLONIAL BENTGRASS FAIRWAY TURF, 2011

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## INTRODUCTION

Brown patch (caused by *Rhizoctonia solani*) commonly affects high-maintenance turfgrasses. Symptoms appear as blighted patches (4-12 inch diam.) with a thin margin of dark, water-soaked plants, or "smoke ring," at the leading edge of the patch. This disease is particularly severe on colonial bentgrass fairway turf. Avoiding excessive nitrogen fertility and minimizing leaf wetness period are effective practices to reduce the incidence and severity of brown patch. However, repeat fungicide applications may be required to control the disease. Over the past few years, systemic fungicides have become increasingly available in granular formulations. Traditionally, granular fungicide formulations have provided less effective control of foliar diseases due to their reduced coverage of the turf canopy compared to spray applications. However, newer technology has developed prills which rapidly breakdown in the presence of water, improving dispersion of the fungicide in the lower turf canopy. The objective of this trial was to evaluate the efficacy of currently available and experimental fungicides, applied with liquid or granular carriers, for preventative brown patch control in fairway turf.

## MATERIALS & METHODS

A field study was conducted on an 'Alister' colonial bentgrass (*Agrostis capillaris*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three times a week at 0.5 inches and the area was irrigated three times aa week at 6 pm. Nitrogen was applied at 0.25, 1.0, and 0.5 lbs N 1000-ft$^{-2}$ on 27 Apr., 7 June, and 5 July, respectively.

Treatments consisted of currently available and experimental fungicides applied individually or in alternation programs. Initial application of all fungicides was on 6 June. Spray treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft$^{-2}$ at 40 psi. Granular treatments were applied by hand using a shaker jar. Immediately following application, a 0.1 inch of irrigation was applied to plots receiving granular treatments with a watering can. 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 *R. solani*. Turf quality was visually assessed on a 1 to 9 scale; 9 = best quality turf and 6 = minimum acceptable level. Phytotoxicity was visually assessed on a 0-5 scale; where 0 represented no phytotoxicity observed. Ratings were taken on a weekly basis. Data were subjected to an analysis of variance and means separated using Fisher's protected least significant difference test.


## RESULTS

Brown patched developed the first week of July in the trial during conditions favorable for the disease. Conditions remained conducive for brown patch throughout July and August with severity steadily increasing from 11 to 90% plot area blighted in untreated controls (Table 1a & 1b). Most treatments provided complete control of brown patch through 20 July. However, a limited amount of disease symptoms were observed in ProStar 70WG (1.5 oz) and Daconil Ultrex (3.2 oz) applied every 21 d during the early stages of the epidemic (Table 1a). By 27 July, disease increased to 55% in untreated turf. Applications of Prophesy 0.072G failed to provide acceptable brown patch control (i.e., ≤ 10 % plot area blighted) on this date or throughout the remainder of the study regardless of rate or application interval (Table 1a & 1b). In comparison, Banner MAXX applied to deliver an equivalent amount of active ingredient as Prophesy 0.072G at the 14 and 21 d intervals provided good to acceptable brown patch control, respectively, during periods of routine application.

Residual treatment effects on brown patch were assessed from 10 August through 31 August. Banner MAXX, UC11-13 and Daconil Ultrex failed to provide acceptable brown patch control by 23 August, 34 days after the last application (Table 1b). Excellent brown patch control (i.e., ≤ 1 % plot area blighted) was observed in Tourney, UC11-11, and Heritage TL (1.0 fl oz) up to the last observation date (42 DAT). Good brown patch control (i.e., ≤ 5 % plot area blighted) was also observed on this date in turf treated with UC11-14, Heritage G (2.0 lbs), QP Tebuconazole + Foursome, and QP Tebuconazole alternated with QP TM/C and Foursome.

Turf quality was high in most treatments prior to disease developing in the trial (Table 2a). Reduced turf quality was typically associated with increased brown patch severity. No phytotoxicity was observed in any treatment throughout the duration of the trial (Table 3a & 3b).

## DISCUSSION

The severe epidemic in July and August provided for a stringent assessment of treatment efficacy for brown patch control. Nearly all treatments provided acceptable control of the disease during routine applications except the granular formulation of propiconazole (Prophesy 0.072G). Liquid sprays of propiconazole, applied as Banner MAXX, were generally more effective than granular applications of the active ingredient when routinely applied. Conversely, no statistical differences were observed between the liquid and granular formulations of Heritage throughout the trial. Azoxystrobin is known to be a highly effective brown patch fungicide; whereas propiconazole generally provides only moderate to good control of the disease. Therefore, applications of the granular fungicide Heritage G appear to be an acceptable alternative to spray applications of the active ingredient; whereas the best control of brown patch with propiconazole remains to be with liquid applications. The DMI fungicides Tourney, Torque and QP Tebuconazole provided longer residual brown patch control than propiconazole (Prophesy 0.072G or Banner MAXX). QP Tebuconazole and Torque provided comparable brown patch control throughout the trial. The addition of an alternation partner (i.e., QP Chlorothalonil DF, QP TM/C) 14 days opposite QP Tebuconazaole applications did not statistically improve brown patch control in this trial compared to QP Tebuconazole applied alone every 28 days.

Experimental fungicides evaluated in this trial provided excellent to good brown patch control up to 34 days after treatment. Treatment UC11-11 provided complete control of brown patch throughout the trial. Treatment UC11-13 provided excellent control of the disease until 29 days after treatment. Thereafter, the ability of this fungicide to suppress the disease was reduced.

Table 1a. Brown patch severity on ‘Alister’ colonial bentgrass fairway turf treated preventively with various fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment Rate per 1000 ft$^{-2}$ | Int.[y] | Brown Patch Severity 10 Jul | 13 Jul | 20 Jul | 27 Jul |
|---|---|---|---|---|---|
| | | ------------------% plot area blighted------------------ | | | |
| Tourney……….……….…..0.37 oz | 14d | 0.0 c [w] | 0.0 b | 0.0 b | 0.0 d |
| UC11-14………..……..…0.96 fl oz | 21d | 0.0 c | 0.0 b | 0.0 b | 2.5 d |
| UC11-11…………..……0.506 fl oz | 21d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| UC11-13……..…...........…0.5 fl oz | 21d | 0.0 c | 1.3 b | 0.5 b | 0.0 d |
| Heritage TL……………..…1.0 fl oz | 14d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| Heritage TL……………..…2.0 fl oz | 28d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| Heritage G [z]……..……...…..….2.0 lb | 14d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| Heritage G [z]……………..……4.0 lb | 28d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| Banner MAXX 1.3ME..…..1.0 fl oz | 14d | 0.0 c | 0.0 b | 0.0 b | 1.0 d |
| Banner MAXX 1.3ME …...2.0 fl oz | 21d | 0.0 c | 0.0 b | 0.3 b | 10.0 cd |
| Prophesy 0.072G [z]…...……1.66 lb | 14d | 0.0 c | 0.0 b | 0.8 b | 18.5 bc |
| Prophesy 0.072G [z]…..……..2.49 lb | 21d | 0.0 c | 0.0 b | 3.3 b | 30.5 b |
| Torque……………………..…0.6 fl oz | 28d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| QP Tebuconazole……….…0.6 fl oz | 28d | 0.0 c | 0.3 b | 0.3 b | 0.0 d |
| QP Tebuconazole……….…0.6 fl oz<br>+ Foursome…………….…0.4 fl oz | 28d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| QP Tebuconazole……….…0.6 fl oz<br>- QP IPRO 2SE…..……..…4.0 fl oz<br>+ Foursome…….…………0.4 fl oz | 28d<br>alt [x]<br>14d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| QP Tebuconazole……….…0.6 fl oz<br>- QP Chlorothalonil DF…......3.2 oz<br>+ Foursome………………..0.4 fl oz | 28d<br>alt [x]<br>14d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| QP Tebuconazole…………0.6 fl oz<br>- QP TM/C………………..…4.0 oz<br>+ Foursome………………..0.4 fl oz | 28d<br>alt [x]<br>14d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| QP Tebuconazole……….…0.6 fl oz<br>- QP TM…………...…….2.0 fl oz<br>+ Foursome………………..0.4 fl oz | 28d<br>alt [x]<br>14d | 0.0 c | 0.0 b | 0.0 b | 0.0 d |
| ProStar 70WG……………..…1.5 oz | 21d | 3.8 bc | 5.0 b | 4.0 b | 0.0 d |
| Daconil Ultrex……………….3.2 oz | 21d | 6.3 b | 15.5 a | 1.3 b | 2.5 d |
| Endorse……………….…..…..4.04 oz | 14d | 5.0 b | 0.0 b | 0.0 b | 0.0 d |
| Compass……………………0.15 oz | 21d | 0.0 c | 0.0 b | 0.0 b | 3.0 d |
| Untreated | -- | 11.3 a | 20.0 a | 27.5 a | 55.0 a |
| ANOVA: Treatment (P > F) | | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | 14 d | 9 | 12 | 6 | 13 |
| | 21 d | 3 | 6 | 12 | 19 |
| | 28 d | 24 | 27 | 6 | 13 |

[z] Individual plots received 0.1 inches of irrigation with a watering can immediately after fungicide application

[y] Initial applications were applied on 16 June. Thereafter, 14-d treatments were applied on 1 July, 14 July, 27 July; 21-d treatments were applied 7 July, 27 July; and 28-d treatments were applied on 14 July.

[x] Alternation partner was applied 14-d after each QP Tebuconazole application.

[w] Treatment means followed by the same letter within each column are not significantly different based on Fisher’s protected least significant difference test.

Table 1b. Brown patch severity on 'Alister' colonial bentgrass fairway turf treated preventively with various fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft$^{-2}$ | Int.[y] | Brown Patch Severity 3 Aug | 10 Aug | 18 Aug | 23 Aug | 31 Aug |
|---|---|---|---|---|---|---|---|
| | | | -------------------------% plot area blighted------------------------- | | | | |
| Tourney | 0.37 oz | 14d | 0.0 d[w] | 0.0 d | 0.0 c | 0.0 e | 1.0 e |
| UC11-14 | 0.96 fl oz | 21d | 1.8 cd | 2.5 cd | 0.0 c | 0.5 e | 1.5 e |
| UC11-11 | 0.506 fl oz | 21d | 0.0 d | 0.0 d | 0.0 c | 0.0 e | 0.0 e |
| UC11-13 | 0.5 fl oz | 21d | 0.0 d | 0.0 d | 4.0 c | 11.5 de | 51.8 bc |
| Heritage TL | 1.0 fl oz | 14d | 0.0 d | 0.0 d | 0.0 c | 0.0 e | 0.0 e |
| Heritage TL | 2.0 fl oz | 28d | 0.0 d | 0.0 d | 0.8 c | 1.3 e | 5.3 e |
| Heritage G [z] | 2.0 lb | 14d | 0.0 d | 0.0 d | 1.3 c | 2.0 e | 5.0 e |
| Heritage G [z] | 4.0 lb | 28d | 0.5 d | 0.5 d | 0.5 c | 2.8 e | 17.0 de |
| Banner MAXX 1.3ME | 1.0 fl oz | 14d | 0.5 d | 1.3 cd | 7.8 c | 29.8 bc | 52.8 bc |
| Banner MAXX 1.3ME | 2.0 fl oz | 21d | 9.0 bc | 8.8 bc | 4.3 c | 24.3 cd | 39.0 cd |
| Prophesy 0.072G [z] | 1.66 lb | 14d | 10.0 b | 12.5 b | 27.5 b | 41.3 b | 82.5 a |
| Prophesy 0.072G [z] | 2.49 lb | 21d | 14.5 b | 15.0 b | 28.0 b | 39.3 b | 50.5 bc |
| Torque | 0.6 fl oz | 28d | 0.0 d | 0.0 d | 0.5 c | 2.3 e | 9.3 e |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 d | 0.0 d | 2.3 c | 5.5 e | 17.8 de |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 d | 0.0 d | 1.5 c | 2.8 e | 5.0 e |
| + Foursome | 0.4 fl oz | | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 d | 0.0 d | 0.5 c | 2.5 e | 15.8 de |
| - QP IPRO 2SE | 4.0 fl oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 d | 0.0 d | 0.0 c | 1.0 e | 19.5 de |
| - QP Chlorothalonil DF | 3.2 oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 d | 0.0 d | 0.0 c | 0.3 e | 3.8 e |
| - QP TM/C | 4.0 oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 d | 0.0 d | 0.0 c | 0.5 e | 6.3 e |
| - QP TM | 2.0 fl oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| ProStar 70WG | 1.5 oz | 21d | 1.3 d | 1.3 cd | 0.0 c | 0.5 e | 22.0 de |
| Daconil Ultrex | 3.2 oz | 21d | 0.5 d | 1.3 cd | 6.8 c | 12.8 de | 67.0 ab |
| Endorse | 4.04 oz | 14d | 0.3 d | 0.3 d | 0.8 c | 5.0 e | 37.0 cd |
| Compass | 0.15 oz | 21d | 1.5 cd | 1.5 cd | 0.3 c | 2.5 e | 7.3 e |
| Untreated | | -- | 57.5 a | 61.3 a | 66.3 a | 81.3 a | 90.0 a |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 14 d | 7 | 21 | 29 | 34 | 42 |
| | | 21 d | 7 | 21 | 29 | 34 | 42 |
| | | 28 d | 20 | 34 | 42 | 47 | 55 |

[z] Individual plots received 0.1 inches of irrigation with a watering can immediately after fungicide application

[y] Initial applications were applied on 16 June. Thereafter, 14-d treatments were applied on 1 July, 14 July, 27 July; 21-d treatments were applied 7 July, 27 July; and 28-d treatments were applied on 14 July.

[x] Alternation partner was applied 14-d after each QP Tebuconazole application.

[w] Treatment means followed by the same letter within each column are not significantly different based on Fisher's protected least significant difference test.



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Table 2a. Turf Quality of an 'Alister' colonial bentgrass fairway turf treated preventively with various fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 $ft^{-2}$ | Int.[y] | Turf Quality 10 Jul | 13 Jul | 20 Jul | 27 Jul |
|---|---|---|---|---|---|---|
| | | | ----------------1-9; 6 = min acceptable---------------- | | | |
| Tourney | 0.37 oz | 14d | 7.0 bc [w] | 8.0 ab | 8.0 abc | 8.3 ab |
| UC11-14 | 0.96 fl oz | 21d | 7.3 bc | 7.5 abc | 8.0 abc | 7.5 bcd |
| UC11-11 | 0.506 fl oz | 21d | 7.0 bc | 8.3 a | 8.3 ab | 8.0 abc |
| UC11-13 | 0.5 fl oz | 21d | 7.0 bc | 7.3 bc | 7.8 bcd | 7.3 cd |
| Heritage TL | 1.0 fl oz | 14d | 7.0 bc | 8.0 ab | 8.0 abc | 8.0 abc |
| Heritage TL | 2.0 fl oz | 28d | 7.0 bc | 7.8 ab | 7.8 bcd | 8.0 abc |
| Heritage G [z] | 2.0 lb | 14d | 7.0 bc | 7.5 abc | 8.0 abc | 8.3 ab |
| Heritage G [z] | 4.0 lb | 28d | 7.0 bc | 8.0 ab | 8.0 abc | 7.8 bcd |
| Banner MAXX 1.3ME | 1.0 fl oz | 14d | 7.0 bc | 7.5 abc | 8.0 abc | 7.3 cd |
| Banner MAXX 1.3ME | 2.0 fl oz | 21d | 7.0 bc | 8.3 a | 8.0 abc | 6.0 f |
| Prophesy 0.072G [z] | 1.66 lb | 14d | 7.0 bc | 7.8 ab | 7.8 bcd | 6.3 ef |
| Prophesy 0.072G [z] | 2.49 lb | 21d | 7.0 bc | 7.8 ab | 7.3 d | 6.0 f |
| Torque | 0.6 fl oz | 28d | 7.0 bc | 7.8 ab | 8.0 abc | 8.0 abc |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.0 bc | 7.5 abc | 8.0 abc | 7.8 bcd |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.5 a | 8.0 ab | 8.3 ab | 8.0 abc |
| + Foursome | 0.4 fl oz | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.0 bc | 8.0 ab | 8.0 abc | 8.0 abc |
| - QP IPRO 2SE | 4.0 fl oz | alt [x] | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.5 a | 8.0 ab | 8.5 a | 7.8 bcd |
| - QP Chlorothalonil DF | 3.2 oz | alt [x] | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.3 ab | 8.3 a | 8.0 abc | 8.8 a |
| - QP TM/C | 4.0 oz | alt [x] | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.0 bc | 8.3 a | 8.0 abc | 8.0 abc |
| - QP TM | 2.0 fl oz | alt [x] | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | |
| ProStar 70WG | 1.5 oz | 21d | 6.8 c | 6.8 c | 7.8 bcd | 7.0 de |
| Daconil Ultrex | 3.2 oz | 21d | 6.8 c | 6.8 c | 7.5 cd | 7.0 de |
| Endorse | 4.04 oz | 14d | 7.0 bc | 7.3 bc | 7.8 bcd | 8.3 ab |
| Compass | 0.15 oz | 21d | 7.0 bc | 7.3 bc | 7.8 bcd | 7.0 de |
| Untreated | | -- | 6.3 d | 5.5 d | 5.5 e | 4.8 g |
| ANOVA: Treatment (P > F) | | | 0.0005 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 14 d | 9 | 12 | 6 | 13 |
| | | 21 d | 3 | 6 | 12 | 19 |
| | | 28 d | 24 | 27 | 6 | 13 |

[z] Individual plots received 0.1 inches of irrigation with a watering can immediately after fungicide application

[y] Initial applications were applied on 16 June. Thereafter, 14-d treatments were applied on 1 July, 14 July, 27 July; 21-d treatments were applied 7 July, 27 July; and 28-d treatments were applied on 14 July.

[x] Alternation partner was applied 14-d after each QP Tebuconazole application.

[w] Treatment means followed by the same letter within each column are not significantly different based on Fisher's protected least significant difference test.

Table 2b. Turf Quality of an 'Alister' colonial bentgrass fairway turf treated preventively with various fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft$^{-2}$ | Int.[y] | Turf Quality 3 Aug | 10 Aug | 18 Aug | 23 Aug | 31 Aug |
|---|---|---|---|---|---|---|---|
| | | | ------------------------1-9; 6 = min acceptable------------------------ | | | | |
| Tourney | 0.37 oz | 14d | 8.0 ab [w] | 8.0 a | 8.3 ab | 7.3 ab | 7.5 ab |
| UC11-14 | 0.96 fl oz | 21d | 7.8 ab | 7.5 ab | 8.0 abc | 6.5 a-d | 7.0 b |
| UC11-11 | 0.506 fl oz | 21d | 7.8 ab | 7.8 a | 8.0 abc | 7.3 ab | 8.0 a |
| UC11-13 | 0.5 fl oz | 21d | 8.0 ab | 7.5 ab | 6.0 fg | 5.0 ef | 4.0 g |
| Heritage TL | 1.0 fl oz | 14d | 7.8 ab | 7.8 a | 8.0 abc | 7.0 abc | 8.0 a |
| Heritage TL | 2.0 fl oz | 28d | 8.0 ab | 8.0 a | 6.8 def | 6.3 bcd | 5.3 def |
| Heritage G [z] | 2.0 lb | 14d | 8.0 ab | 7.8 a | 7.8 a-d | 6.3 bcd | 5.5 de |
| Heritage G [z] | 4.0 lb | 28d | 7.8 ab | 8.3 a | 7.3 b-e | 6.0 cde | 4.8 efg |
| Banner MAXX 1.3ME | 1.0 fl oz | 14d | 7.8 ab | 8.0 a | 6.3 efg | 5.0 ef | 4.5 fg |
| Banner MAXX 1.3ME | 2.0 fl oz | 21d | 6.5 c | 6.8 bc | 6.8 def | 4.8 fg | 4.5 fg |
| Prophesy 0.072G [z] | 1.66 lb | 14d | 6.5 c | 6.5 c | 5.5 g | 4.8 fg | 4.3 g |
| Prophesy 0.072G [z] | 2.49 lb | 21d | 6.5 c | 6.5 c | 5.3 gh | 4.8 fg | 4.8 efg |
| Torque | 0.6 fl oz | 28d | 8.0 ab | 8.3 a | 7.8 a-d | 6.3 bcd | 5.3 def |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.8 ab | 8.0 a | 7.0 c-f | 6.0 cde | 4.8 efg |
| QP Tebuconazole | 0.6 fl oz | 28d | 8.0 ab | 8.0 a | 7.5 a-d | 6.5 a-d | 6.0 cd |
| + Foursome | 0.4 fl oz | | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 8.0 ab | 8.0 a | 7.5 a-d | 6.5 a-d | 5.5 de |
| - QP IPRO 2SE | 4.0 fl oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 7.8 ab | 7.8 a | 8.5 a | 6.8 a-d | 5.8 d |
| - QP Chlorothalonil DF | 3.2 oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 8.5 a | 8.0 a | 8.0 abc | 7.5 a | 6.8 bc |
| - QP TM/C | 4.0 oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| QP Tebuconazole | 0.6 fl oz | 28d | 8.3 ab | 8.0 a | 8.5 a | 7.0 abc | 6.0 cd |
| - QP TM | 2.0 fl oz | alt [x] | | | | | |
| + Foursome | 0.4 fl oz | 14d | | | | | |
| ProStar 70WG | 1.5 oz | 21d | 7.5 b | 7.5 ab | 7.5 a-d | 7.3 ab | 5.5 de |
| Daconil Ultrex | 3.2 oz | 21d | 7.5 b | 7.5 ab | 6.0 fg | 5.0 ef | 4.0 g |
| Endorse | 4.04 oz | 14d | 8.0 ab | 7.8 a | 7.3 b-e | 5.8 def | 5.3 def |
| Compass | 0.15 oz | 21d | 7.5 b | 7.5 ab | 8.0 abc | 6.3 bcd | 5.3 def |
| Untreated | | -- | 4.5 d | 4.5 d | 4.3 h | 3.8 g | 4.3 g |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 14 d | 7 | 21 | 29 | 34 | 42 |
| | | 21 d | 7 | 21 | 29 | 34 | 42 |
| | | 28 d | 20 | 34 | 42 | 47 | 55 |

[z] Individual plots received 0.1 inches of irrigation with a watering can immediately after fungicide application

[y] Initial applications were applied on 16 June. Thereafter, 14-d treatments were applied on 1 July, 14 July, 27 July; 21-d treatments were applied 7 July, 27 July; and 28-d treatments were applied on 14 July.

[x] Alternation partner was applied 14-d after each QP Tebuconazole application.

[w] Treatment means followed by the same letter within each column are not significantly different based on Fisher's protected least significant difference test.

Table 3a. Phytotoxicity of an 'Alister' colonial bentgrass fairway turf treated preventively with various fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment Rate per 1000 $ft^{-2}$ | Int.[y] | Phytotoxicity | | | |
|---|---|---|---|---|---|
| | | 10 Jul | 13 Jul | 20 Jul | 27 Jul |
| | | ----------------0-5; 2 = min acceptable--------------- | | | |
| Tourney……….……….…..0.37 oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| UC11-14……….……..…0.96 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| UC11-11…………..……0.506 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| UC11-13……..…...........…0.5 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage TL……………..…1.0 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage TL………………..…2.0 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage G [z]……..……...….….2.0 lb | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage G [z]……………..……4.0 lb | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| Banner MAXX 1.3ME..…..1.0 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| Banner MAXX 1.3ME …...2.0 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| Prophesy 0.072G [z]…...…….1.66 lb | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| Prophesy 0.072G [z]…..……..2.49 lb | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| Torque……………….…….…0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole…………0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole…………0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome……………..…0.4 fl oz | | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole…………0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP IPRO 2SE…..……..…4.0 fl oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome….…………….0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole…………0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP Chlorothalonil DF….......3.2 oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome………………..0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole………….0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP TM/C………………..….4.0 oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome………………..0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole…………0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP TM…………….……..2.0 fl oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome………………..0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| ProStar 70WG……………..…1.5 oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| Daconil Ultrex……………….3.2 oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| Endorse……………….…..…..4.04 oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 |
| Compass……………………0.15 oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 |
| Untreated | -- | 0.0 | 0.0 | 0.0 | 0.0 |
| ANOVA: Treatment (P > F) | | NS | NS | NS | NS |
| Days after treatment | 14 d | 9 | 12 | 6 | 13 |
| | 21 d | 3 | 6 | 12 | 19 |
| | 28 d | 24 | 27 | 6 | 13 |

[z] Individual plots received 0.1 inches of irrigation with a watering can immediately after fungicide application

[y] Initial applications were applied on 16 June. Thereafter, 14-d treatments were applied on 1 July, 14 July, 27 July; 21-d treatments were applied 7 July, 27 July; and 28-d treatments were applied on 14 July.

[x] Alternation partner was applied 14-d after each QP Tebuconazole application.

[w] Treatment means followed by the same letter within each column are not significantly different based on Fisher's protected least significant difference test.



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Table 3b. Phytotoxicity of an 'Alister' colonial bentgrass fairway turf treated preventively with various fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 $ft^{-2}$ | Int.[y] | Phytotoxicity | | | | |
|---|---|---|---|---|---|---|---|
| | | | 3 Aug | 10 Aug | 18 Aug | 23 Aug | 31 Aug |
| | | | -------------------------0-5; 2 = min acceptable----------------------- | | | | |
| Tourney | 0.37 oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UC11-14 | 0.96 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UC11-11 | 0.506 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| UC11-13 | 0.5 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage TL | 1.0 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage TL | 2.0 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage G [z] | 2.0 lb | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Heritage G [z] | 4.0 lb | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Banner MAXX 1.3ME | 1.0 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Banner MAXX 1.3ME | 2.0 fl oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Prophesy 0.072G [z] | 1.66 lb | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Prophesy 0.072G [z] | 2.49 lb | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Torque | 0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome | 0.4 fl oz | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP IPRO 2SE | 4.0 fl oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome | 0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP Chlorothalonil DF | 3.2 oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome | 0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP TM/C | 4.0 oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome | 0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| QP Tebuconazole | 0.6 fl oz | 28d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| - QP TM | 2.0 fl oz | alt [x] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| + Foursome | 0.4 fl oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ProStar 70WG | 1.5 oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Daconil Ultrex | 3.2 oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Endorse | 4.04 oz | 14d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Compass | 0.15 oz | 21d | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Untreated | | -- | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| ANOVA: Treatment (P > F) | | | NS | NS | NS | NS | NS |
| Days after treatment | | 14 d | 7 | 21 | 29 | 34 | 42 |
| | | 21 d | 7 | 21 | 29 | 34 | 42 |
| | | 28 d | 20 | 34 | 42 | 47 | 55 |

[z] Individual plots received 0.1 inches of irrigation with a watering can immediately after fungicide application

[y] Initial applications were applied on 16 June. Thereafter, 14-d treatments were applied on 1 July, 14 July, 27 July; 21-d treatments were applied 7 July, 27 July; and 28-d treatments were applied on 14 July.

[x] Alternation partner was applied 14-d after each QP Tebuconazole application.

[w] Treatment means followed by the same letter within each column are not significantly different based on Fisher's protected least significant difference test.

# CURATIVE DOLLAR SPOT CONTROL IN CREEPING BENTGRASS FAIRWAY TURF, 2011

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## INTRODUCTION

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

## MATERIALS & METHODS

A field study was conducted on a 'Putter' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk$^{-1}$ at a bench setting of 0.5-inches. A total of 0.85 lbs. of N was applied to the site from 27 April to 1 September. Overhead irrigation was applied every other night to prolong leaf wetness period and enhance disease.

Treatments were made curatively as a single application of available fungicides on 2 September when disease incidence reached approximately 60 dollar spot foci plot$^{-1}$. All treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft$^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot was assessed as a count of individual disease foci within each plot at the time of initial application and subsequently at approximately 7-d intervals. 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. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

## RESULTS & DISCUSSION

At the time of the initial application dollar spot ranged from 45 to 74 foci plot$^{-1}$. Seven days after the curative application dollar spot incidence was reduced in all treatments compared to the untreated plots (Table 1). The fewest number of dollar spot foci were observed in turf treated with Daconil Ultrex (5.0 oz.) alone or the tank-mix of Daconil Ultrex (3.25 oz.) and Trinity (1.0 fl.oz.), although Velista, Honor, Trinity (2.0 fl.oz.) and Curalan all provided comparable control on

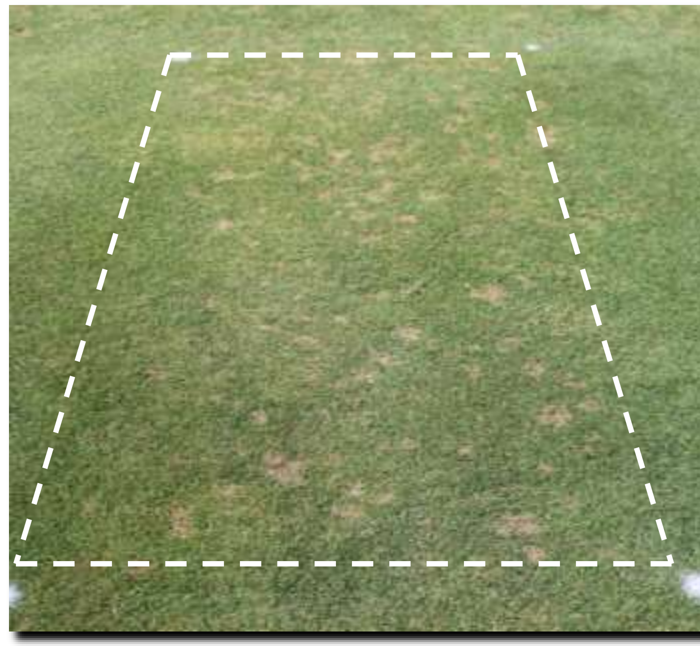

**Figure 1. Dollar spot incidence in untreated 'Putter' creeping bentgrass turf on 9 Sep in Storrs, CT.**

that date. Disease severity increased in all treatments 14 DAT during extremely favorable dollar spot conditions. At that time, only Honor and Curalan maintained adequate dollar spot control (i.e., < 30 foci plot$^{-1}$) and acceptable turf quality (> 6). However, these treatments were not significantly different than those containing Daconil Ultrex or Trinity. Emerald reduced dollar spot compared to the untreated control, but was less effective than other fungicide treatments during this 14 day long trial. Chipco 26GT (2.0 fl.oz.) initially reduced dollar spot, although the low application rate failed to provide effective curative control 14 DAT.

Few treatments applied as a single application provided acceptable curative control in this trial. For best curative dollar spot control, repeat applications of systemic fungicides at high rates are generally required to arrest latent infections and to prevent new ones from occurring. Increased nitrogen fertility may also improve recovery, by encouraging rapid re-growth of blighted tillers.

Table 1. Dollar spot incidence and turf quality in a 'Putter' creeping bentgrass turf maintained at 0.5 inches treated curatively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2011.

| | Dollar Spot Incidence | | | Turf Quality |
|---|---|---|---|---|
| Treatment[z] Rate per 1000 $ft^{-2}$ | 2 Sep | 9 Sep | 15 Sep | 15 Sep |
| | --number of foci per 18 $ft^{-2}$ -- | | | --1-9-- |
| Chipco 26GT………2.0 fl oz | 74.0 a[y] | 36.3 b | 163.0 a | 3.3 e |
| Velista……………...0.5 fl oz | 61.8 abc | 13.5 de | 78.8 b | 4.3 d |
| Emerald…………...0.18 fl oz | 51.8 cd | 29.3 bc | 79.5 b | 4.5 cd |
| Emerald…………...0.18 fl oz<br>+Par………………..0.3 fl oz | 44.5 d | 23.0 cd | 72.5 b | 5.0 bcd |
| Honor………………1.1 fl oz | 64.8 abc | 12.3 e | 23.5 c | 6.3 a |
| Daconil Ultrex……..5.0 fl oz | 55.8 bcd | 9.3 e | 34.8 c | 5.5 ab |
| Trinity……………...2.0 fl oz | 60.0 a-d | 17.0 de | 72.3 c | 5.3 bc |
| Daconil Ultrex……3.25 fl oz<br>+Trinity…………….1.0 fl oz | 60.3 a-d | 9.5 e | 36.0 c | 5.8 ab |
| Curalan…………….1.0 fl oz | 67.8 ab | 14.8 de | 29.0 c | 6.3 a |
| Untreated | 60.0 a-d | 62.8 a | 159.8 a | 3.3 e |
| ANOVA: Treatment (P > F) | 0.0491 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | 0 | 7 | 13 | 13 |

[z] Treatments were applied as a single curative application on 2 September.

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

# EVALUATION OF FUNGICIDE SPRAY PROGRAMS FOR SUMMER DISEASE CONTROL IN A MIXED CREEPING BENTGRASS AND ANNUAL BLUEGRASS PUTTING GREEN TURF, 2011

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## INTRODUCTION

Putting greens are the highest priority playing surfaces on the entire golf course. Irregularities in the putting surface can misdirect putts; reducing the functionality of the surface by imposing an unintended disruption to the game. Extensive management is required to maintain true putting surfaces and avoid non-uniformity due to environmental stress or disease. Several diseases (e.g., dollar spot, brown patch, pythium, take-all patch) may affect putting green turf throughout the season. Cultural practices are employed to minimize favorable conditions for these diseases, however due to the high value of putting surfaces, comprehensive fungicide programs are often developed to further reduce risk of turf loss caused by various diseases throughout the year. In addition to providing disease control, some fungicides have improved root growth in greenhouse studies conducted in controlled environments. The objectives of this study were to evaluate disease control efficacy and turf quality provided with various fungicide programs, and to assess whether different strobilurin fungicides improved root length in a field situation.

## MATERIALS & METHODS

A field study was conducted on a mixed 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*; < 10%) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk$^{-1}$ at a bench setting of 0.130-inches. The site was irrigated as necessary to avoid drought stress.

Treatments consisted of various fungicides applied in rotational programs or individually. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. Treatments were initiated prior to disease development on 13 May and continued until 17 August. Specific application dates are provided in the accompanying tables. All treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft$^{-2}$ at 40 psi.

Dollar spot was assessed as a count of individual disease foci within each plot from 1 June to 15 September. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually on a 0 to 5 scale; where 0 equaled no discoloration and 2 represented the maximum acceptable level. Similarly, algae was assessed visually on a 0 to 5 scale, where 0 indicated no algae was observed, 2 represented the maximum acceptable amount of algae, and 5 represented complete infestation of algae throughout the plot area. Relative chlorophyll index was determined using the FieldScout CM 1000 (Spectrum Technologies, Inc.) chlorophyll meter. Higher values represent greener reflectance. Ten readings were taken per plot with the mean used for data analysis. Root samples were taken at the conclusion of the trial (15 DAT) to assess differences in root length. Three intact 0.5-inch diameter cores were taken per plot and trimmed to a length of 12-inches. Cores were cold-packed in a Styrofoam cooler and sent to All-Tech Research and Development (Sparta, IL) for total root length assessment using Winrhizo root scanning software. 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 was initially observed on 1 June, and symptoms continued to develop in untreated turf throughout the duration of the trial (Table 1). However, disease pressure was considered low with a maximum of 45 dollar spot infection centers (DISC) plot$^{-1}$ observed in untreated turf. All treatments provided acceptable dollar spot control (< 25 DISC plot$^{-1}$) and reduced the disease compared to untreated turf. However, no dollar spot differences were observed between any of the fungicide programs or individual treatments throughout the trial.

Turf quality was high among all treatments, with no significant differences observed through mid-July (Table 2). By 20 August, turf quality differences had become apparent among treatments as dollar spot (Table 1) and algae (Table 3) developed in the trial. All programs provided similarly high turf quality at this time. This is most likely related to reductions in algae within programmatic treatments due to the addition of chlorothalonil in each program. Conversely, algae was generally greater in treatments where no chlorothalonil had been applied (i.e., strobilurins only treatments) compared to programmatic treatments. Turf quality of Disarm and Compass applied individually did not differ from untreated at this time (Table 2). At the conclusion of the trial (28 DAT), turf quality was highest in BASF Program 1, Arysta Program, and Insignia SC applied alone every 14 d. No phytoxicity was observed in any treatments throughout the trial (Table 3).

Limited differences in chlorophyll reflectance were observed on 10 August (Table 4). Disarm, Compass and untreated plots had the highest reflectance values on this date, although these high values may have been influenced by the presence of algae in these plots rather than actually darker green foliage. No root length differences were observed among any of the treatments tested (Table 3).

## CONCLUSION

Well conceived fungicide programs are an effective approach to managing common diseases of putting green turf. The success of such programs is dependent on proper identification of problematic diseases, and knowledge of when those diseases are likely to occur. It is also important to remember that fungicide selection, timing and rate decisions made during program planning stages need to be flexible within the season to permit adjustment of the program to compensate for unusual environmental conditions.

In this trial, similar programs differing in strobilurin and DMI active ingredients were evaluated. Overall, few differences were observed between these various programs. A slight improvement in turf quality was observed at the conclusion of the study in programs containing the active ingredient pyraclostrobin or fluxostrobin, or when pyraclostrobin was applied alone every 14 d. These data demonstrate that in many cases, a well planned rotational program should provide good season-long disease control and turf quality regardless of specific components.

Results from this field study did not show improved root growth associated with any of the treatments evaluated.

Table 1. Dollar spot incidence in a mixed 'Penn A-4' creeping bentgrass and annual bluegrass green treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 $ft^2$ | App Code[z] | Dollar spot incidence 1 Jun | 1 Jul | 13 Jul | 22 Jul | 29 Jul | 9 Aug | 20 Aug | 15 Sep |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ---number of foci per 18 $ft^2$--- | | | | | | | |
| BASF Program 1 | | | 0.0 | 0.0 b[y] | 0 .0 | 0.0 b | 0.0 b | 0.0 b | 0.3 b | 0.5 b |
| Honor | 1.1 oz | AO | | | | | | | | |
| Insignia SC | 0.7fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Syngenta Program | | | 0.3 | 1.0 b | 2.3 | 5.8 b | 5.3 b | 6.3 b | 2.5 b | 4.0 b |
| Headway | 3.0 fl oz | AO | | | | | | | | |
| Heritage TL | 2.0 fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Arysta Program | | | 0.0 | 0.0 b | 0.0 | 1.0 b | 0.3 b | 0.8 b | 1.0 b | 12.3 b |
| Disarm M | 1.0 fl oz | AO | | | | | | | | |
| Disarm | 0.36 fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Bayer Program | | | 0.0 | 0.3 b | 0.5 | 0.5 b | 0.3 b | 2.5 b | 0.8 b | 3.8 b |
| Tartan | 2.0 fl oz | AO | | | | | | | | |
| Compass | 0.25 oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| BASF Program 2 | | | 0.0 | 0.0 b | 3.3 | 1.8 b | 2.5 b | 3.3 b | 2.8 b | 4.8 b |
| Emerald | 0.18 oz | AO | | | | | | | | |
| Trinity | 1.0 fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Insignia SC | 0.7 fl oz | A – O | 0.3 | 0.0 b | 0.8 | 0.0 b | 0.0 b | 0.3 b | 0.3 b | 1.0 b |
| Heritage TL | 2.0 fl oz | A – O | 0.3 | 0.0 b | 0.0 | 0.3 b | 0.8 b | 1.3 b | 1.3 b | 3.8 b |
| Disarm | 0.36 fl oz | A – O | 0.3 | 0.0 b | 0.3 | 0.0 b | 0.0 b | 0.3 b | 0.3 b | 7.3 b |
| Compass | 0.25 oz | A – O | 0.3 | 0.0 b | 0.5 | 0.0 b | 0.8 b | 0.8 b | 2.3 b | 2.8 b |
| Untreated | | -- | 1.0 | 3.0 a | 3.3 | 12.3 a | 24.0 a | 30.8 a | 27.0 a | 44.8 a |
| ANOVA: Treatment ($P > F$) | | | 0.3022 | 0.0226 | 0.4101 | 0.0037 | 0.0021 | 0.0065 | 0.0015 | 0.0004 |
| Days after treatment | | | 7 | 8 | 6 | 3 | 10 | 6 | 3 | 28 |

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 13 May, C = 25 May, E = 6 June, G = 23June, I = 7 July, K = 19 July, M = 3 Aug, O = 17 August.

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

Table 2. Turf quality in a mixed 'Penn A-4' creeping bentgrass and annual bluegrass green treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft$^2$ | App Code[z] | Turf Quality 1 Jun | 1 Jul | 13 Jul | 22 Jul | 29 Jul | 20 Aug | 15 Sep |
|---|---|---|---|---|---|---|---|---|---|
| | | | -----------------------1-9; 6=minimum acceptable----------------------- | | | | | | |
| BASF Program 1 | | | 8.0 | 7.3 | 8.0 | 7.8 | 6.3 | 7.0 abc[y] | 7.3 a |
| Honor | 1.1 oz | AO | | | | | | | |
| Insignia SC | 0.7fl oz | CI | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | |
| Syngenta Program | | | 8.5 | 8.3 | 8.0 | 7.8 | 6.5 | 6.8 abc | 6.0 bc |
| Headway | 3.0 fl oz | AO | | | | | | | |
| Heritage TL | 2.0 fl oz | CI | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | |
| Arysta Program | | | 8.0 | 7.8 | 7.5 | 7.8 | 6.3 | 7.5 a | 6.8 ab |
| Disarm M | 1.0 fl oz | AO | | | | | | | |
| Disarm | 0.36 fl oz | CI | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | |
| Bayer Program | | | 7.8 | 7.3 | 7.3 | 7.3 | 6.0 | 7.3 ab | 5.5 cd |
| Tartan | 2.0 fl oz | AO | | | | | | | |
| Compass | 0.25 oz | CI | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | |
| BASF Program 2 | | | 7.3 | 7.3 | 7.0 | 7.5 | 5.5 | 6.5 abc | 5.3 cde |
| Emerald | 0.18 oz | AO | | | | | | | |
| Trinity | 1.0 fl oz | CI | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | |
| Insignia SC | 0.7 fl oz | A – O | 7.3 | 6.8 | 7.5 | 7.5 | 6.8 | 6.8 abc | 6.8 ab |
| Heritage TL | 2.0 fl oz | A – O | 7.5 | 7.5 | 8.0 | 7.5 | 6.5 | 6.3 abc | 5.3 cde |
| Disarm | 0.36 fl oz | A – O | 7.8 | 7.3 | 7.5 | 7.5 | 7.0 | 6.0 bcd | 5.3 cde |
| Compass | 0.25 oz | A – O | 8.3 | 6.5 | 7.0 | 6.3 | 5.5 | 5.8 cd | 4.5 de |
| Untreated | | -- | 7.3 | 6.5 | 7.5 | 6.8 | 6.0 | 4.8 d | 4.3 e |
| ANOVA: Treatment (P > F) | | | 0.6745 | 0.2367 | 0.9099 | 0.5067 | 0.7980 | 0.0136 | 0.0001 |
| Days after treatment | | | 7 | 8 | 6 | 3 | 10 | 3 | 28 |

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 13 May, C = 25 May, E = 6 June, G = 23June, I = 7 July, K = 19 July, M = 3 Aug, O = 17 August.

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

Table 3. Phytotoxicity, algae, and root length in a mixed 'Penn A-4' creeping bentgrass and annual bluegrass green treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment Rate per 1000 ft$^2$ | App[z] | Phytotoxicity 1 Jun | Phytotoxicity 22 Jul | Phytotoxicity 29 Jul | Phytotoxicity 20 Aug | Algae 20 Aug | Total root length 1 Sept |
|---|---|---|---|---|---|---|---|
| | | --rating 0-5; 2=max acceptable-- | | | | 0-5 | cm |
| BASF Program 1 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 d[y] | 451.3 |
| Honor..............................1.1 oz | AO | | | | | | |
| Insignia SC..................0.7fl oz | CI | | | | | | |
| Spectro 90....................5.75 oz | E | | | | | | |
| Chipco Signature............4.0 oz | GK | | | | | | |
| Daconil Ultrex..............3.25 oz | GK | | | | | | |
| Chipco 26GT..............4.0 fl oz | M | | | | | | |
| Syngenta Program | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 d | 398.3 |
| Headway.....................3.0 fl oz | AO | | | | | | |
| Heritage TL.................2.0 fl oz | CI | | | | | | |
| Spectro 90.....................5.75 oz | E | | | | | | |
| Chipco Signature............4.0 oz | GK | | | | | | |
| Daconil Ultrex..............3.25 oz | GK | | | | | | |
| Chipco 26GT..............4.0 fl oz | M | | | | | | |
| Arysta Program | | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 cd | 375.4 |
| Disarm M....................1.0 fl oz | AO | | | | | | |
| Disarm.......................0.36 fl oz | CI | | | | | | |
| Spectro 90.....................5.75 oz | E | | | | | | |
| Chipco Signature............4.0 oz | GK | | | | | | |
| Daconil Ultrex..............3.25 oz | GK | | | | | | |
| Chipco 26GT..............4.0 fl oz | M | | | | | | |
| Bayer Program | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 d | 298.00 |
| Tartan..........................2.0 fl oz | AO | | | | | | |
| Compass.......................0.25 oz | CI | | | | | | |
| Spectro 90....................5.75 oz | E | | | | | | |
| Chipco Signature............4.0 oz | GK | | | | | | |
| Daconil Ultrex..............3.25 oz | GK | | | | | | |
| Chipco 26GT..............4.0 fl oz | M | | | | | | |
| BASF Program 2 | | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 cd | ND |
| Emerald........................0.18 oz | AO | | | | | | |
| Trinity.........................1.0 fl oz | CI | | | | | | |
| Spectro 90....................5.75 oz | E | | | | | | |
| Chipco Signature............4.0 oz | GK | | | | | | |
| Daconil Ultrex..............3.25 oz | GK | | | | | | |
| Chipco 26GT..............4.0 fl oz | M | | | | | | |
| Insignia SC.....................0.7 fl oz | A – O | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 bc | ND |
| Heritage TL....................2.0 fl oz | A – O | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 b | ND |
| Disarm..........................0.36 fl oz | A – O | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 b | ND |
| Compass..........................0.25 oz | A – O | 0.0 | 0.0 | 0.0 | 0.0 | 2.0 b | ND |
| Untreated | -- | 0.0 | 0.0 | 0.0 | 0.0 | 3.3 a | 354.1 |
| ANOVA: Treatment (P > F) | | 1.0 | 1.0 | 1.0 | 1.0 | 0.0001 | 0.0622 |
| Days after treatment | | 7 | 3 | 10 | 3 | 3 | 15 |

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 13 May, C = 25 May, E = 6 June, G = 23June, I = 7 July, K = 19 July, M = 3 Aug, O = 17 August.

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



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Table 4. Chlorophyll reflective index of a mixed 'Penn A-4' creeping bentgrass and annual bluegrass green treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| | | | Chlorophyll Reflectance | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 $ft^2$ | App[z] | 1 Jun | 16 Jun | 1 Jul | 13 Jul | 27 Jul | 5 Aug | 10 Aug | 26 Aug |
| | | | --------------chlorophyll index-------------- | | | | | | | |
| BASF Program 1 | | | 280.0 | 270.5 | 280.8 | 267.5 | 270.5 | 298.3 | 274.0 e[y] | 232.3 |
| Honor | 1.1 oz | AO | | | | | | | | |
| Insignia SC | 0.7fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Syngenta Program | | | 292.0 | 275.8 | 287.3 | 267.8 | 265.5 | 291.8 | 278.5 cde | 236.5 |
| Headway | 3.0 fl oz | AO | | | | | | | | |
| Heritage TL | 2.0 fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Arysta Program | | | 288.8 | 269.3 | 285.8 | 270.5 | 255.3 | 292.0 | 275.5 de | 228.0 |
| Disarm M | 1.0 fl oz | AO | | | | | | | | |
| Disarm | 0.36 fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Bayer Program | | | 285.3 | 260.8 | 280.3 | 266.0 | 260.0 | 292.5 | 277.0 cde | 225.0 |
| Tartan | 2.0 fl oz | AO | | | | | | | | |
| Compass | 0.25 oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| BASF Program 2 | | | 283.8 | 262.5 | 278.0 | 261.5 | 254.3 | 289.3 | 274.0 e | 230.3 |
| Emerald | 0.18 oz | AO | | | | | | | | |
| Trinity | 1.0 fl oz | CI | | | | | | | | |
| Spectro 90 | 5.75 oz | E | | | | | | | | |
| Chipco Signature | 4.0 oz | GK | | | | | | | | |
| Daconil Ultrex | 3.25 oz | GK | | | | | | | | |
| Chipco 26GT | 4.0 fl oz | M | | | | | | | | |
| Insignia SC | 0.7 fl oz | A – O | 273.5 | 259.8 | 281.8 | 268.5 | 271.0 | 308.5 | 297.5 bc | 241.8 |
| Heritage TL | 2.0 fl oz | A – O | 281.3 | 275.5 | 284.8 | 266.8 | 278.0 | 302.3 | 296.0 bcd | 233.5 |
| Disarm | 0.36 fl oz | A – O | 284.5 | 278.0 | 285.5 | 277.3 | 289.8 | 308.3 | 310.5 ab | 242.5 |
| Compass | 0.25 oz | A – O | 277.8 | 262.3 | 278.3 | 262.5 | 259.8 | 298.8 | 303.5 ab | 228.3 |
| Untreated | | -- | 277.0 | 261.3 | 283.3 | 268.0 | 279.3 | 311.3 | 319.0 a | 242.8 |
| ANOVA: Treatment (P > F) | | | 0.893 | 0.577 | 0.995 | 0.894 | 0.052 | 0.480 | 0.0003 | 0.092 |
| Days after treatment | | | 7 | 10 | 8 | 6 | 8 | 2 | 7 | 9 |

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 13 May, C = 25 May, E = 6 June, G = 23June, I = 7 July, K = 19 July, M = 3 Aug, O = 17 August.

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

# EARLY CURATIVE DOLLAR SPOT CONTROL WITH COMMERCIALLY AVALIABLE AND EXPERIMENTAL FUNGICIDES IN A MIXED CREEPING BENTGRASS AND ANNUAL BLUEGRASS PUTTING GREEN TURF, 2011

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## INTRODUCTION

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

## MATERIALS & METHODS

A field study was conducted on a mixed 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*; < 10%) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days $wk^{-1}$ at a bench setting of 0.130-inches. The site was irrigated as necessary to avoid drought stress. Daconil Ultrex was applied at 5 oz 1000-$ft^{-2}$ on 21 June to limit dollar spot development in the treatment area until the initiation of study.

Treatments consisted of various fungicides applied individually or as tank mixes and rotational programs. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. Treatments were initiated as an early curative application on 13 July and continued until 6 September. Specific application dates are provided within the tables. All treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-$ft^{-2}$ at 40 psi.

Dollar spot was assessed as a count of individual disease foci within each plot from 29 July to 15 September. Dollar spot was also assessed on 7 October as percent area of blighted turf per 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 on a 0 to 5 scale; where 0 equaled no discoloration and 2 represented the maximum acceptable level. Relative chlorophyll index was determined using the FieldScout CM 1000 (Spectrum Technologies, Inc.) chlorophyll meter. Higher values represent greener reflectance. Ten readings were taken per plot with the mean used for data analysis. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

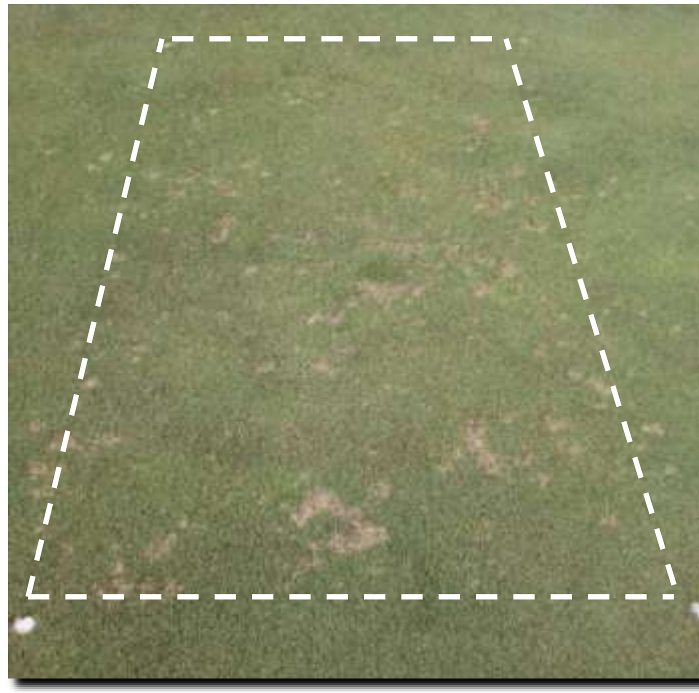

**Figure 2 Dollar spot incidence in untreated 'Penn A-4' creeping bentgrass/annual bluegrass turf on 9 Aug in Storrs, CT.**

## RESULTS

*Dollar Spot*

Dollar spot developed in the trial on 10 July, before initial treatment applications were made. All treatments reduced dollar spot infection centers (DSIC) compared to untreated turf 16 days after initial application, on 29 July (Table 1). However, the low rate of Reserve (2.5 fl.oz.) applied every 14-d and UC11-10 appeared to be less effective than other treatments on this date. By 9 August, near complete dollar spot recovery had occurred, with no significant differences observed among all treated plots. Most treatments continued to provide good dollar spot control (< 10 DSIC $plot^{-1}$) as disease pressure increased during late August and September. Turf treated every 7 d with Reserve (2.5 fl.oz) or Concert (2.5 fl.oz.) or 14 d treatments of Tartan, Tourney, Banner MAXX, Insignia SC + Par, or Velista (0.5 oz.) provided near complete control of dollar spot on 15 September. Poor dollar spot control was observed in turf treated with the tank mix of UC11-4 and the low rate of UC11-19 (0.31 fl.oz.) and applications of Reserve (2.5 fl.oz.) every 14 d. Residual dollar spot control was assessed as the percent plot area blighted 31 DAT on 7 October. Several treatments continued to provide good dollar spot control (< 1% plot area blighted) at this time including Reserve (7 d intervals), Concert, Tartan, Tourney, Banner MAXX, UC11-7, Velista, and Interface (3.0 fl.oz.).

*Turf Quality, Phytotoxicity, Chlorophyll Reflectance*

Turf quality of individual treatments varied throughout the study based on dollar spot, phytotoxicity and algae. On 29 July, quality was generally highest in turf treated with Interface, Reserve, or Insignia + Par; all materials containing green pigments (Table 2). However, algae and dollar spot developed by 24 August, reducing turf quality in many treatments throughout the trial. The best quality observed at this time was in turf treated with Reserve (3.5 & 3.6 fl.oz.; 14 d), Reserve (2.5 fl.oz.; 7 d), Velista + Daconil Ultrex, and UC11-19 (0.625 fl.oz.) + UC11-4; each of these treatments contained the active ingredient chlorothalonil which helped maintain good quality by suppressing algae. By 7 October (31 DAT), severe algae had developed throughout the trial resulting in unacceptable quality in all treatments except Concert at a 7-d interval. Unacceptable phytotoxicity was observed in turf treated every 14-d with Concert or Banner MAXX (Table 2).

Chlorophyll reflectance was highest in turf treated with Interface, Insignia SC, Velista, Tourney, UC11-7, UC11-12 and Iprodione Pro (Table 3).

## DISCUSSION

All treatments were effective at reducing dollar spot. DMI fungicides appeared to be particularly effective in controlling dollar spot in this trial. However, important differences in phytosafety were observed between treatments within this chemical class. In this trial, Banner MAXX, Concert, and Tartan tended to cause phytotoxicty that was slightly more severe compared to Tourney. Conversely, Reserve applied at low rates every 7 to 14 days appeared to be safer than other known DMIs in this trial. Moreover, Reserve applied at 2.5 fl.oz. every 7 d provided improved turf quality and dollar spot control compared to similar or higher rates applied every 14 days.

Velista is a new SDHI fungicide that is scheduled to be released in 2012. Repeat applications of this material provided excellent dollar spot control in the current trial without causing significant phytotoxicity.

The tank-mix of the experimental fungicide UC11-19 and UC11-4 provided good dollar spot control when the former was applied at 0.5 fl.oz. Increased rates did not significantly improve dollar spot control in this study under moderate disease pressure.



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Table 1. Dollar spot incidence and severity in a mixed 'Penn A-4' creeping bentgrass and annual bluegrass putting green turf treated with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft$^{-2}$ | Int[z] | Dollar spot incidence 29 Jul | 9 Aug | 24 Aug | 15 Sep | Dollar spot severity 7 Oct |
|---|---|---|---|---|---|---|---|
| | | | --------number of foci per 18 ft$^2$-------- | | | | --% area-- |
| Reserve | 2.5 fl oz | 14 d[y] | 0.5 d[v] | 0.0 b | 2.3 c | 6.3 cd | 1.6 b-f |
| -Interface | 3.0 fl oz | | | | | | |
| Reserve | 3.5 fl oz | 14 d | 4.5 cd | 0.0 b | 3.3 bc | 8.5 cd | 1.6 b-f |
| Concert | 5.5 fl oz | 14 d | 0.3 d | 0.0 b | 1.0 c | 2.0 d | 1.0 def |
| Interface | 3.0 fl oz | 14 d | 0.3d | 0.0 b | 0.8 c | 0.8 d | 0.6 def |
| Interface | 4.0 fl oz | 14 d | 0.0 d | 0.0 b | 1.0 c | 12.3 cd | 1.8 b-f |
| Iprodione Pro | 4.0 fl oz | 14 d | 0.0 d | 0.0 b | 1.0 c | 5.5 cd | 1.8 b-f |
| Tartan | 1.5 fl oz | 14 d | 0.5 d | 0.0 b | 0.8 c | 0.5 d | 0.0 f |
| Reserve | 1.6 fl oz | 7 d | 1.3 cd | 0.3 b | 1.0 c | 2.3 d | 1.0 def |
| Reserve | 2.5 fl oz | 7 d | 0.0 d | 0.0 b | 0.0 c | 0.0 d | 0.9 def |
| Reserve | 2.5 fl oz | 14 d | 17.5 b | 7.8 b | 24.0 b | 36.5 bc | 4.8 bc |
| Reserve | 3.6 fl oz | 14 d | 4.8 bcd | 1.8 b | 9.5 bc | 22.5 bcd | 3.0 b-f |
| Concert | 2.5 fl oz | 7 d | 0.3 d | 0.0 b | 0.3 c | 0.0 d | 0.1 ef |
| Tourney | 0.28 oz | 14 d | 1.5 cd | 0.0 b | 1.3 c | 0.5 d | 0.5 def |
| Insignia SC | 0.7 fl oz | 14 d | 8.3 bcd | 0.0 b | 1.3 c | 2.0 d | 1.0 def |
| Insignia SC | 0.7 fl oz | 14 d | 3.0 cd | 0.0 b | 2.0 c | 0.5 d | 0.9 def |
| +Par | 0.3 fl oz | | | | | | |
| UC11-6 | 0.494 fl oz | 14 d[x] | 9.3 bcd | 2.3 b | 11.8 bc | 18.8 bcd | 3.5 b-e |
| -UC11-4 | 3.6 fl oz | | | | | | |
| UC11-8 | 1.6 fl oz | 14 d[w] | 10.8 bcd | 5.8 b | 12.3 bc | 30.0 bcd | 3.9 bcd |
| -UC11-4 | 3.6 fl oz | | | | | | |
| UC11-2 | 4.0 fl oz | 14 d | 4.0 cd | 0.3 b | 3.3 bc | 7.0 cd | 1.0 def |
| UC11-6 | 0.494 fl oz | 14 d | 11.8 bcd | 5.0 b | 5.5 bc | 6.0 cd | 2.0 b-f |
| UC11-10 | 1.0 fl oz | 14 d | 13.5 bc | 3.3 b | 11.0 bc | 6.8 cd | 2.8 b-f |
| UC11-7 | 0.37 oz | 14 d | 5.5 bcd | 0.8 b | 1.3 c | 1.0 d | 0.8 def |
| UC11-12 | 3.0 fl oz | 14 d | 7.3 bcd | 3.3 b | 11.5 bc | 27.8 bcd | 3.5 b-e |
| Velista | 0.3 oz | 14 d | 8.3 bcd | 0.5 b | 4.5 bc | 22.5 bcd | 2.9 b-f |
| +Daconil Ultrex | 3.25 fl oz | | | | | | |
| Velista | 0.3 fl oz | 14 d | 9.0 bcd | 1.0 b | 1.3 c | 0.8 d | 0.6 def |
| Velista | 0.5 fl oz | 14 d | 1.3 cd | 0.0 b | 0.8 c | 0.0 d | 0.4 ef |
| Banner MAXX | 1.0 fl oz | 14 d | 1.3 cd | 0.0 b | 0.3 c | 0.5 d | 0.1 ef |
| UC11-19 | 0.31 fl oz | 14 d | 10.0 bcd | 4.8 b | 14.5 bc | 45.0 b | 5.0 b |
| +Daconil Action | 3.6 fl oz | | | | | | |
| UC11-19 | 0.5 fl oz | 14 d | 1.5 cd | 0.3 b | 3.3 bc | 5.8 cd | 1.5 c-f |
| +UC11-4 | 3.6 fl oz | | | | | | |
| UC11-19 | 0.625 fl oz | 14 d | 2.5 cd | 0.3 b | 1.8 c | 9.8 cd | 2.6 b-f |
| +UC11-4 | 3.6 fl oz | | | | | | |
| Untreated | | -- | 68.5 a | 73.5 a | 84.5 a | 111.5 a | 14.3 a |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 7 d | 2 | 6 | 1 | 9 | 31 |
| | | 14 d | 2 | 14 | 1 | 9 | 31 |

[z] Initial application was made on 13 Jul. Subsequent 7 d applications were made on 19 Jul, 27 Jul, 3 Aug, 10 Aug, 17 Aug, 23 Aug, 30 Aug, and 6 Sep. Subsequent 14 d applications were made on 27 Jul, 10 Aug, 23 Aug, and 6 Sep.

[y] Reserve and Interface were applied in rotation every 14 d. Reserve was applied on 13 Jul, 10 Aug and 6 Sep; Interface was applied on 27 Jul and 23 Aug.

[x] UC11-6 and UC11-4 were applied in rotation every 14 d. UC11-6 was applied on 13 Jul, 10 Aug and 6 Sep; UC11-4 was applied on 27 Jul and 23 Aug.

[w] UC11-8 and UC11-4 were applied in rotation every 14 d. UC11-8 was applied on 13 Jul, 10 Aug and 6 Sep; UC11-4 was applied on 27 Jul and 23 Aug.

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

Table 2. Turf quality and phytotoxicity in a mixed ‘Penn A-4’ creeping bentgrass and annual bluegrass putting green turf treated with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 $ft^{-2}$ | Int[z] | Turf Quality 29 Jul | Turf Quality 24 Aug | Turf Quality 15 Sep | Turf Quality 7 Oct | Phytotoxicity 29 Jul | Phytotoxicity 24 Aug |
|---|---|---|---|---|---|---|---|---|
| | | | -------------------1-9; 6=min acceptable- | | | | -0-5; 2=max acceptable- | |
| Reserve……………… | 2.5 fl oz | 14 d[y] | 7.5 a-d | 6.3 c-g | 5.5 cde | 4.8 c-f | 0.0 e | 0.3 ef |
| -Interface…………….. | 3.0 fl oz | | | | | | | |
| Reserve……………… | 3.5 fl oz | 14 d | 7.3 b-e | 7.0 a-d | 5.0 d-g | 5.0 b-e | 0.0 e | 0.0 f |
| Concert……………… | 5.5 fl oz | 14 d | 5.0 j | 5.8 e-h | 4.5 e-i | 5.5 abc | 3.0 a | 0.8 c-f |
| Interface……………… | 3.0 fl oz | 14 d | 7.8 abc | 6.3 c-g | 4.0 g-k | 5.3 a-d | 0.0 e | 0.3 ef |
| Interface……………… | 4.0 fl oz | 14 d | 8.5 a | 6.5 b-f | 4.5 e-i | 4.8 c-f | 0.0 e | 0.0 f |
| Iprodione Pro……… | 4.0 fl oz | 14 d | 6.8 c-g | 6.0 d-g | 4.0 g-k | 5.0 b-e | 0.0 e | 0.8 c-f |
| Tartan………………… | 1.5 fl oz | 14 d | 5.5 hij | 4.5 ij | 3.0 k | 5.0 b-e | 1.5 c | 1.3 bcd |
| Reserve……………… | 1.6 fl oz | 7 d | 7.0 b-f | 6.8 b-e | 6.3 bc | 5.3 a-d | 0.3 e | 0.0 f |
| Reserve……………… | 2.5 fl oz | 7 d | 7.8 abc | 8.0 a | 8.0 a | 5.8 ab | 0.0 e | 0.0 f |
| Reserve……………… | 2.5 fl oz | 14 d | 6.5 d-h | 6.0 d-g | 4.8 d-h | 4.3 ef | 0.0 e | 0.0 f |
| Reserve……………… | 3.6 fl oz | 14 d | 7.5 a-d | 7.5 ab | 5.0 d-g | 4.8 c-f | 0.0 e | 0.0 f |
| Concert……………… | 2.5 fl oz | 7 d | 5.8 g-j | 5.8 e-h | 5.0 d-g | 6.0 a | 2.0 b | 0.5 def |
| Tourney……………….. | 0.28 oz | 14 d | 7.0 b-f | 5.3 ghi | 3.8 h-k | 5.0 b-e | 0.0 e | 1.5 bc |
| Insignia SC…………... | 0.7 fl oz | 14 d | 6.3 e-i | 6.3 c-g | 5.3 c-f | 5.5 abc | 0.3 e | 0.5 def |
| Insignia SC…………... | 0.7 fl oz | 14 d | 8.0 ab | 6.3 c-g | 7.0 ab | 5.3 a-d | 0.0 e | 0.0 f |
| +Par………………….. | 0.3 fl oz | | | | | | | |
| UC11-6………...….. | 0.494 fl oz | 14 d[x] | 6.0 f-j | 6.5 b-f | 5.5 cde | 4.5 def | 0.0 e | 0.5 def |
| -UC11-4…….............… | 3.6 fl oz | | | | | | | |
| UC11-8…………...….. | 1.6 fl oz | 14 d[w] | 6.8 c-g | 6.3 c-g | 5.8 cd | 4.3 ef | 0.0 e | 0.3 ef |
| -UC11-4…….............… | 3.6 fl oz | | | | | | | |
| UC11-2…………...….. | 4.0 fl oz | 14 d | 5.0 j | 6.0 d-g | 5.0 d-g | 5.5 abc | 1.8 bc | 0.8 c-f |
| UC11-6………...….. | 0.494 fl oz | 14 d | 6.3 e-i | 4.8 hij | 4.3 f-j | 4.8 c-f | 0.0 e | 2.0 b |
| UC11-10………….….. | 1.0 fl oz | 14 d | 6.3 e-i | 4.8 hij | 4.0 g-k | 4.5 def | 0.0 e | 0.8 c-f |
| UC11-7……………..… | 0.37 oz | 14 d | 6.5 d-h | 5.3 ghi | 3.5 ijk | 5.3 a-d | 0.0 e | 1.0 cde |
| UC11-12….….……… | 3.0 fl oz | 14 d | 6.8 c-g | 6.8 b-e | 5.8 cd | 4.5 def | 0.0 e | 0.0 f |
| Velista………………….. | 0.3 oz | 14 d | 6.3 e-i | 7.3 abc | 6.3 bc | 4.3 ef | 0.0 e | 0.0 f |
| +Daconil Ultrex…….. | 3.25 fl oz | | | | | | | |
| Velista………………... | 0.3 fl oz | 14 d | 6.3 e-i | 5.5 f-i | 4.0 g-k | 5.5 abc | 0.0 e | 0.0 f |
| Velista………………... | 0.5 fl oz | 14 d | 6.8 c-g | 5.3 ghi | 4.5 e-i | 5.3 a-d | 0.0 e | 0.5 def |
| Banner MAXX………. | 1.0 fl oz | 14 d | 5.8 g-j | 4.0 j | 3.0 k | 4.8 c-f | 2.0 b | 3.0 a |
| UC11-19…………….. | 0.31 fl oz | 14 d | 5.8 g-j | 6.5 b-f | 5.8 cd | 4.0 f | 0.8 d | 0.0 f |
| +Daconil Action…....... | 3.6 fl oz | | | | | | | |
| UC11-19……….…….. | 0.5 fl oz | 14 d | 6.0 f-j | 6.5 b-f | 6.3 bc | 5.3 a-d | 0.8 d | 0.3 ef |
| +UC11-4…..............….. | 3.6 fl oz | | | | | | | |
| UC11-19…………... | 0.625 fl oz | 14 d | 5.8 g-j | 7.3 abc | 7.3 ab | 5.0 b-e | 1.0 d | 0.3 ef |
| +UC11-4……............... | 3.6 fl oz | | | | | | | |
| Untreated | | -- | 5.3 ij | 4.0 j | 3.3 jk | 2.8 g | 0.0 e | 0.5 def |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 7 d | 2 | 1 | 9 | 31 | 2 | 1 |
| | | 14 d | 2 | 1 | 9 | 31 | 2 | 1 |

[z] Initial application was made on 13 Jul. Subsequent 7 d applications were made on 19 Jul, 27 Jul, 3 Aug, 10 Aug, 17 Aug, 23 Aug, 30 Aug, and 6 Sep. Subsequent 14 d applications were made on 27 Jul, 10 Aug, 23 Aug, and 6 Sep.

[y] Reserve and Interface were applied in rotation every 14 d. Reserve was applied on 13 Jul, 10 Aug and 6 Sep; Interface was applied on 27 Jul and 23 Aug.

[x] UC11-6 and UC11-4 were applied in rotation every 14 d. UC11-6 was applied on 13 Jul, 10 Aug and 6 Sep; UC11-4 was applied on 27 Jul and 23 Aug.

[w] UC11-8 and UC11-4 were applied in rotation every 14 d. UC11-8 was applied on 13 Jul, 10 Aug and 6 Sep; UC11-4 was applied on 27 Jul and 23 Aug.

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

Table 3. Chlorophyll reflective index in a mixed ‘Penn A-4’ creeping bentgrass and annual bluegrass putting green turf treated with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft$^{-2}$ | Int[z] | Chlorophyll Reflectance 15 Jul | Chlorophyll Reflectance 5 Aug |
|---|---|---|---|---|
| | | | --chlorophyll index-- | |
| Reserve | 2.5 fl oz | 14 d[y] | 240.5 | 310.3 d-h[v] |
| -Interface | 3.0 fl oz | | | |
| Reserve | 3.5 fl oz | 14 d | 239.8 | 315.3 b-h |
| Concert | 5.5 fl oz | 14 d | 229.3 | 309.0 d-h |
| Interface | 3.0 fl oz | 14 d | 243.3 | 318.3 a-f |
| Interface | 4.0 fl oz | 14 d | 246.0 | 323.5 a-d |
| Iprodione Pro | 4.0 fl oz | 14 d | 234.8 | 315.5 a-g |
| Tartan | 1.5 fl oz | 14 d | 236.3 | 301.0 gh |
| Reserve | 1.6 fl oz | 7 d | 234.0 | 314.0 b-h |
| Reserve | 2.5 fl oz | 7 d | 241.0 | 311.3 c-h |
| Reserve | 2.5 fl oz | 14 d | 238.0 | 311.5 b-h |
| Reserve | 3.6 fl oz | 14 d | 235.5 | 315.3 b-h |
| Concert | 2.5 fl oz | 7 d | 231.8 | 313.3 b-h |
| Tourney | 0.28 oz | 14 d | 240.0 | 320.5 a-f |
| Insignia SC | 0.7 fl oz | 14 d | 230.5 | 320.0 a-f |
| Insignia SC | 0.7 fl oz | 14 d | 248.8 | 331.0 a |
| +Par | 0.3 fl oz | | | |
| UC11-6 | 0.494 fl oz | 14 d[x] | 243.5 | 312.3 b-h |
| -UC11-4 | 3.6 fl oz | | | |
| UC11-8 | 1.6 fl oz | 14 d[w] | 235.5 | 310.5 d-h |
| -UC11-4 | 3.6 fl oz | | | |
| UC11-2 | 4.0 fl oz | 14 d | 230.8 | 312.5 b-h |
| UC11-6 | 0.494 fl oz | 14 d | 236.0 | 313.0 b-h |
| UC11-10 | 1.0 fl oz | 14 d | 235.5 | 314.5 b-h |
| UC11-7 | 0.37 oz | 14 d | 238.0 | 322.5 a-e |
| UC11-12 | 3.0 fl oz | 14 d | 234.8 | 316.0 a-g |
| Velista | 0.3 oz | 14 d | 231.5 | 307.8 e-h |
| +Daconil Ultrex | 3.25 fl oz | | | |
| Velista | 0.3 fl oz | 14 d | 237.0 | 326.8 abc |
| Velista | 0.5 fl oz | 14 d | 237.3 | 327.0 ab |
| Banner MAXX | 1.0 fl oz | 14 d | 242.0 | 312.8 b-h |
| UC11-19 | 0.31 fl oz | 14 d | 228.0 | 308.8 d-h |
| +Daconil Action | 3.6 fl oz | | | |
| UC11-19 | 0.5 fl oz | 14 d | 232.5 | 306.5 fgh |
| +UC11-4 | 3.6 fl oz | | | |
| UC11-19 | 0.625 fl oz | 14 d | 226.8 | 308.5 d-h |
| +UC11-4 | 3.6 fl oz | | | |
| Untreated | | -- | 243.8 | 299.8 h |
| ANOVA: Treatment (P > F) | | | 0.0815 | 0.0306 |
| Days after treatment | | 7 d | 5 | 2 |
| | | 14 d | 5 | 9 |

Initial application was made on 13 Jul. Subsequent 7 d applications were made on 19 Jul, 27 Jul, 3 Aug, 10 Aug, 17 Aug, 23 Aug, 30 Aug, and 6 Sep. Subsequent 14 d applications were made on 27 Jul, 10 Aug, 23 Aug, and 6 Sep.

Reserve and Interface were applied in rotation every 14 d. Reserve was applied on 13 Jul, 10 Aug and 6 Sep; Interface was applied on 27 Jul and 23 Aug.

UC11-6 and UC11-4 were applied in rotation every 14 d. UC11-6 was applied on 13 Jul, 10 Aug and 6 Sep; UC11-4 was applied on 27 Jul and 23 Aug.

' UC11-8 and UC11-4 were applied in rotation every 14 d. UC11-8 was applied on 13 Jul, 10 Aug and 6 Sep; UC11-4 was applied on 27 Jul and 23 Aug.

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

# PREVENTIVE DOLLAR SPOT CONTROL IN CREEPING BENTGRASS FAIRWAY TURF USING AVAILABLE AND EXPERIMENTAL FUNGICIDES, 2011

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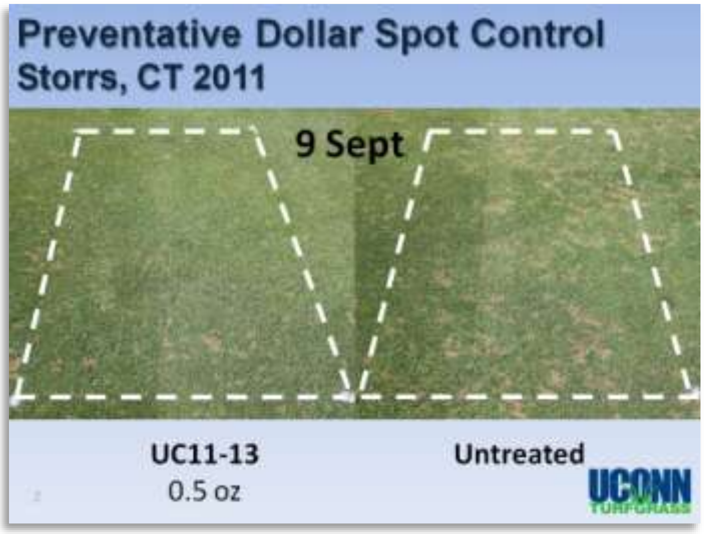
## INTRODUCTION

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




## MATERIALS & METHODS

A field study was conducted on a 'Putter' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk$^{-1}$ at a bench setting of 0.5-inches. The site was irrigated as necessary to avoid drought stress. Nitrogen in the form of urea was applied monthly for a total of 0.85 pounds nitrogen between 27 April and 15 August.

Treatments consisted of experimental and currently available fungicides applied individually or in combination at either 14- or 21-d intervals. Initial treatment applications were made on 21 May prior to disease developing in the trial area. Subsequent applications were made at the specified intervals (dates listed in Tables 1 – 4) until 29 Jul for 14-d treatments and 22 Jul for 21-d application. All treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 1 gal 1000-ft$^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot was assessed as a count of individual disease foci within each plot from 26 June to 2 September. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. Chlorophyll reflective index was determined using the FieldScout CM 1000 (Spectrum Technologies, Inc.) chlorophyll meter. Ten readings were taken per plot with the mean used for data analysis. Canopy temperature was determined using the IR Temp Meter (Spectrum Technologies, Inc.). Five readings were taken per plot with the mean used for data analysis. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

## RESULTS

*Dollar Spot*

Dollar spot pressure was low throughout the trial in 2011. Initial symptoms developed on 26 June, although few dollar spot foci were observed in untreated turf until 9 August (Table 1). On this date, all treatments containing UC11-13 alone or as a tank mix, the high rate of UC11-4 (3.6 fl. oz.), Interface (4.0 fl.oz.), and Honor provided complete dollar spot control. However, statistically similar disease control was observed in nearly all other treatments on this date except Chipco 26019, UC11-20 and the low rate (1.3 fl.oz.) of UC11-15 and UC11-5. Similar results were observed on 16 August. Residual treatment efficacy was assessed on 2 September. Turf treated with UC11-13 and Honor continued to have the fewest dollar spot foci among all treatments 35 and 42 days after the last application, respectively.

*Turf Quality, Phytotoxicity, Chlorophyll Index, and Canopy Temperature*

Turf quality was high among all treatments on 29 June before dollar spot increased in the trial (Table 2). Differences in turf quality observed on 19 August were largely influenced by the presence or absence of dollar spot foci. No phytotoxicity was observed thorough the trial (Table 2). However, differences in canopy chlorophyll reflectance, an indication of darker green turf, were frequently observed (Tables 3a & 3b). Turf treated with UC11-13 alone at 1.0 fl.oz., or the same material applied at 0.5 fl.oz. in a tank mix with UC11-16 consistently were among those plots with the highest reflectance values. Conversely, turf treated with UC11-20 routinely had the lowest reflectance values. No significant differences in reflectance were observed among plots treated with different rates of green pigmented materials

(UC11-5 or Interface). Canopy temperatures were assessed in July and August, although no significant differences were observed (Table 4).

## DISCUSSION

UC11-4 applied at 1.3 to 2.0 fl.oz. every 14 days provided good dollar spot control in this trial. However, these rates are lower than label recommendations for this application interval. It is likely that increased rates would be required to achieve comparable control under more favorable dollar spot conditions. UC11-13 provided excellent control of dollar spot during routine applications and also provided good residual control (35 DAT), although residual activity was typically improved at the 1.0 fl.oz. rate, or by the addition of a tank-mix partner. The increased rate of Interface (4.0 fl.oz.), a premix fungicide containing iprodione, trifloxystrobin and Stressgard, provided good dollar spot control, and was generally more effective than Chipco 26019 a similar, non-pigmented, premix. However, Interface was not significantly different from Iprodione Pro (4.0 fl.oz.) containing a similar amount of iprodione in this trial.

Table 1. Dollar spot foci in 'Putter' creeping bentgrass fairway turf treated preventively with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft$^2$ | Int[z] | Dollar Spot Incidence 26 Jun | 12 Jul | 29 Jul | 9 Aug | 16 Aug | 2 Sep |
|---|---|---|---|---|---|---|---|---|
| | | | ----------number of foci per 18 ft$^2$---------- | | | | | |
| UC11-4 | 2.0 fl oz | 14 d | 0.0 b[y] | 0.3 b | 0.0 c | 2.5 cd | 3.8 ef | 34.0 ef |
| UC11-4 | 1.82 fl oz | 14 d | 0.0 b | 0.3 b | 0.5 c | 0.8 d | 3.3 ef | 30.0 ef |
| UC11-4 | 1.59 fl oz | 14 d | 0.0 b | 0.0 b | 1.0 c | 3.8 cd | 5.3 def | 37.5 def |
| UC11-4 | 1.3 fl oz | 14 d | 0.0 b | 0.0 b | 1.0 c | 3.3 cd | 6.0 def | 42.3 cde |
| UC11-15 | 2.0 fl oz | 14 d | 0.5 ab | 0.3 b | 1.0 c | 4.3 cd | 6.8 def | 37.3 def |
| UC11-15 | 1.82 fl oz | 14 d | 1.0 a | 0.5 b | 7.0 b | 12.5 b | 18.8 bc | 65.3 ab |
| UC11-15 | 1.59 fl oz | 14 d | 0.0 b | 0.0 b | 0.5 c | 2.8 cd | 4.5 ef | 33.8 ef |
| UC11-15 | 1.3 fl oz | 14 d | 0.5 ab | 0.5 b | 3.0 c | 11.8 b | 18.3 bc | 52.5 bcd |
| UC11-5 | 2.0 fl oz | 14 d | 0.3 b | 0.3 b | 0.3 c | 2.0 cd | 5.0 ef | 24.0 fg |
| UC11-5 | 1.82 fl oz | 14 d | 0.0 b | 0.0 b | 1.0 c | 2.8 cd | 5.5 def | 38.5 def |
| UC11-5 | 1.59 fl oz | 14 d | 0.0 b | 0.3 b | 0.3 c | 4.3 cd | 6.0 def | 30.8 ef |
| UC11-5 | 1.3 fl oz | 14 d | 0.5 ab | 0.5 b | 3.0 c | 6.3 c | 12.0 cd | 38.8 def |
| UC11-13 | 0.5 fl oz | 14 d | 0.0 b | 0.0 b | 0.0 c | 0.0 d | 0.0 f | 11.0 gh |
| UC11-13 | 1.0 fl oz | 14 d | 0.0 b | 0.0 b | 0.0 c | 0.0 d | 0.0 f | 3.3 h |
| UC11-13<br>+UC11-3 | 0.5 fl oz<br>1.0 fl oz | 14 d | 0.0 b | 0.0 b | 0.0 c | 0.0 d | 0.0 f | 8.8 gh |
| UC11-13<br>+ UC11-4 | 0.5 fl oz<br>2.0 fl oz | 14 d | 0.0 b | 0.3 b | 0.0 c | 0.0 d | 0.0 f | 2.0 h |
| UC11-4 | 3.6 fl oz | 14 d | 0.0 b | 0.3 b | 0.0 c | 0.0 d | 1.0 f | 22.8 fg |
| UC11-13<br>+UC11-14 | 0.5 fl oz<br>0.6 fl oz | 14 d | 0.0 b | 0.0 b | 0.0 c | 0.0 d | 0.0 f | 2.0 h |
| UC11-13<br>+UC11-16 | 0.5 fl oz<br>0.236 fl oz | 14 d | 0.0 b | 0.3 b | 0.0 c | 0.0 d | 0.0 f | 4.8 h |
| Chipco 26GT | 2.0 fl oz | 21 d | 0.0 b | 0.0 b | 0.0 c | 0.5 d | 3.3 ef | 30.3 ef |
| Interface | 3.0 fl oz | 21 d | 0.0 b | 0.0 b | 0.0 c | 2.0 cd | 5.3 def | 57.5 abc |
| Interface | 4.0 fl oz | 21 d | 0.0 b | 0.0 b | 0.0 c | 0.0 d | 1.8 f | 28.5 ef |
| Chipco 26019 | 4.0 fl oz | 21 d | 0.0 b | 0.0 b | 0.0 c | 6.0 c | 9.3 de | 44.8 cde |
| Iprodione Pro | 4.0 fl oz | 21 d | 0.0 b | 0.0 b | 0.0 c | 3.0 cd | 5.5 def | 37.0 def |
| Daconil Weather Stik | 2.0 fl oz | 14 d | 0.0 b | 0.0 b | 0.3 c | 1.5 cd | 3.0 ef | 24.5 fg |
| UC11-20 | 0.023 oz | 14 d | 0.0 b | 2.0 a | 11.3 a | 23.0 a | 28.3 a | 72.8 a |
| Honor | 1.1 oz | 21 d | 0.0 b | 0.3 b | 0.0 c | 0.0 d | 0.3 f | 9.0 gh |
| Chipco 26GT | 4.0 fl oz | 21 d | 0.0 b | 0.0 b | 0.0 c | 2.0 cd | 5.3 def | 41.8 cde |
| Banner MAXX | 1.0 fl oz | 21 d | 0.0 b | 0.0 b | 0.0 c | 0.8 d | 2.5 ef | 23.5 fg |
| Untreated | | -- | 0.0 b | 0.5 b | 7.8 ab | 16.5 b | 25.0 ab | 64.5 ab |
| ANOVA: Treatment (P > F) | | | 0.0388 | 0.0131 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 14 d | 10 | 11 | 14 | 11 | 18 | 35 |
| | | 21 d | 16 | 11 | 7 | 18 | 25 | 42 |

[z] Treatments were initiated on 21 May. Subsequent 14 d applications were made on 3 Jun, 16 Jun, 1 Jul, 15 Jul, and 29 Jul; 21 d applications were made on 10 Jun, 1 Jul, and 22 Jul

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

Table 2. Turf quality and phytotoxicity of 'Putter' creeping bentgrass fairway turf preventatively treated with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| | | | Turf Quality | | Phytotoxicity | |
|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 ft$^2$ | Int[z] | 29 Jun | 19 Aug | 29 Jun | 19 Aug |
| | | | -1-9; 6=min acceptable- | | -0-5; 2=max acceptable- | |
| UC11-4 | 2.0 fl oz | 14 d | 7.5 | 7.5 bcd[y] | 0.0 | 0.0 b |
| UC11-4 | 1.82 fl oz | 14 d | 8.0 | 7.3 cde | 0.0 | 0.0 b |
| UC11-4 | 1.59 fl oz | 14 d | 7.8 | 6.8 def | 0.0 | 0.0 b |
| UC11-4 | 1.3 fl oz | 14 d | 7.8 | 7.0 de | 0.0 | 0.0 b |
| UC11-15 | 2.0 fl oz | 14 d | 7.8 | 6.5 ef | 0.0 | 0.0 b |
| UC11-15 | 1.82 fl oz | 14 d | 7.8 | 5.5 g | 0.0 | 0.0 b |
| UC11-15 | 1.59 fl oz | 14 d | 7.8 | 7.5 bcd | 0.0 | 0.0 b |
| UC11-15 | 1.3 fl oz | 14 d | 7.5 | 5.5 g | 0.0 | 0.0 b |
| UC11-5 | 2.0 fl oz | 14 d | 8.3 | 7.5 bcd | 0.0 | 0.0 b |
| UC11-5 | 1.82 fl oz | 14 d | 8.5 | 7.0 de | 0.0 | 0.0 b |
| UC11-5 | 1.59 fl oz | 14 d | 8.0 | 7.0 de | 0.0 | 0.0 b |
| UC11-5 | 1.3 fl oz | 14 d | 8.0 | 6.0 fg | 0.0 | 0.0 b |
| UC11-13 | 0.5 fl oz | 14 d | 7.5 | 8.5 a | 0.0 | 0.0 b |
| UC11-13 | 1.0 fl oz | 14 d | 8.0 | 8.3 ab | 0.0 | 0.0 b |
| UC11-13<br>+UC11-3 | 0.5 fl oz<br>1.0 fl oz | 14 d | 8.3 | 8.5 a | 0.0 | 0.0 b |
| UC11-13<br>+ UC11-4 | 0.5 fl oz<br>2.0 fl oz | 14 d | 7.5 | 8.3 ab | 0.0 | 0.0 b |
| UC11-4 | 3.6 fl oz | 14 d | 7.5 | 8.0 abc | 0.0 | 0.0 b |
| UC11-13<br>+UC11-14 | 0.5 fl oz<br>0.6 fl oz | 14 d | 7.0 | 6.8 def | 0.0 | 1.0 a |
| UC11-13<br>+UC11-16 | 0.5 fl oz<br>0.236 fl oz | 14 d | 7.5 | 8.8 a | 0.0 | 0.0 b |
| Chipco 26GT | 2.0 fl oz | 21 d | 7.8 | 6.8 def | 0.0 | 0.0 b |
| Interface | 3.0 fl oz | 21 d | 7.8 | 7.0 de | 0.0 | 0.0 b |
| Interface | 4.0 fl oz | 21 d | 8.3 | 7.3 cde | 0.0 | 0.0 b |
| Chipco 26019 | 4.0 fl oz | 21 d | 7.8 | 6.0 fg | 0.0 | 0.0 b |
| Iprodione Pro | 4.0 fl oz | 21 d | 7.5 | 6.8 def | 0.0 | 0.0 b |
| Daconil Weather Stik | 2.0 fl oz | 14 d | 8.0 | 8.3 ab | 0.0 | 0.0 b |
| UC11-20<br>Honor | 0.023 oz<br>1.1 oz | 14 d<br>21 d | 7.3<br>7.8 | 5.3 g<br>8.0 abc | 0.0<br>0.0 | 0.0 b<br>0.0 b |
| Chipco 26GT<br>Banner MAXX | 4.0 fl oz<br>1.0 fl oz | 21 d<br>21 d | 7.8<br>7.8 | 6.8 def<br>6.5 ef | 0.0<br>0.0 | 0.0 b<br>0.0 b |
| Untreated | | -- | 7.0 | 5.3 g | 0.0 | 0.0 b |
| ANOVA: Treatment (P > F) | | | 0.1115 | 0.0001 | 1.0000 | 1.0000 |
| Days after treatment | | 14 d | 13 | 21 | 13 | 21 |
| | | 21 d | 19 | 28 | 19 | 28 |

[z] Treatments were initiated on 21 May. Subsequent 14 d applications were made on 3 Jun, 16 Jun, 1 Jul, 15 Jul, and 29 Jul; 21 d applications were made on 10 Jun, 1 Jul, and 22 Jul

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

Table 3a. Chlorophyll reflective index of 'Putter' creeping bentgrass fairway turf preventatively treated with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| | | | Chlorophyll Reflectance | | | |
|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 ft$^2$ | Int[z] | 30 Jun | 13 Jul | 27 Jul | 5 Aug |
| | | | --------------------chlorophyll index-------------------- | | | |
| UC11-4……...............……2.0 fl oz | | 14 d | 340.0 abc[y] | 353.0 ab | 355.3 c-f | 412.0 b-f |
| UC11-4……......................1.82 fl oz | | 14 d | 322.0 d-j | 345.8 a-e | 344.8 e-h | 420.0 b-e |
| UC11-4……......................1.59 fl oz | | 14 d | 327.3 b-h | 341.3 a-f | 362.0 a-d | 412.3 b-f |
| UC11-4……........................1.3 fl oz | | 14 d | 326.8 b-i | 347.0 a-e | 354.5 c-f | 409.8 b-f |
| UC11-15..............................2.0 fl oz | | 14 d | 331.5 b-g | 337.5 b-g | 351.3 c-h | 421.5 b-e |
| UC11-15............................1.82 fl oz | | 14 d | 316.3 g-j | 321.8 gh | 354.3 c-f | 422.0 b-e |
| UC11-15............................1.59 fl oz | | 14 d | 337.0 a-d | 347.0 a-e | 365.8 abc | 426.8 bcd |
| UC11-15..............................1.3 fl oz | | 14 d | 331.8 b-g | 325.3 fg | 353.3 c-f | 416.0 b-f |
| UC11-5................................2.0 fl oz | | 14 d | 327.3 b-h | 340.8 a-f | 359.8 b-f | 419.3 b-f |
| UC11-5..............................1.82 fl oz | | 14 d | 326.8 b-i | 347.5 a-d | 352.5 c-g | 415.0 b-f |
| UC11-5..............................1.59 fl oz | | 14 d | 334.0 a-f | 350.5 abc | 361.5 a-f | 415.3 b-f |
| UC11-5................................1.3 fl oz | | 14 d | 321.0 d-j | 337.8 b-g | 357.0 b-f | 409.5 b-f |
| UC11-13..............................0.5 fl oz | | 14 d | 331.3 b-g | 330.5 d-g | 348.5 d-h | 422.0 b-e |
| UC11-13..............................1.0 fl oz | | 14 d | 350.5 a | 346.8 a-e | 373.0 ab | 456.5 a |
| UC11-13..............................0.5 fl oz<br>+UC11-3..............................1.0 fl oz | | 14 d | 342.8 ab | 346.3 a-e | 361.8 a-e | 403.3 c-g |
| UC11-13..............................0.5 fl oz<br>+ UC11-4……......................2.0 fl oz | | 14 d | 342.5 abc | 347.8 a-d | 367.0 abc | 400.0 d-g |
| UC11-4………....................3.6 fl oz | | 14 d | 331.5 b-g | 335.8 b-g | 353.3 c-f | 408.3 b-g |
| UC11-13..............................0.5 fl oz<br>+UC11-14............................0.6 fl oz | | 14 d | 341.3 abc | 353.3 ab | 350.3 c-h | 413.5 b-f |
| UC11-13..............................0.5 fl oz<br>+UC11-16........................0.236 fl oz | | 14 d | 340.5 abc | 357.3 a | 377.3 a | 431.5 ab |
| Chipco 26GT.......................2.0 fl oz | | 21 d | 321.8 d-j | 328.5 efg | 347.5 d-h | 391.3 fg |
| Interface...............................3.0 fl oz | | 21 d | 325.3 c-j | 336.5 b-g | 351.5 c-h | 421.3 b-e |
| Interface...............................4.0 fl oz | | 21 d | 334.3 a-e | 330.5 d-g | 360.0 b-f | 399.5 d-g |
| Chipco 26019.......................4.0 fl oz | | 21 d | 316.8 f-j | 328.8 efg | 335.8 ghi | 406.8 b-g |
| Iprodione Pro.......................4.0 fl oz | | 21 d | 317.3 e-j | 332.0 c-g | 345.0 d-h | 415.3 b-f |
| Daconil Weather Stik............2.0 fl oz | | 14 d | 326.8 b-i | 341.0 a-f | 359.5 b-f | 429.3 abc |
| UC11-20..............................0.023 oz | | 14 d | 309.3 j | 303.5 h | 322.3 i | 381.0 g |
| Honor.......................................1.1 oz | | 21 d | 321.5 d-j | 330.5 d-g | 345.5 d-h | 404.5 b-g |
| Chipco 26GT........................4.0 fl oz | | 21 d | 312.3 hij | 327 fg | 335.0 hi | 396.3 efg |
| Banner MAXX.....................1.0 fl oz | | 21 d | 309.8 ij | 334 c-g | 350.0 c-h | 411.8 b-f |
| Untreated | | -- | 309.8 ij | 322.8 fg | 344.5 fgh | 414.0 b-f |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 14 d | 14 | 12 | 12 | 7 |
| | | 21 d | 20 | 12 | 5 | 14 |

[z] Treatments were initiated on 21 May. Subsequent 14 d applications were made on 3 Jun, 16 Jun, 1 Jul, 15 Jul, and 29 Jul; 21 d applications were made on 10 Jun, 1 Jul, and 22 Jul

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

Table 3b. Chlorophyll reflective index of 'Putter' creeping bentgrass fairway turf preventatively treated with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft$^2$ | Int[z] | Chlorophyll Reflectance | | |
|---|---|---|---|---|---|
| | | | 10 Aug | 18 Aug | 23 Aug |
| | | | -----------chlorophyll index----------- | | |
| UC11-4 | 2.0 fl oz | 14 d | 419.8 b-g[y] | 430.3 a-e | 292.0 a-e |
| UC11-4 | 1.82 fl oz | 14 d | 404.0 e-k | 439.3 abc | 284.3 c-i |
| UC11-4 | 1.59 fl oz | 14 d | 407.5 d-j | 417.5 b-h | 282.5 d-i |
| UC11-4 | 1.3 fl oz | 14 d | 395.3 h-k | 423.5 a-e | 277.3 e-j |
| UC11-15 | 2.0 fl oz | 14 d | 419.8 b-g | 418.5 b-g | 288.5 b-h |
| UC11-15 | 1.82 fl oz | 14 d | 414.5 c-h | 413.8 b-h | 275.8 f-j |
| UC11-15 | 1.59 fl oz | 14 d | 416.5 b-h | 418.5 b-g | 294.0 a-d |
| UC11-15 | 1.3 fl oz | 14 d | 400.5 f-k | 407.5 b-h | 274.5 g-j |
| UC11-5 | 2.0 fl oz | 14 d | 427.0 a-d | 425.0 a-e | 286.5 c-i |
| UC11-5 | 1.82 fl oz | 14 d | 414.8 c-h | 418.3 b-g | 278.5 d-j |
| UC11-5 | 1.59 fl oz | 14 d | 424.8 a-e | 440.5 ab | 280.5 d-i |
| UC11-5 | 1.3 fl oz | 14 d | 407.5 d-j | 433.0 a-e | 282.8 d-i |
| UC11-13 | 0.5 fl oz | 14 d | 433.5 abc | 420.5 a-f | 286.0 c-i |
| UC11-13 | 1.0 fl oz | 14 d | 437.5 ab | 437.8 a-d | 299.3 abc |
| UC11-13 | 0.5 fl oz | 14 d | 411.0 d-h | 411.5b-h | 289.8 b-g |
| +UC11-3 | 1.0 fl oz | | | | |
| UC11-13 | 0.5 fl oz | 14 d | 420.8 b-g | 428.5 a-e | 303.8 ab |
| + UC11-4 | 2.0 fl oz | | | | |
| UC11-4 | 3.6 fl oz | 14 d | 413.5 c-h | 426.3 a-e | 290.5 b-f |
| UC11-13 | 0.5 fl oz | 14 d | 424.0 b-e | 414.3 b-h | 281.5 d-i |
| +UC11-14 | 0.6 fl oz | | | | |
| UC11-13 | 0.5 fl oz | 14 d | 447.0 a | 456.5 a | 307.3 a |
| +UC11-16 | 0.236 fl oz | | | | |
| Chipco 26GT | 2.0 fl oz | 21 d | 401.3 f-k | 396.5 e-h | 276.8 e-j |
| Interface | 3.0 fl oz | 21 d | 399.3 g-k | 410.3 b-h | 277.0 e-j |
| Interface | 4.0 fl oz | 21 d | 405.8 d-k | 383.0 gh | 284.3 c-i |
| Chipco 26019 | 4.0 fl oz | 21 d | 403.5 e-k | 403.5 b-h | 273.0 hij |
| Iprodione Pro | 4.0 fl oz | 21 d | 414.5 c-h | 415.5 b-h | 276.5 e-j |
| Daconil Weather Stik | 2.0 fl oz | 14 d | 422.8 b-f | 437.8 a-d | 290.3 b-f |
| UC11-20 | 0.023 oz | 14 d | 348.8 l | 383.5 fgh | 264.8 j |
| Honor | 1.1 oz | 21 d | 408.5 d-i | 401.3 d-h | 275.3 f-j |
| Chipco 26GT | 4.0 fl oz | 21 d | 385.3 jk | 417.8 b-g | 278.0 e-j |
| Banner MAXX | 1.0 fl oz | 21 d | 387.8 ijk | 403.3 c-h | 264.8 j |
| Untreated | | -- | 384.3 k | 380.5 h | 271.5 ij |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0178 | 0.0001 |
| Days after treatment | | 14 d | 12 | 20 | 25 |
| | | 21 d | 19 | 27 | 32 |

[z] Treatments were initiated on 21 May. Subsequent 14 d applications were made on 3 Jun, 16 Jun, 1 Jul, 15 Jul, and 29 Jul; 21 d applications were made on 10 Jun, 1 Jul, and 22 Jul

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

Table 4. Canopy temperature of 'Putter' creeping bentgrass fairway turf preventatively treated with fungicides at the Plant Science Research Facility in Storrs, CT during 2011.

| Treatment | Rate per 1000 ft² | Int[z] | Canopy Temperature 13 Jul | 21 Jul | 12 Aug | 18 Aug | 23 Aug |
|---|---|---|---|---|---|---|---|
| | | | -----------------degrees Fahrenheit----------------- | | | | |
| UC11-4 | 2.0 fl oz | 14 d | 91.3 | 96.2 | 82.9 | 88.2 | 91.1 |
| UC11-4 | 1.82 fl oz | 14 d | 96.6 | 96.5 | 84.1 | 85.7 | 87.4 |
| UC11-4 | 1.59 fl oz | 14 d | 95.4 | 95.9 | 83.9 | 88.0 | 89.0 |
| UC11-4 | 1.3 fl oz | 14 d | 92.2 | 95.3 | 84.2 | 88.3 | 89.5 |
| UC11-15 | 2.0 fl oz | 14 d | 94.4 | 96.8 | 83.7 | 88.1 | 89.9 |
| UC11-15 | 1.82 fl oz | 14 d | 92.5 | 94.1 | 85.0 | 85.7 | 88.5 |
| UC11-15 | 1.59 fl oz | 14 d | 94.2 | 95.1 | 83.0 | 87.2 | 90.8 |
| UC11-15 | 1.3 fl oz | 14 d | 93.7 | 95.5 | 82.6 | 85.1 | 89.5 |
| UC11-5 | 2.0 fl oz | 14 d | 94.4 | 97.5 | 83.6 | 87.6 | 87.1 |
| UC11-5 | 1.82 fl oz | 14 d | 94.9 | 96.4 | 83.5 | 85.8 | 88.2 |
| UC11-5 | 1.59 fl oz | 14 d | 93.5 | 94.5 | 86.3 | 83.3 | 87.8 |
| UC11-5 | 1.3 fl oz | 14 d | 94.6 | 97.5 | 84.4 | 87.5 | 89.8 |
| UC11-13 | 0.5 fl oz | 14 d | 94.9 | 98.2 | 83.1 | 86.6 | 86.1 |
| UC11-13 | 1.0 fl oz | 14 d | 95.8 | 95.3 | 80.4 | 87.4 | 90.1 |
| UC11-13 | 0.5 fl oz | 14 d | 91.9 | 96.8 | 84.5 | 86.5 | 89.6 |
| +UC11-3 | 1.0 fl oz | | | | | | |
| UC11-13 | 0.5 fl oz | 14 d | 92.8 | 97.8 | 83.5 | 88.5 | 89.2 |
| + UC11-4 | 2.0 fl oz | | | | | | |
| UC11-4 | 3.6 fl oz | 14 d | 93.1 | 96.0 | 84.3 | 86.6 | 89.7 |
| UC11-13 | 0.5 fl oz | 14 d | 93.9 | 95.4 | 82.9 | 84.3 | 88.4 |
| +UC11-14 | 0.6 fl oz | | | | | | |
| UC11-13 | 0.5 fl oz | 14 d | 95.4 | 94.1 | 83.2 | 87.1 | 89.7 |
| +UC11-16 | 0.236 fl oz | | | | | | |
| Chipco 26GT | 2.0 fl oz | 21 d | 94.4 | 98.7 | 83.4 | 86.3 | 90.3 |
| Interface | 3.0 fl oz | 21 d | 95.0 | 93.3 | 81.6 | 86.9 | 89.1 |
| Interface | 4.0 fl oz | 21 d | 95.4 | 96.1 | 84.1 | 87.0 | 90.1 |
| Chipco 26019 | 4.0 fl oz | 21 d | 94.8 | 96.1 | 85.3 | 85.1 | 87.8 |
| Iprodione Pro | 4.0 fl oz | 21 d | 93.8 | 95.8 | 82.6 | 86.7 | 87.6 |
| Daconil Weather Stik | 2.0 fl oz | 14 d | 93.2 | 96.5 | 84.7 | 84.9 | 88.7 |
| UC11-20 | 0.023 oz | 14 d | 94.8 | 97.3 | 85.0 | 88.3 | 88.9 |
| Honor | 1.1 oz | 21 d | 95.3 | 95.9 | 84.3 | 86.6 | 89.3 |
| Chipco 26GT | 4.0 fl oz | 21 d | 95.0 | 97.0 | 84.3 | 87.3 | 89.1 |
| Banner MAXX | 1.0 fl oz | 21 d | 92.7 | 96.0 | 83.8 | 87.2 | 89.0 |
| Untreated | | -- | 96.3 | 96.3 | 83.9 | 88.1 | 90.6 |
| ANOVA: Treatment ($P > F$) | | | 0.0553 | 0.0861 | 0.6786 | 0.7788 | 0.2079 |
| Days after treatment | | 14 d | 12 | 7 | 14 | 20 | 25 |
| | | 21 d | 12 | 20 | 21 | 27 | 32 |

[z] Treatments were initiated on 21 May. Subsequent 14 d applications were made on 3 Jun, 16 Jun, 1 Jul, 15 Jul, and 29 Jul; 21 d applications were made on 10 Jun, 1 Jul, and 22 Jul

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

## PREVENTIVE DOLLAR SPOT CONTROL IN CREEPING BENTGRASS FAIRWAY TURF WITH EXTENDED INTERVALS OF EXPERIMENTAL FUNGICIDES, 2011

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### INTRODUCTION

Dollar spot (caused by *Sclerotinia homoeocarpa*) is a common disease of golf course fairway turf occurring from May to October throughout New England. Control of this disease is achieved through integrated management plans utilizing improved bentgrass varieties, cultural and chemical approaches. However, acceptable control often still requires fungicide applications every 21 to 28 days with currently available materials. New fungicides with greater efficacy may permit turf managers to achieve acceptable control with extended application intervals (i.e., 35 days). Use of new materials with extended intervals could reduce the total number of chemical applications required to control dollar spot as well as reduce labor costs. The objective of this study was to evaluate the efficacy of extended application intervals of experimental and commercially available fungicides for preventive control of dollar spot in fairway turf.

### MATERIALS & METHODS

A field study was conducted on a 'Putter' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk$^{-1}$ at a bench setting of 0.5-inches. A total of 0.85 lbs. of N was applied to the site from 27 April to 1 September. Overhead irrigation was applied every other night to prolong leaf wetness period and enhance disease.

Treatments consisted of several experimental fungicides and one currently available fungicide applied individually every 21, 28, or 35-days. Initial treatment applications were made on 21 May prior to disease developing in the trial area. Subsequent applications were made at the specified intervals (dates listed in Tables 1 – 4) until 12 August. All treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1 gal 1000-ft$^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot was assessed as a count of individual disease foci within each plot from 10 June to 1 September, and as a percentage of the plot area blighted by *S. homoeocarpa* once disease severity increased on 1 September. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. Chlorophyll reflective index was determined using the FieldScout CM 1000 chlorophyll meter. (Spectrum Technologies, Inc.). Ten readings were taken per plot with the mean used for data analysis. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

**Figure 3. Dollar spot incidence in untreated 'Putter' creeping bentgrass turf on 8 August in Storrs, CT.**

### RESULTS

*Dollar Spot*

Dollar spot developed on 10 June, approximately 3 weeks after initial applications. Disease pressure was relatively low at that time with plots of untreated turf containing 3.5 to 35.5 dollar spot foci in June and July (Table 1a & 1b). Thereafter, dollar spot incidence increased during August with untreated plots containing 46.8 to 185.5 foci per plot. There were no treatment differences during June due to limited symptom development across the study. By 12 July all treatments significantly reduced disease compared to untreated turf, with most providing complete control (Table 1a). However, all treatments applied every 28 d showed initial symptom development on this date, 28 days after treatment (DAT). UC11-10 (28 d interval) treated turf contained slightly more disease than other treatments on this date, but no differences were observed between fungicide treatments 7 days later (19 July) following reapplication. On 29 July (35 DAT), dollar spot had increased to 13.8 foci in plots treated with UC11-10 every 35 d (Table 1b). Dollar spot incidence remained higher in this treatment throughout the remainder of the study compared to other treatments resulting in an unacceptable level of disease (41 foci) by 17 August. All other treatments provided excellent to good dollar spot control through 17

August. Dollar spot incidence increased in all treatments by 1 September. Generally, fungicides applied every 35 d were less effective than the same materials applied every 21 or 28 d, except UC11-11, UC11-7 and Emerald where there were no foci differences between intervals. Treatments resulting in the fewest dollar spot foci by 1 September were UC11-14 (21 & 28 d intervals), UC11-9 and Emerald (28 d interval). Percent plot area blighted by dollar spot was assessed due to increased disease development on 1 September. Untreated turf had reached 17% plot area blighted by this date. All other treatments provided good dollar spot control (≤ 2% blighted turf) except UC11-10 (28 & 35 d) and UC11-7 (35 d).

*Turf quality, Phytotoxcity, and Chlorophyll Index*

Turf quality was very good (≥ 7.0) in all treated plots from June through 12 July (Table 2). Quality remained high in most treatments during late July and August, but was slightly lower in UC11-10 (35 d interval) due to increased dollar spot incidence. Quality of UC11-9 treated turf was lower, albeit acceptable, on 29 July (Table 2) due to slight phytotoxcicity (Table 3). All treatments had slightly lower turf quality on 1 September as disease increased throughout the trial. However, most treatments maintained acceptable quality levels accept UC11-11 (28 & 35 d intervals) and UC11-7 (35 d int.) which failed to control dollar spot. Chlorophyll index was assessed but was unaffected by treatments throughout the trial, except on 13 July when UC11-11 (28 d int.), UC11-9 and Emerald (21 d int.) increased chlorophyll index values compared to untreated turf (Table 4). No treatments resulted in chlorophyll index values lower than untreated turf on this date. Generally, chlorophyll index values of treated turf were greater than untreated turf throughout the study.

## DISCUSSION

Dollar spot severity (% plot area blighted) at the end of this trial did not differ among application intervals ranging from 21 to 35 d for effective fungicides. However, individual dollar spot foci in plots treated every 35 d were greater than plots receiving more frequent applications for several of the fungicides tested. Extended application intervals (35 d) may not differ from shorter intervals (28 or 21 d) during moderate disease pressure, although the increased disease incidence observed at extended intervals in this trial suggests that significant differences between intervals may occur if disease pressure were higher.



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Table 1a. Dollar spot incidence in ‘Putter’ creeping bentgrass fairway turf treated preventively with fungicides at different intervals at the Plant Science Research Center in Storrs, CT during 2011.

| | | | Dollar spot incidence | | | |
|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 $ft^{-2}$ | Int[z] | 10 Jun | 24 Jun | 12 Jul | 19 Jul |
| | | | --------------------number of foci per 18 $ft^2$-------------------- | | | |
| UC11-14 | 0.96 fl oz | 21 d | 0.0 | 0.0 | 0.0 c[y] | 0.0 b |
| UC11-14 | 1.3 fl oz | 28 d | 0.0 | 0.0 | 1.0 bc | 1.0 b |
| UC11-14 | 1.3 fl oz | 35 d | 0.0 | 0.0 | 0.0 c | 0.0 b |
| UC11-11 | 0.506 fl oz | 21 d | 0.3 | 0.3 | 0.3 c | 0.8 b |
| UC11-11 | 0.69 fl oz | 28 d | 0.0 | 0.0 | 2.8 bc | 1.8 b |
| UC11-11 | 0.69 fl oz | 35 d | 0.3 | 0.3 | 0.0 c | 0.0 b |
| UC11-10 | 2.0 fl oz | 28 d | 0.0 | 0.0 | 5.5 b | 2.3 b |
| UC11-10 | 2.0 fl oz | 35 d | 2.5 | 2.5 | 1.0 bc | 3.3 b |
| UC11-7 | 0.37 fl oz | 28 d | 0.0 | 0.0 | 2.3 bc | 0.8 b |
| UC11-7 | 0.37 fl oz | 35 d | 0.3 | 0.3 | 0.8 c | 1.5 b |
| UC11-9 | 4.0 fl oz | 21 d | 0.0 | 0.0 | 0.5 c | 0.0 b |
| UC11-1 | 1.28 fl oz | 21 d | 0.0 | 0.0 | 0.3 c | 0.3 b |
| Emerald | 0.18 oz | 21 d | 3.3 | 3.3 | 0.0 c | 0.3 b |
| Emerald | 0.18 oz | 28 d | 0.0 | 0.0 | 1.0 bc | 0.3 b |
| Emerald | 0.18 oz | 35 d | 0.0 | 0.0 | 0.5 c | 0.0 b |
| Untreated | | -- | 3.5 | 3.5 | 15.3 a | 18.0 a |
| ANOVA: Treatment (P > F) | | | 1.0000 | 0.3514 | 0.0001 | 0.0001 |
| Days after treatment | | 21 d | 20 | 14 | 11 | 18 |
| | | 28 d | 20 | 8 | 28 | 4 |
| | | 35 d | 20 | 35 | 18 | 24 |

[z] All treatments were initiated on 21 May. Subsequent 21 d treatments were applied on 10 Jun, 1 Jul, 22 Jul, and 12 Aug; 28 d treatments were applied on 16 Jun, 15 Jul, and 12 Aug; 35 d treatments were applied on 24 Jun and 29 Jul.

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

Table 1b. Dollar spot foci and percent area blighted by dollar spot in ‘Putter’ creeping bentgrass fairway turf treated preventively with fungicides at different intervals at the Plant Science Research Center in Storrs, CT during 2011.

| | | | Dollar spot incidence | | | | Blight |
|---|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 $ft^{-2}$ | Int[z] | 29 Jul | 9 Aug | 17 Aug | 1 Sep | 1 Sep |
| | | | ---------------number of foci per 18 $ft^2$--------------- | | | | % |
| UC11-14 | 0.96 fl oz | 21 d | 0.3 c[y] | 0.3 c | 0.8 c | 10.8 ef | 0.6 c |
| UC11-14 | 1.3 fl oz | 28 d | 0.0 c | 0.3 c | 0.8 c | 17.0 def | 0.5 c |
| UC11-14 | 1.3 fl oz | 35 d | 4.5 c | 0.5 c | 4.5 c | 50.0 cd | 2.8 c |
| UC11-11 | 0.506 fl oz | 21 d | 0.0 c | 0.3 c | 0.8 c | 24.0 c-f | 0.8 c |
| UC11-11 | 0.69 fl oz | 28 d | 0.0 c | 2.5 c | 2.8 c | 33.5 c-f | 1.9 c |
| UC11-11 | 0.69 fl oz | 35 d | 0.5 c | 0.0 c | 1.5 c | 27.8 c-f | 1.3 c |
| UC11-10 | 2.0 fl oz | 28 d | 0.5 c | 5.8 c | 8.5 c | 52.0 cd | 3.0 c |
| UC11-10 | 2.0 fl oz | 35 d | 13.8 b | 16.3 b | 41.0 b | 144.0 b | 9.5 b |
| UC11-7 | 0.37 fl oz | 28 d | 0.0 c | 3.5 c | 4.5 c | 42.5 cde | 2.0 c |
| UC11-7 | 0.37 fl oz | 35 d | 5.5 bc | 1.5 c | 11.0 c | 57.0 c | 3.0 c |
| UC11-9 | 4.0 fl oz | 21 d | 0.0 c | 0.0 c | 0.0 c | 4.3 f | 0.1 c |
| UC11-1 | 1.28 fl oz | 21 d | 1.0 c | 4.8 c | 6.8 c | 36.0 c-f | 1.8 c |
| Emerald | 0.18 oz | 21 d | 0.0 c | 1.0 | 0.3 c | 24.3 c-f | 1.1 c |
| Emerald | 0.18 oz | 28 d | 0.3 c | 0.8 c | 2.0 c | 18.5 def | 0.8 c |
| Emerald | 0.18 oz | 35 d | 2.3 c | 0.3 c | 2.3 c | 29.3 c-f | 1.1 c |
| Untreated | | -- | 35.5 a | 46.8 a | 90.5 a | 185.5 a | 17.3 a |
| ANOVA: Treatment (P > F) | | | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Days after treatment | | 21 d | 7 | 18 | 5 | 27 | 27 |
| | | 28 d | 14 | 24 | 5 | 27 | 27 |
| | | 35 d | 35 | 11 | 19 | 34 | 34 |

[z] All treatments were initiated on 21 May. Subsequent 21 d treatments were applied on 10 Jun, 1 Jul, 22 Jul, and 12 Aug; 28 d treatments were applied on 16 Jun, 15 Jul, and 12 Aug; 35 d treatments were applied on 24 Jun and 29 Jul.

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

Table 2. Turf quality of 'Putter' creeping bentgrass fairway turf treated preventively with fungicides at different intervals at the Plant Science Research Center in Storrs, CT during 2011.

| Treatment Rate per 1000 ft$^{-2}$ | Int[z] | Turf Quality | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 Jun | 24 Jun | 12 Jul | 22 Jul | 29 Jul | 19 Aug | 1 Sep |
| | | ---------------------------1-9; 6=minimum acceptable--------------------------- | | | | | | |
| UC11-14…………....…..0.96 fl oz | 21 d | 7.5 | 7.8 | 7.8 | 7.5abc[y] | 7.5 ab | 7.8 a | 7.0 ab |
| UC11-14………....……1.3 fl oz | 28 d | 7.3 | 7.8 | 8.0 | 7.3 bc | 7.8 a | 7.0 ab | 6.5 bc |
| UC11-14.……….…..…1.3 fl oz | 35 d | 7.3 | 8.0 | 8.3 | 7.8 ab | 7.5 ab | 7.8 a | 6.0 cde |
| UC11-11……….…....0.506 fl oz | 21 d | 7.0 | 7.5 | 8.5 | 8.0 ab | 7.8 a | 7.3 ab | 6.5 bc |
| UC11-11……….….…0.69 fl oz | 28 d | 7.3 | 8.0 | 8.0 | 7.8 ab | 7.0 abc | 7.8 a | 6.3 bcd |
| UC11-11….………..…0.69 fl oz | 35 d | 7.3 | 8.3 | 8.5 | 8.0 ab | 7.5 ab | 7.5 ab | 6.5 bc |
| UC11-10…………..….2.0 fl oz | 28 d | 7.8 | 8.0 | 7.8 | 7.8 ab | 7.3 abc | 6.8 b | 5.5 de |
| UC11-10.…………….…..2.0 fl oz | 35 d | 7.5 | 7.3 | 7.5 | 6.8 c | 6.5 cd | 5.5 c | 4.3 f |
| UC11-7..……………..0.37 fl oz | 28 d | 7.3 | 7.8 | 7.8 | 7.5 abc | 7.3 abc | 7.3 ab | 6.5 bc |
| UC11-7..……………..0.37 fl oz | 35 d | 7.3 | 7.5 | 8.0 | 7.5 abc | 6.8 bc | 7.0 ab | 5.3 e |
| UC11-9…...…………...4.0 fl oz | 21 d | 7.3 | 8.0 | 8.0 | 8.3 a | 6.5 cd | 7.5 ab | 7.5 a |
| UC11-1……………....1.28 fl oz | 21 d | 8.0 | 8.0 | 8.0 | 7.3 bc | 7.5 ab | 7.0 ab | 6.3 bcd |
| Emerald………………...0.18 oz | 21 d | 8.0 | 7.8 | 8.5 | 7.3 bc | 7.3 abc | 7.3 ab | 6.8 abc |
| Emerald………………...0.18 oz | 28 d | 7.5 | 8.5 | 8.0 | 7.5 abc | 7.3 abc | 7.8 a | 6.8 abc |
| Emerald………………...0.18 oz | 35 d | 7.8 | 7.8 | 8.5 | 7.8 ab | 7.3 abc | 7.3 ab | 6.5 bc |
| Untreated | -- | 7.8 | 7.8 | 6.8 | 5.8 d | 5.8 d | 4.3 d | 3.5 f |
| ANOVA: Treatment (P > F) | | 0.6200 | 0.7675 | 0.1635 | 0.0008 | 0.0093 | 0.0001 | 0.0001 |
| Days after treatment | 21 d | 20 | 14 | 11 | 18 | 7 | 7 | 27 |
| | 28 d | 20 | 8 | 28 | 4 | 14 | 7 | 27 |
| | 35 d | 20 | 35 | 18 | 24 | 35 | 21 | 34 |

[z] All treatments were initiated on 21 May. Subsequent 21 d treatments were applied on 10 Jun, 1 Jul, 22 Jul, and 12 Aug; 28 d treatments were applied on 16 Jun, 15 Jul, and 12 Aug; 35 d treatments were applied on 24 Jun and 29 Jul.

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

Table 3. Phytotoxicity of 'Putter' creeping bentgrass fairway turf treated preventively with fungicides at different intervals at the Plant Science Research Center in Storrs, CT during 2011.

| Treatment Rate per 1000 ft$^{-2}$ | Int[z] | Phytotoxicity | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 10 Jun | 24 Jun | 12 Jul | 22 Jul | 29 Jul | 19 Aug | 1 Sep |
| | | ------------------------0-5; 2=maximum acceptable------------------------ | | | | | | |
| UC11-14…………....…..0.96 fl oz | 21 d | 0.0 | 0.3 ab[y] | 0.0 | 0.0 | 0.5 b | 0.8 ab | 0.0 |
| UC11-14………....……1.3 fl oz | 28 d | 0.0 | 0.5 ab | 0.0 | 0.0 | 0.3 bc | 0.5 abc | 0.0 |
| UC11-14.……….…..…1.3 fl oz | 35 d | 0.0 | 0.0 b | 0.0 | 0.0 | 0.0 c | 0.0 c | 0.0 |
| UC11-11……….…....0.506 fl oz | 21 d | 0.0 | 0.5 ab | 0.0 | 0.0 | 0.3 bc | 0.8 ab | 0.0 |
| UC11-11………..……0.69 fl oz | 28 d | 0.0 | 0.8 a | 0.0 | 0.0 | 0.5 b | 0.8 ab | 0.0 |
| UC11-11….………..…0.69 fl oz | 35 d | 0.0 | 0.8 a | 0.0 | 0.0 | 0.3 bc | 0.8 ab | 0.0 |
| UC11-10…………..….2.0 fl oz | 28 d | 0.0 | 0.0 b | 0.0 | 0.0 | 0.0 c | 0.0 c | 0.0 |
| UC11-10.…………….…..2.0 fl oz | 35 d | 0.0 | 0.0 b | 0.0 | 0.0 | 0.0 c | 0.0 c | 0.0 |
| UC11-7..……………..0.37 fl oz | 28 d | 0.0 | 0.3 ab | 0.0 | 0.0 | 0.0 c | 0.3 bc | 0.0 |
| UC11-7..……………..0.37 fl oz | 35 d | 0.0 | 0.3 ab | 0.0 | 0.0 | 0.0 c | 0.3 bc | 0.0 |
| UC11-9…...…………...4.0 fl oz | 21 d | 0.0 | 0.8 a | 0.0 | 0.0 | 1.3 a | 1.0 a | 0.0 |
| UC11-1……………....1.28 fl oz | 21 d | 0.0 | 0.0 b | 0.0 | 0.0 | 0.0 c | 0.3 bc | 0.0 |
| Emerald………………...0.18 oz | 21 d | 0.0 | 0.0 b | 0.0 | 0.0 | 0.3 bc | 0.3 bc | 0.0 |
| Emerald………………...0.18 oz | 28 d | 0.0 | 0.0 b | 0.0 | 0.0 | 0.0 c | 0.3 bc | 0.0 |
| Emerald………………...0.18 oz | 35 d | 0.0 | 0.0 b | 0.0 | 0.0 | 0.0 c | 0.0 c | 0.0 |
| Untreated | -- | 0.0 | 0.3 ab | 0.0 | 0.0 | 0.0 c | 0.0 c | 0.0 |
| ANOVA: Treatment (P > F) | | 1.0000 | 0.0179 | 0.1635 | 1.0000 | 0.0002 | 0.0001 | 1.0000 |
| Days after treatment | 21 d | 20 | 14 | 11 | 18 | 7 | 7 | 27 |
| | 28 d | 20 | 8 | 28 | 4 | 14 | 7 | 27 |
| | 35 d | 20 | 35 | 18 | 24 | 35 | 21 | 34 |

[z] All treatments were initiated on 21 May. Subsequent 21 d treatments were applied on 10 Jun, 1 Jul, 22 Jul, and 12 Aug; 28 d treatments were applied on 16 Jun, 15 Jul, and 12 Aug; 35 d treatments were applied on 24 Jun and 29 Jul.

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

Table 4. Chlorophyll reflective index of 'Putter' creeping bentgrass fairway turf treated preventively with fungicides at different intervals at the Plant Science Research Center in Storrs, CT during 2011.

| Treatment Rate per 1000 $ft^{-2}$ | Int[z] | Chlorophyll Reflectance | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 30 Jun | 13 Jul[y] | 27 Jul | 5 Aug | 10 Aug | 19 Aug | 23 Aug |
| | | ---------------------------------chlorophyll index--------------------------------- | | | | | | |
| UC11-14……..…...…..0.96 fl oz | 21 d | 257.8 | 277.5 bcd | 268.8 | 311.8 | 299.3 | 331.5 | 227.8 |
| UC11-14……..…..……1.3 fl oz | 28 d | 263.0 | 282.0 bcd | 282.5 | 310.5 | 303.5 | 326.3 | 225.3 |
| UC11-14.……..…..……1.3 fl oz | 35 d | 255.3 | 285.8 bcd | 282.0 | 322.0 | 306.8 | 333.3 | 230.5 |
| UC11-11……………...0.506 fl oz | 21 d | 270.3 | 283.3 bcd | 278.3 | 311.0 | 291.0 | 325.3 | 233.3 |
| UC11-11………..……0.69 fl oz | 28 d | 272.3 | 289.3 ab | 281.8 | 326.3 | 304.8 | 343.5 | 233.8 |
| UC11-11…..……..……0.69 fl oz | 35 d | 264.5 | 271.8 d | 279.3 | 313.3 | 306.5 | 336.3 | 235.5 |
| UC11-10……………..…..2.0 fl oz | 28 d | 264.3 | 277.5 bcd | 278.5 | 312.8 | 298.0 | 331.5 | 227.8 |
| UC11-10.………………..2.0 fl oz | 35 d | 280.5 | 275.8 bcd | 276.8 | 306.8 | 296.0 | 309.8 | 213.0 |
| UC11-7...……………..0.37 fl oz | 28 d | 262.3 | 278.3 bcd | 279.5 | 305.5 | 306.0 | 338.5 | 234.8 |
| UC11-7...……………..0.37 fl oz | 35 d | 251.8 | 272.3 cd | 272.3 | 316.0 | 285.8 | 339.0 | 223.8 |
| UC11-9…...…………...4.0 fl oz | 21 d | 266.8 | 301.8 a | 284.8 | 335.0 | 310.3 | 348.0 | 239.5 |
| UC11-1……………....1.28 fl oz | 21 d | 262.3 | 284.5 bcd | 282.5 | 322.5 | 305.0 | 331.0 | 230.5 |
| Emerald………………...0.18 oz | 21 d | 274.8 | 287.0 abc | 280.0 | 313.3 | 305.3 | 342.8 | 235.0 |
| Emerald………………...0.18 oz | 28 d | 258.8 | 272.5 cd | 274.3 | 303.5 | 301.3 | 335.5 | 225.3 |
| Emerald………………...0.18 oz | 35 d | 266.5 | 281.5 bcd | 277.8 | 301.5 | 300.5 | 327.3 | 226.5 |
| Untreated | -- | 259.0 | 271.8 d | 266.5 | 296.0 | 279.5 | 307.3 | 215.5 |
| ANOVA: Treatment (P > F) | | 0.5955 | 0.0129 | 0.0880 | 0.1608 | 0.6453 | 0.1503 | 0.3214 |
| Days after treatment | 21 d | 20 | 12 | 5 | 14 | 19 | 7 | 11 |
| | 28 d | 20 | 27 | 12 | 21 | 26 | 7 | 11 |
| | 35 d | 20 | 19 | 33 | 6 | 11 | 20 | 24 |

[z] All treatments were initiated on 21 May. Subsequent 21 d treatments were applied on 10 Jun, 1 Jul, 22 Jul, and 12 Aug; 28 d treatments were applied on 16 Jun, 15 Jul, and 12 Aug; 35 d treatments were applied on 24 Jun and 29 Jul.

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

# EFFICACY OF VELISTA AGAINST DOLLAR SPOT AND BROWN PATCH COMPARED TO CONVENTIONAL PREVENTATIVE PROGRAMS FOR CONTROL IN CREEPING BENTGRASS FAIRWAY TURF, 2011

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## INTRODUCTION

Dollar spot (caused by *Sclerotinia homoeocarpa*) and brown patch (*Rhizoctonia solani)* are two common diseases of golf course fairway turf throughout New England. Utilizing proper cultural practices such as moderate fertility, resistant cultivars irrigation can minimize the incidence of these diseases. However, acceptable control often still requires preventive fungicide applications every 21 to 28 days with currently available materials. The objective of this study was to compare the efficacy of a conventional preventative fungicide program with a program incorporating Velista, a new SDHI fungicide (FRAC 7) scheduled to be released in 2012.

## MATERIALS & METHODS

A field study was conducted on a mixed 'Seaside II' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) fairway at the Lake of Isles Golf Course in North Stonington, CT. Turf was mowed three days $wk^{-1}$ at a bench setting of 0.5-inches. The site was irrigated as necessary to avoid drought stress. Nitrogen was applied as Sustain at 0.4 pounds N 1000-$ft^2$ on 16 June and ammonium sulfate at 0.1 pounds N 1000-$ft^2$ monthly throughout the trial.

Treatments consisted of two programs, one with currently available fungicides and the other with Velista applied in combination with other available products. The two programs were applied every 21-d during the early and late portions of the season (listed in Tables 1 & 2). During the mid-season, the facility applied Concert at 5.5 fl.oz. 1000-$ft^2$ and Subdue MAXX at 0.75 oz. 1000-$ft^2$ per their normal program on 28 Jul. Initial treatment applications were made on 25 May prior to disease developing in the trial area. All treatments were applied using a Toro Multi Pro sprayer equipped with flat fan nozzles calibrated to deliver 2 gal 1000-$ft^2$ at 50 psi. Between treatments the sprayer was triple rinsed and drained thoroughly to minimize cross contamination. Plots measured 20 x 100 ft and were arranged in a randomized complete block design with three replications.

Dollar spot was assessed as a count of individual disease foci every two inches along a 50 foot transect of each plot. Five transects were assessed within each plot and the mean was used for analysis. Residual dollar spot damage was assessed on a 0-5 scale; where 0 was equal to no damage and 2 was the maximum acceptable rating. 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. Algae was also assessed visually on a 1-9 scale; where 1 was equal to minimal algae development and 6 represented the maximum acceptable level. Five quality and algae ratings of approximately 18 $ft^{-2}$ areas at regularly spaced intervals were taken per plot, and the mean was used for analysis. Data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

## RESULTS

*Dollar Spot*

Dollar spot developed on 24 June, approximately 4 weeks after initial applications. Disease pressure was very low in June and July with plots of untreated turf containing 1.3 dollar spot foci in July (Table 1). Thereafter, dollar spot incidence increased slightly through September with untreated plots containing 25.5 foci per plot. On 20 September and 11 October both treatments significantly reduced disease compared to untreated turf (Table 1). However, there were no significant differences between the two programs at any time during the study. Residual dollar spot control was apparent in November (57 DAT) with both program treatments continuing to provide acceptable control. However, there were no significant differences between the two programs (Table 1).

*Turf quality, Algae, and Brown Patch*

Turf quality was generally good in all treated plots throughout the course of the study (Table 2). Algae infestation resulted in lower quality ratings on 24 Jun and dollar spot development contributed to lower quality ratings on 11 Oct in all treatments. No difference was observed at any point between the two fungicide treatments.

Algae developed throughout the treatment area during June with the programs being no different than the untreated control plots (Table 2).

No brown patch was observed at any time during the course of the study.

## DISCUSSION

In this study, two fungicide programs were evaluated for their ability to control turfgrass diseases. Overall, no differences were observed between the programs evaluated in this study under low disease pressure. Although, both programs did reduce dollar spot and improve turf quality compared to the untreated control.

Table 1. Dollar spot incidence and residual dollar spot damage in mixed 'Seaside' creeping bentgrass and annual bluegrass fairway turf maintained at 0.5 inches treated preventively with fungicides at Lake of Isles GC, North Stonington, CT during 2011.

| Treatment Rate per 1000 $ft^{-2}$ | Int[z] | Dollar Spot Incidence 15 Jun | 24 Jun | 14 Jul | 20 Sep | 11 Oct | Residual Dollar Spot 18 Nov |
|---|---|---|---|---|---|---|---|
| | | -avg. number of foci from five transect counts - | | | | | --0-5; 2 = max-- |
| Velista……………………0.3 oz | A | 0.0 | 0.1 | 0.3 | 6.0 b[y] | 1.9 b | 0.7 b |
| +Curalan…………………1.0 oz | AD | | | | | | |
| +Velista…………………0.5 oz | BCD | | | | | | |
| +Banner MAXX……...1.0 fl oz | BC | | | | | | |
| Emerald………………...0.18 oz | AD | 0.0 | 0.1 | 0.5 | 3.8 b | 6.7 b | 0.7 b |
| +Daconil Ultrex……..…...1.8 oz | BC | | | | | | |
| +Banner MAXX……….1.0 fl oz | BC | | | | | | |
| Untreated | -- | 0.0 | 0.3 | 1.3 | 25.5 a | 69.7 a | 2.8 a |
| ANOVA: Treatment (P > F) | | 0.0000 | 0.4952 | 0.6206 | 0.6351 | 0.0050 | 0.0029 |
| Days after treatment: | A | 21 | 30 | 50 | -- | -- | -- |
| | B | -- | 9 | 29 | -- | -- | -- |
| | C | -- | -- | -- | 26 | 47 | 78 |
| | D | -- | -- | -- | 5 | 26 | 57 |

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 24 May, B = 15 Jun, C = 25 Aug, D = 15 Sep

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

Table 2. Turf quality and algae rating of mixed 'Seaside' creeping bentgrass and annual bluegrass fairway turf maintained at 0.375 inches treated preventively with fungicides at Lake of Isles GC, North Stonington, CT during 2011.

| Treatment Rate per 1000 $ft^{-2}$ | Int[z] | Turf Quality 15 Jun | 24 Jun | 14 Jul | 20 Sep | 11 Oct | 18 Nov | Algae 24 Jun |
|---|---|---|---|---|---|---|---|---|
| | | ----------------1-9; 6 = minimum acceptable---------------- | | | | | | -1-9; 6 = max- |
| Velista……………………0.3 oz | A | 7.8 | 6.8 | 8.0 | 7.5 a | 6.8 a | 7.0 a | 5.8 |
| +Curalan…………………1.0 oz | AD | | | | | | | |
| +Velista…………………0.5 oz | BCD | | | | | | | |
| +Banner MAXX……...1.0 fl oz | BC | | | | | | | |
| Emerald………………...0.18 oz | AD | 7.1 | 6.8 | 7.9 | 7.5 a | 6.5 a | 7.2 a | 5.5 |
| +Daconil Ultrex……..…...1.8 oz | BC | | | | | | | |
| +Banner MAXX……….1.0 fl oz | BC | | | | | | | |
| Untreated | -- | 7.3 | 6.6 | 7.3 | 6.5 b | 5.0 b | 5.47 b | 5.9 |
| ANOVA: Treatment (P > F) | | 0.3332 | 0.8900 | 0.0562 | 0.0039 | 0.0047 | 0.0145 | 0.6490 |
| Days after treatment: | A | 21 | 30 | 50 | -- | -- | -- | 30 |
| | B | -- | 9 | 29 | -- | -- | -- | 9 |
| | C | -- | -- | -- | 26 | 47 | 78 | -- |
| | D | -- | -- | -- | 5 | 26 | 57 | -- |

[z] Treatments were applied on the following dates corresponding with the letters listed above: A = 24 May, B = 15 Jun, C = 25 Aug, D = 15 Sep

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

# CURATIVE RED THREAD CONTROL IN FINE FESCUE LAWN TURF WITH FUNGICIDES AND BIORATIONAL PRODUCTS, 2011

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## INTRODUCTION

Red thread (caused by *Laetisaria fuciformis*) commonly affects turfgrasses used in residential lawns during the late spring and early fall months. Symptoms appear as discrete spots (2-4 inch diam.) of tan colored necrotic tissue, which may coalesce to produce a uniform blighting of affected areas. This disease is particularly severe in under-fertilized fine fescue and perennial ryegrass lawns. Maintaining sufficient nitrogen fertility and minimizing leaf wetness period are effective practices to reduce the incidence and severity of red thread. However, fungicides may be required to control the disease in areas particularly prone to the disease. The objective of this study was to evaluate the efficacy of commercial fungicides and readily accessible consumer plant protectants for curative control of red thread in lawn turf.

## MATERIALS & METHODS

A field study was conducted on a creeping red fescue (*Festuca rubra*) turf grown on a Woodbridge fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. The field was established in 2005 and maintained as a low input lawn. Turf was mowed once a week at 3.0 inches and the area did not receive any supplemental irrigation. Nitrogen was applied at 0.5 lbs N 1000-ft$^{-2}$ during the trial as urea on 20 June 2011 to improve recovery rate 21 days after initial treatment.

Treatments consisted of currently available fungicides applied at recommended curative rates, and a fertilizer treatment applied at 0.5 lbs N 1000-ft$^{-2}$ as urea, irrigated-in with 0.1-inch of water immediately following application. Treatments were initiated as a curative application on 30 May and a follow-up application was made on 21 June. All treatments were applied using a hand held $CO_2$ powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 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.

Red thread was assessed visually as a percentage of the plot area blighted by *L. fuciformis*. 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. Chlorophyll index values were also assessed 21-days after the first application to determine green color differences among treatments. Ten readings were taken randomly per plot using a Field Scout CM 1000 chlorophyll meter and averaged prior to statistical analysis. Data were subjected to an analysis of variance and means separated using Fisher's protected least significant difference test.

## RESULTS & DISCUSSION

A severe red thread epidemic developed within the trial area prior to the initiation of treatments due to favorable environmental conditions for disease development in early May. By late-May, just before treatments were applied, plot area blighted by red thread was 49 to 56% throughout the trial area, although there were no statistical differences among plots at that time. Following initial application, all treatments reduced red thread severity compared to untreated turf on 20 June (21 DAT), except the biorational material, Bayer Natria Disease Control. Heritage TL and urea provided the greatest red thread suppression on this date, with Armada WG and Disarm 480SC providing comparable control (Table 1). However, no treatment provided acceptable red thread control on this date. Poor control was likely due to the inability of this under-fertilized fine fescue turf to rapidly produce new shoots once the disease was arrested. Turf quality was also unacceptable for all treatments on this date due to the level of disease present in plots (Table 2). Therefore, the field was fertilized with 0.5 lbs N 1000-ft$^{-2}$ on 20 June and treatments were reapplied on 21 June.

Red thread severity was reduced in all plots on 29 June (8 DAT) and 13 July (22 DAT), compared to the previous observation date, following N fertilization and the second treatment application. Heritage TL, Disarm 480SC, Armada WG and urea provided good red thread control on these dates. Eagle 20EW, Spectracide Immunox Lawn, and Bayer Natria Disease Control also reduced red thread severity compared to untreated turf on these dates; however the level of control achieved was considered unacceptable in this trial. Turf quality was largely influenced by disease throughout the trial. Therefore, treatments providing acceptable disease control also provided acceptable turf quality on 29 June and 13 July

(Table 2). Chlorophyll index values were also influenced by disease on 20 June (Table 2). Heritage TL, Armada WG, and urea treated turf had the darkest green color on this date. All remaining treatments did not differ from the untreated control.

Strobilurin fungicides provided the greatest red thread control in this trial. After the field was fertilized (20 June), these treatments provided a 75 to 78% disease reduction compared to untreated turf (8 DAT), and improved turf quality to an acceptable level. Red thread severity in nitrogen treated turf was equal to control achieved with strobilurin fungicides throughout the trial. Increased nitrogen fertility is known to suppress red thread symptoms. However, the degree of control achieved with N treatment in this trial may have been enhanced due to extreme N deficiencies inherent to the field, and the significant difference in total N applied compared to fungicide treatments (1.5 vs. 0.5 lbs N 1000-ft$^{-2}$). Nonetheless, these data emphasize the importance of proper cultural practices for managing red thread. An integrated approach using effective fungicides and a water-soluble N source would likely provide the most rapid and complete curative control of red thread.

Readily available consumer materials (e.g., Spectracide Immunox Lawn), applied curatively at maximum label rates, were not as effective as commercial formulated materials (e.g., Armada WG). The biorational Bayer Natria Disease Control did not provide acceptable disease control, but did reduce red thread severity compared to untreated turf. As is the case with many biological controls, effective use of this material may require preventive applications to effectively control red thread.

Table 1. Red thread severity in a fine fescue lawn treated curatively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2011.

| | | | Red Thread | | | |
|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 $ft^{-2}$ | Int.[z] | 27 May | 20 Jun | 29 Jun | 13 Jul |
| | | | --------------------------- % area blighted --------------------------- | | | |
| Armada WG | 1.5 oz | 21-d | 51.3 | 25.0 bc [x] | 5.8 c | 3.0 c |
| Disarm 480SC | 0.18 fl oz | 21-d | 53.8 | 20.0 bc | 5.0 c | 4.8 c |
| Heritage TL | 2.0 fl oz | 21-d | 49.0 | 12.5 c | 2.8 c | 3.5 c |
| Eagle 20EW | 1.1 fl oz | 21-d | 50.0 | 31.3 b | 16.0 b | 11.5 bc |
| Spectracide Immunox Lawn | 10.7 fl oz | 21-d | 51.3 | 33.3 b | 21.3 b | 17.8 b |
| Bayer Natria Disease Control | 4.0 fl oz | 21-d | 55.0 | 55.1 a | 19.5 b | 18.0 b |
| Urea[y] | 0.5 lb | 21-d | 56.3 | 15.0 c | 5.8 c | 4.3 c |
| Untreated | | -- | 54.3 | 50.0 a | 31.3 a | 27.5 a |
| ANOVA: Treatment (P > F) | | | 0.9702 | 0.0001 | 0.0001 | 0.0001 |
| Days after first treatment | | | -3 d | 21 d | 30 d | 44 d |
| Days after second treatment | | | -- | -- | 8 d | 22 d |

[z] Applications were made on 30 May and 21 June.
[y] Urea treatments were irrigated with 0.1 inches of water immediately after application.
[x] Treatment means within each column followed by the same letter are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

Table 2. Turf quality and chlorophyll index in a fine fescue lawn treated curatively with fungicides at the Plant Science Research and Education Facility in Storrs, CT during 2011.

| | | | Turf Quality | | | | Chlorophyll Index |
|---|---|---|---|---|---|---|---|
| Treatment | Rate per 1000 $ft^{-2}$ | Int.[z] | 27 May | 20 Jun | 29 Jun | 13 Jul | 20 Jun |
| | | | ------- 1-9; 6 = min acceptable ------- | | | | |
| Armada WG | 1.5 oz | 21-d | 3.0 | 4.5 a [x] | 6.8 a | 7.0 a | 215.0 ab |
| Disarm 480SC | 0.18 fl oz | 21-d | 3.0 | 4.5 a | 6.8 a | 6.5 ab | 210.3 bc |
| Heritage TL | 2.0 fl oz | 21-d | 3.3 | 5.0 a | 7.3 a | 6.8 ab | 231.8 a |
| Eagle 20EW | 1.1 fl oz | 21-d | 3.0 | 4.3 ab | 5.5 b | 5.8 cd | 196.3 cd |
| Spectracide Immunox Lawn | 10.7 fl oz | 21-d | 3.0 | 3.5 bc | 4.8 b | 5.3 de | 191.0 d |
| Bayer Natria Disease Control | 4.0 fl oz | 21-d | 2.5 | 3.3 c | 4.8 b | 5.3 de | 193.8 cd |
| Urea[y] | 0.5 lb | 21-d | 3.0 | 5.0 a | 7.0 a | 6.3 bc | 223.3 ab |
| Untreated | | -- | 3.0 | 2.8 c | 4.8 b | 4.8 b | 196.0 cd |
| ANOVA: Treatment (P > F) | | | 0.6791 | 0.0006 | 0.0001 | 0.0001 | 0.0003 |
| Days after first treatment | | | -3 d | 21 d | 30 d | 44 d | 21 d |
| Days after second treatment | | | -- | -- | 8 d | 22 d | -- |

[z] Applications were made on 30 May and 21 June.
[y] Urea treatments were irrigated with 0.1 inches of water immediately after application.
[x] Treatment means within each column followed by the same letter are not significantly different based on Fisher's protected least significant difference test (α = 0.05).

## DETERMINING THE IMPORTANCE OF LEAF COMPOST TOPDRESSING WHEN MANAGING ATHLETIC FIELDS ORGANICALLY

**MAY 2011– DECEMBER 2011**

Brian J. Tencza and Jason J. Henderson
Department of Plant Science and Landscape Architecture
University of Connecticut

### INTRODUCTION

Effective July 1, 2010, the state of Connecticut banned the usage of all lawn care pesticides on athletic fields at public and private schools grades pre-K through 8. Currently, the research-based information regarding compost topdressing on athletic fields is limited. Topdressing athletic fields with spent mushroom substrate (SPS) has been evaluated showing many positive impacts such as an increase in percent ground cover after wear, decreased bulk density, increased water retention, and decrease surface hardness (McNitt et al. 2004). However, composts can vary greatly and no research based information exists regarding topdressing leaf composts on athletic fields. Additionally, research on compost topdressing applications to soils ranging in organic matter content is very limited. Therefore, the potential benefit or detriment to increasing the organic matter level in a soil that is already considered suitable (4-8%) is not well understood. The specific objectives of this study are to: 1) Determine the effects of leaf compost and sand topdressing incorporated with core cultivation on soil physical properties when applied to low and high organic matter soils, and 2) Evaluate the effects of leaf compost topdressing and sand topdressing incorporated with core cultivation on the traffic tolerance of Kentucky bluegrass.

### METHODS AND MATERIALS

The study is arranged in a Latin rectangle with three treatments and six replications 1) Leaf compost topdressing applied at ¼" in the spring and fall, 2) Sand topdressing applied at ¼" in the spring and fall (Table 1), and 3) No topdressing applied (Figure 1). Topdressing treatments were applied in the spring and fall of 2011. Plots were split by core cultivation at the end of the 2010 growing season. This means each topdressing treatment (sand, leaf compost and the untreated control) was split into two subplots. Half of each plot was core cultivated in two directions and the other half received no core cultivation. Cultivation was applied using a Ryan GreensAire II equipped with 5/8" hollow core tines. The first topdressing treatments were applied on May 26, 2011. Nutrients were applied according to soil test recommendations and all treatments were fertilized equally. Lime was applied on May 24, 2011 at a rate of 25 lbs per 1000 ft$^2$ to both plot areas to increase soil pH. Plots were mowed at 2" twice per week.

Traffic Simulation was conducted using a Cady Traffic Simulator, a modified walk-behind core cultivation unit. Traffic was applied three times per week for 12 weeks beginning on August 29, 2011 and ending in late November for a total of 23 traffic events. Data collected in this study included ratings of turf quality and color. This was done by visual rating using a scale of 1 to 9, where 1 = brown/dead turf; 6 = minimum acceptable color/quality; and 9 = optimum quality or dark green color. Digital image analysis was utilized in assessing turf color and cover. Controlled light conditions were provided through the use of a light box. Images were scanned using Sigma Scan Software using the following threshold values; hue=55-125 and saturation=10-100. The Dark Green Color Index (DGCI) was calculated based on hue, saturation and brightness values. Color and quality data was collected on a biweekly basis. Surface hardness was measured using a Clegg impact hammer. Data was collected once a month from June 2011 to October 2011. Soil moisture readings were measured using a portable Field Scout TDR 300 probe (12 cm). Data was collected once a month from May 2011 to November 2011. Weed count data was obtained for both crabgrass and broadleaf weeds. Counts were done visually beginning on June 14, 2011 and were completed monthly through November. Percent soil organic matter was assessed in spring 2011before 2011 treatments were applied. Undisturbed soil samples were extracted to assess soil bulk density and percent organic matter.


**Figure 1. a) Sand topdressing being applied to the low organic soil plot area. b) Compost topdressing being applied to the high organic soil plot area. c) Low organic soil plot area after the treatments were applied. d) Incorporation of treatments using a Ryan GreensAire II Aerator.**

| | Soil Separate % | | | | % Retained | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | **Sand** | **Silt** | **Clay** | **No. 10 Gravel 2 mm** | **No. 18 VCS 1 mm** | **No. 35 CS 0.5 mm** | **No. 60 MS 0.25 mm** | **No. 100 FS 0.15 mm** | **No. 140 VFS 0.10 mm** | **No. 270 VFS 0.05 mm** |
| **Coarse Sand** (AA Will Mat. 2mm) | 99.5 | 0.0 | 0.4 | 0.1 | 11.0 | 31.5 | 42.0 | 13.0 | 1.6 | 0.4 |
| **USGA Rec. for Putting Green Const** | | **≤ 5%** | **≤ 3%** | **≤ 3% Gravel ≤ 10% Combined** | | **≥ 60%** | | **≤ 20%** | **≤ 5%** | |

**Table 1: Particle size analyses of sand types. USGA recommendations for putting green.**

## RESULTS TO DATE

The compost treatments produced significantly darker green turf compared to the sand treatments during the spring and summer on the high organic matter soil. The compost treatments produced significantly darker green turf compared to the sand and untreated control treatments during the spring and summer on the low organic matter soil. Treatments did not affect turfgrass color on either soil type by fall 2011 (Figure 2.)

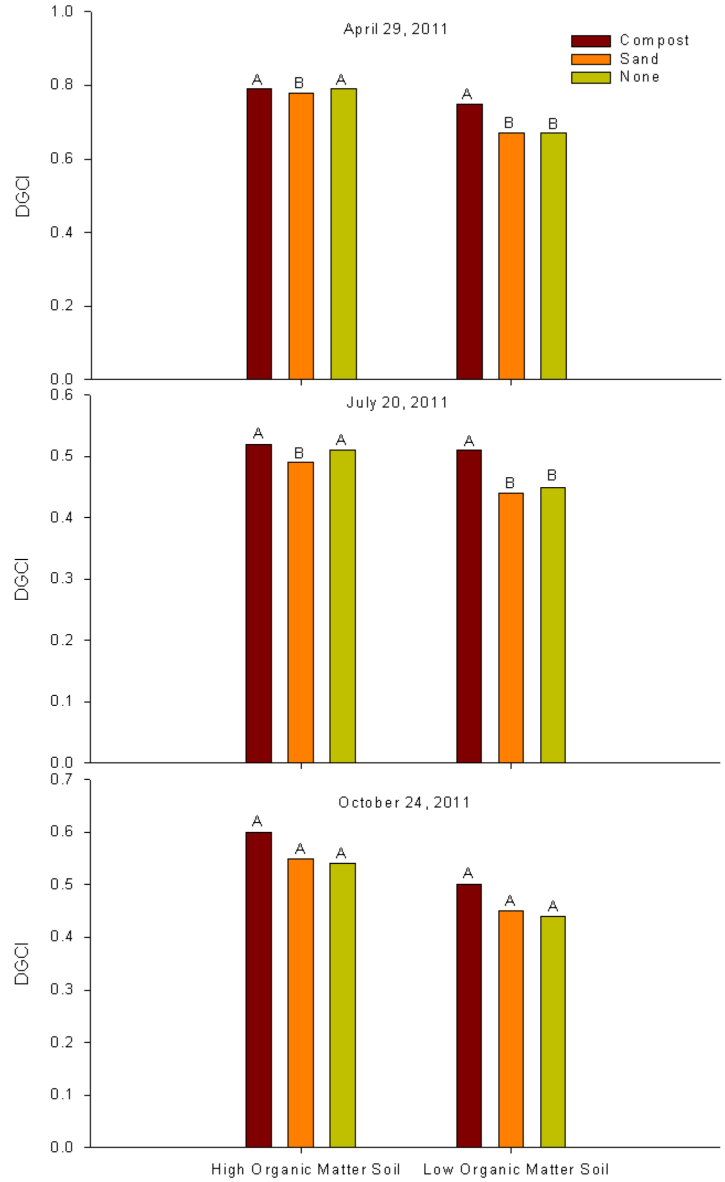


**Figure 2.** The effect of leaf compost and sand topdressing treatments on turfgrass color when applied to two soils, 2011. Turfgrass color was quantified using digital image analysis.

The compost treatments produced significantly greater percent cover regardless of soil type during the spring and summer, but not in fall during the second growing season (Figure 3).

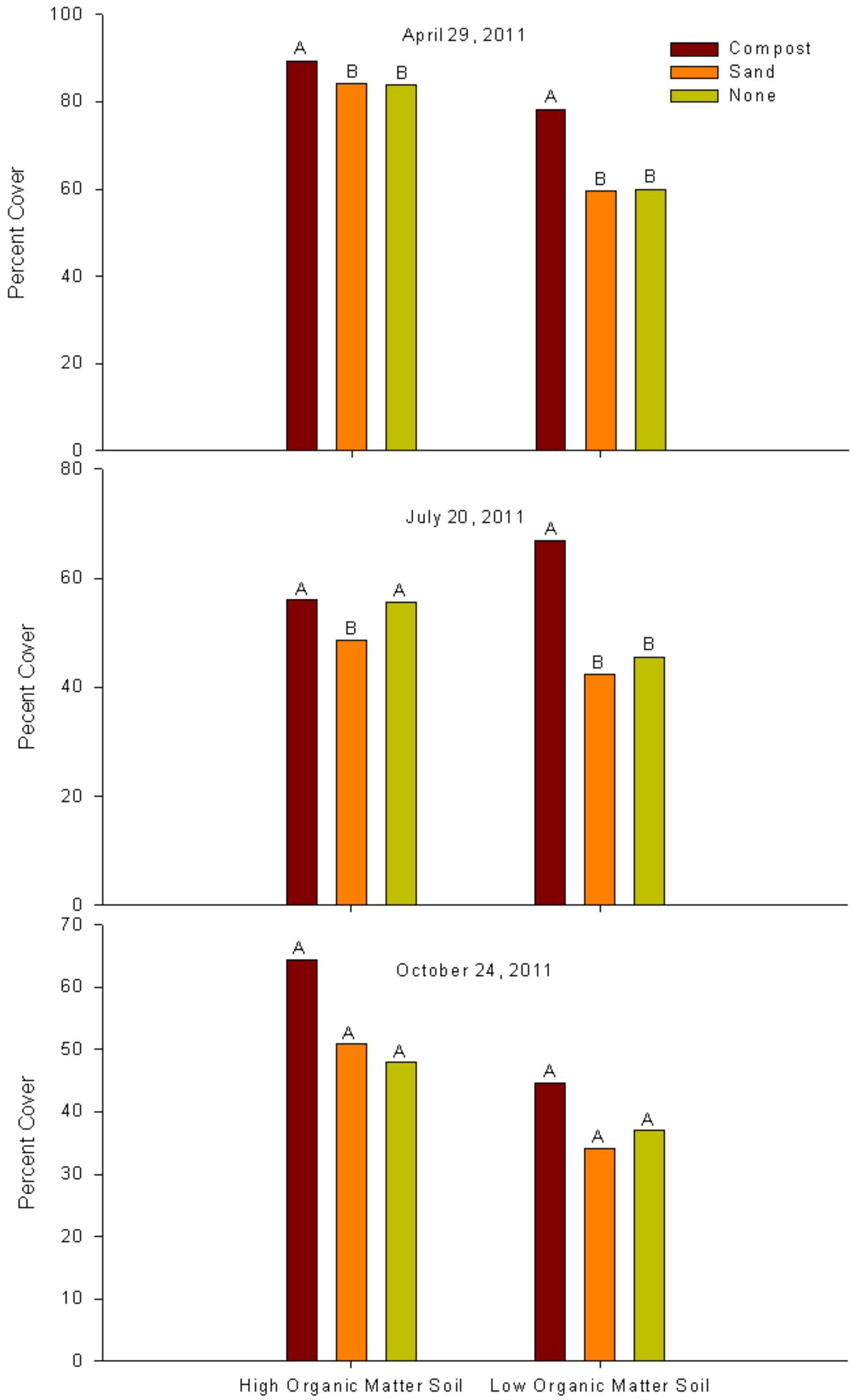


**Figure 3.** The effect of leaf compost and sand topdressing treatments on percent cover when applied to two soils, 2011.

Applying leaf compost produced significant differences in volumetric soil moisture in the top 2” of the profile when compared to the sand or untreated control during the summer and fall, but not during the spring of the second growing season (Figure 4).

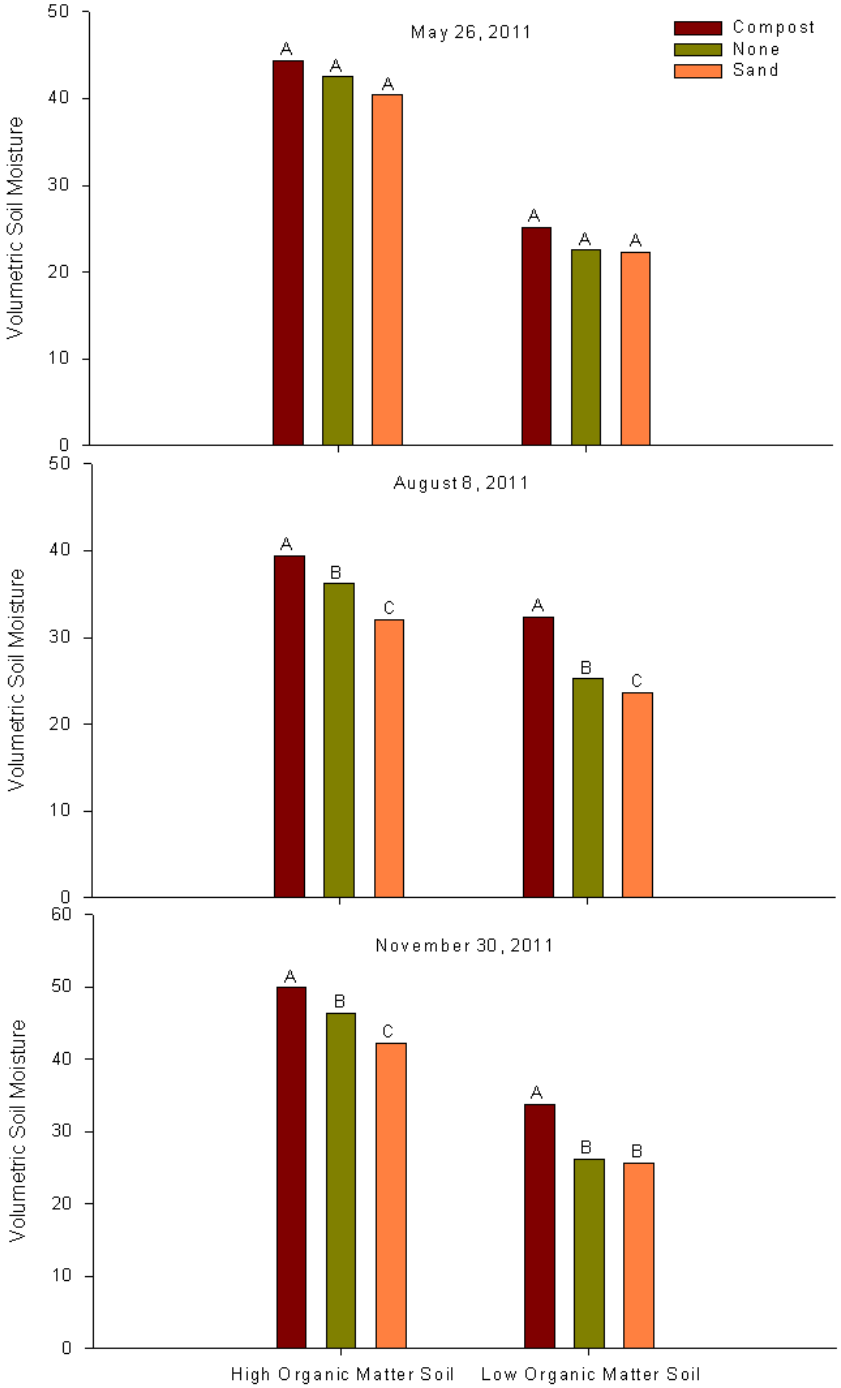


**Figure 4.** The effect of leaf compost and sand topdressing treatments on volumetric soil moisture when applied to two soils, 2011.

Differences in surface hardness were observed as an overall soil and treatment effect. The high organic matter soil had lower gmax values than the low organic matter soil. Additionally, an overall treatment effect was observed with the leaf compost significantly reducing surface hardness compared to the untreated control in both soil types (Figure 5).

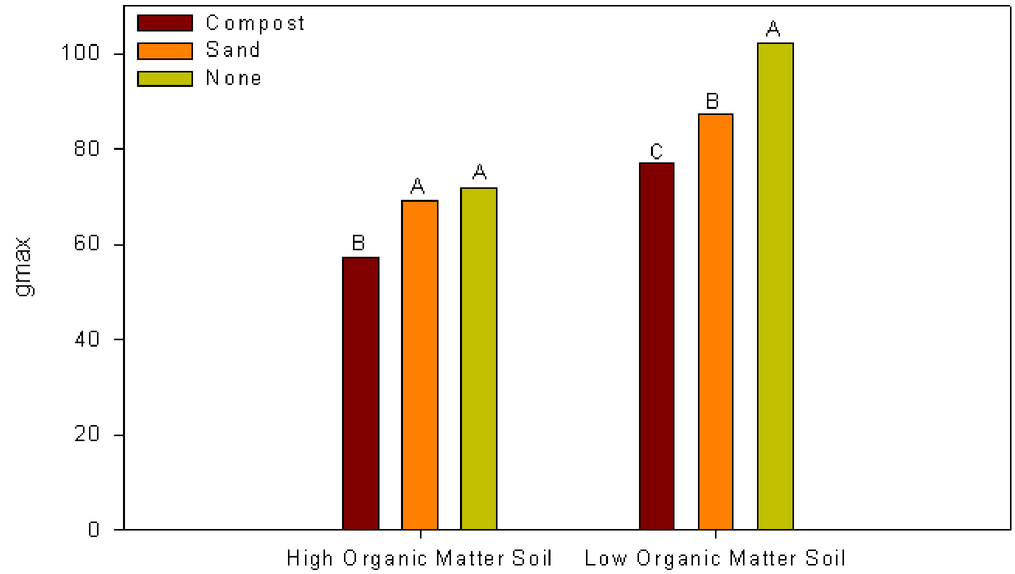


**Figure 5.** The effect of leaf compost and sand topdressing treatments on surface hardness when applied to two soils, July 7, 2011.

Compost applied to the high organic matter soil produced significantly greater organic matter content when compared to the sand and untreated control plots. No differences were noticed in organic matter content when treatments were applied to the low organic matter soil (Figure 6).

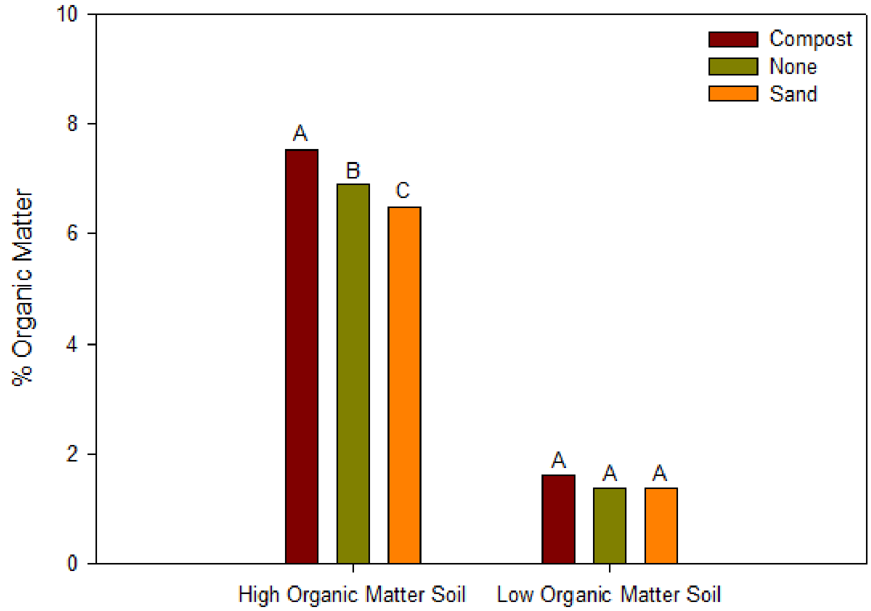


**Figure 6.** The effect of leaf compost and sand topdressing treatments on percent soil organic matter (0-3”) when applied to two soils, May, 2011.

### 2012 and 2013 Growing Seasons

The 2011 growing season was an opportunity to begin to fully evaluate the potential effects from the topdressing treatments and core cultivation. The study will be repeated again in 2012 and data collection will continue. This will provide us with two full years of data to analyze and further help determine if there are any benefits or detriments to incorporating these topdressing materials utilizing core cultivation.

### SUMMARY TO DATE

The composted treatments showed significantly greater turf color on each soil during the spring and summer, but not in the fall.

Leaf compost applications resulted in greater retention of cover during the spring and summer, but not in the fall. Leaf compost applications resulted in greater moisture retention in both soils during the summer and fall.

Leaf compost treatments had lower surface hardness values compared to the untreated control and sand treatment, regardless of soil type.

Organic matter was significantly greater in the compost treatment when compared to the sand and untreated control plots in the high organic matter soil only.

Cultivation showed differences in surface hardness during July, but on no other date during the 2011 growing season.

### LITERATURE CITED

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

**MAY 2011 – DECEMBER 2011**

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### INTRODUCTION

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

**Fig. 1.** Portable roadway systems can cause significant turfgrass damage when used for extended cover periods.

### MATERIALS AND METHODS

This study was performed at the University of Connecticut Plant Science Research and Education Facility located in Storrs, CT. Treatments were applied to a stand of Kentucky bluegrass (*Poa pratensis* L.) beginning in June 2011 and repeated in August 2011. Treatments were arranged as a 6 x 3 (cover type x cover period) factorial in a random complete block design with three replications. The main plots (cover period) were split by cover type. The five turf protection systems evaluated were 1) ¾" Plywood only (2 layers), 2) Enkamat Plus and ¾" Plywood (2 layers), 3) Enkamat Flatback and ¾" Plywood (2 layers), 4) Supa-Trac™ (Rola-Trak North America), 5) TerraTrak Plus™ (CoverMaster, Inc.), and 6) and an uncovered treatment. The second factor, cover period, had three levels: 3, 6, and 9 days. An uncovered/untrafficked control was also included. Treatments were subjected to two traffic events; each consisted of 10 passes with a loaded dump truck (gross vehicle weight of rating of 20,000 lbs. (Fig. 2).

**Fig. 2.** Dump Truck GVWR = 20,000 lbs.

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

Traffic events were conducted on the first and last day of each cover period. The first cover period lasted from June 21, 2011 to June 30, 2011. The second cover period lasted from August 23, 2011 toSept 1, 2011. Plot sizes were 4 ft wide by 16 ft long and treatments were mowed three times per week at a height of 1.5 inches. Data collection included turfgrass performance (turfgrass color, quality and percent cover) and playing surface characteristics (surface hardness, traction, and displacement). Turfgrass color was determined using Digital Image Analysis. Digital images were taken prior to covers being applied and then taken immediately following each cover period. Controlled light conditions were provided through the use of a light box. After all the covers were removed, light box photos were taken every 3 days for a period of two weeks. Photos were taken between the tire tracks on each plot. Images were scanned using Sigma Scan Software using the following threshold values; hue=55-125 and saturation=10-100. The Dark Green Color Index (DGCI) was calculated based on hue, saturation and brightness values (2). Plots were rated biweekly after each cover period. Turfgrass quality was done using a visual rating scale of 1 to 9, where 1=brown/dead turf; 6=minimum acceptable color/quality; and 9=optimum quality or dark green color. Surface hardness was measured using a Clegg Impact Tester. Traction was measured using a Canaway Traction Device (1). Data was collected after each cover period ended. Displacement was measured using a custom designed apparatus that used five measuring pins spaced equally across the tire track to measure the depth of the rut produced by the dump truck. These reading were averaged across both tire tracks (Fig. 5). Soil physical properties were assessed at the end of the final cover period. Comprehensive data collection ensued in June 2011 and continued through September 2011. Color, percent cover, and displacement data following the first cover period of 2011, are discussed in the following sections.

## TURFGRASS COVER

There were no differences in percent cover between cover types following the three day cover period. Following the six and nine day cover periods, TerraTrak Plus and Supa-Trac had higher percent cover than all the plywood treatments, but TerraTrak Plus and Supa-Trac were not different. However, TerraTrak Plus had greater cover than the No Cover with traffic treatment after nine days. (Fig. 3).

### TURFGRASS COLOR

Following the three day cover period, TerraTrak Plus had darker green turfgrass color than all the plywood treatments but was not significantly different from Supa-Trac. Following the 6 day cover period, Terra-Trak Plus had darker green color than all other cover treatments. TerraTrak Plus had the darkest green color out of all the plots that received a cover treatment following the 9 day cover period (Fig. 4).

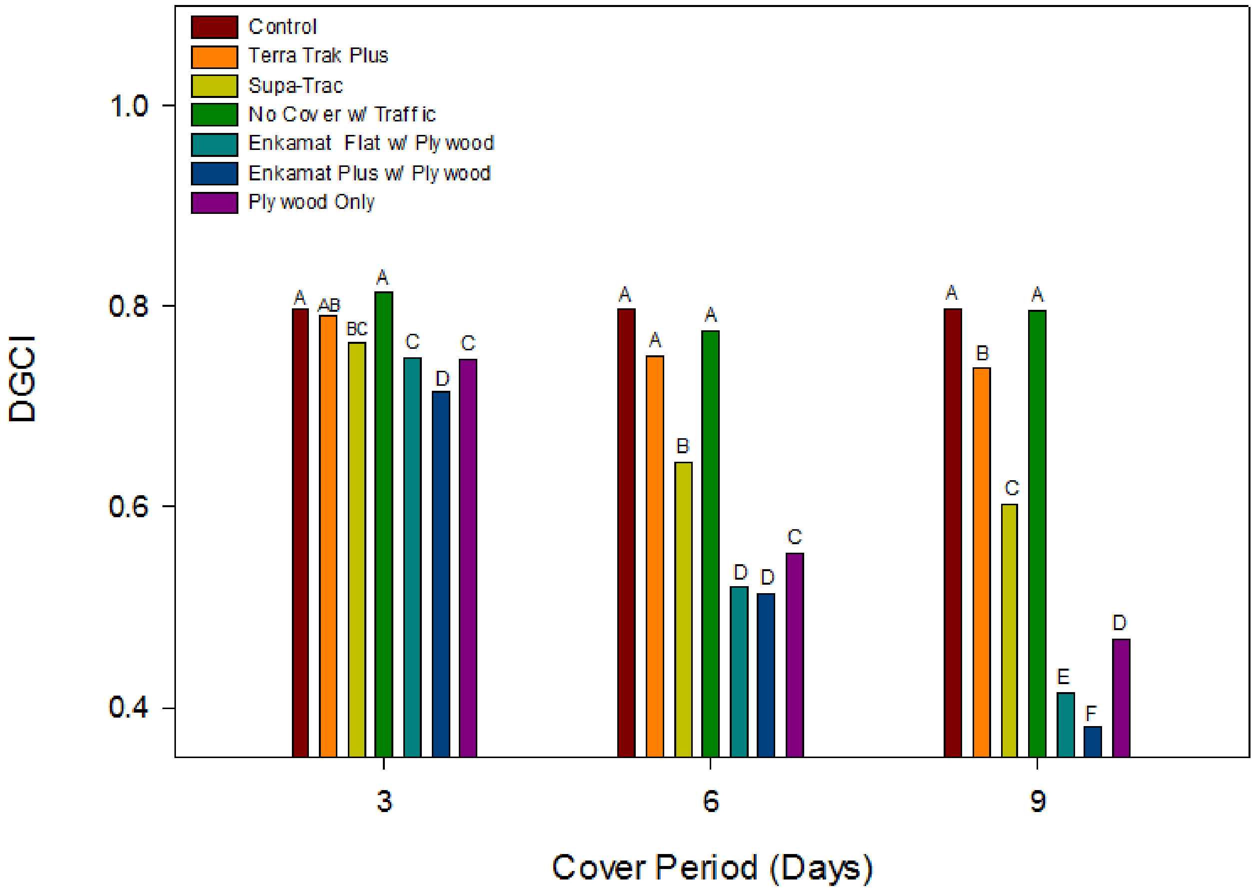


**Fig. 4.** The effect of cover type and cover duration on turfgrass color. June 2011.


**Fig. 5. a)** Three day cover plots after traffic. **b)** Six day cover plots after traffic. **c)** Nine day cover plots after traffic.

## DISPLACEMENT

No Cover w/traffic had the greatest displacement following traffic. Plywood only, Enkamat Plus w/plywood, and Enkamat Flat w/plywood had the least amount of displacement. TerraTrak and Supa-Trac were not statistically different from each other (Fig. 6).

## SUMMARY TO DATE

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

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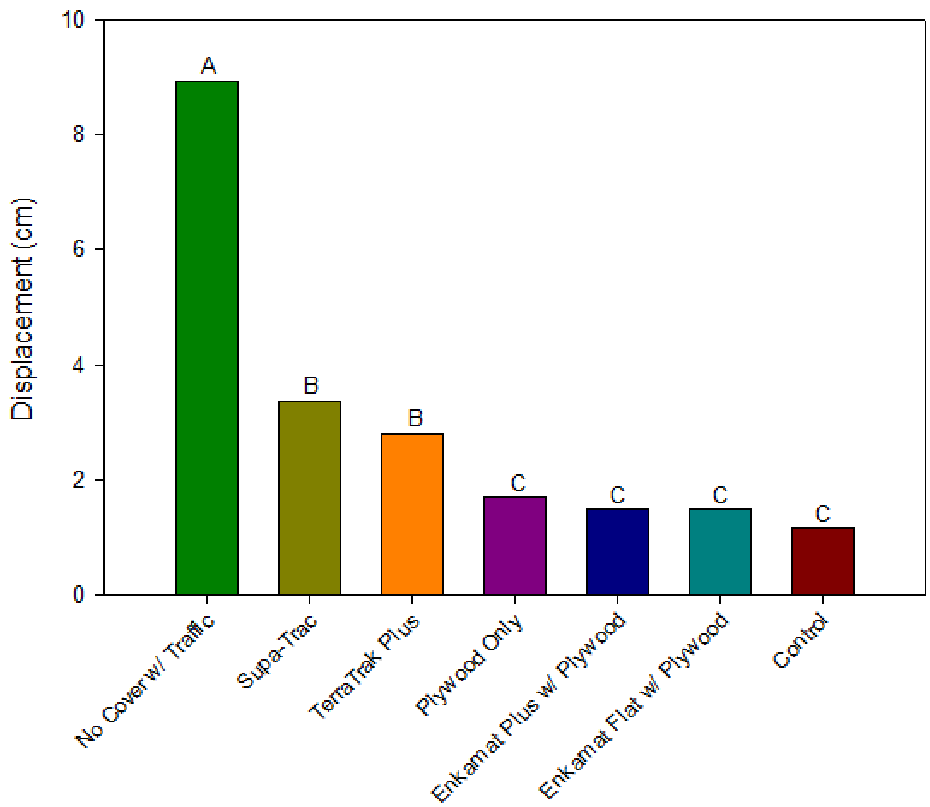


**Fig. 6.** The effect of cover type on surface displacement after 10 passes with a loaded dump truck (GVWR = 20,000lbs).

**AMINO-SUGAR SOIL N TEST (ASNT) AND ACTIVE SOIL C TEST (ASCT) AS PREDICTORS OF LAWN TURF RESPONSE**
**2011**

**Karl Guillard, Xingyuan Geng, and Thomas F. Morris**
Department of Plant Science and Landscape Architecture
University of Connecticut

## INTRODUCTION

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

## MATERIALS & METHODS

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

In the spring of 2011, soil samples were collected from each plot to a depth of 10 cm below the thatch layer, and analyzed for concentrations of soil amino-sugar N and active soil C. During the 2011 growing season, plots were mowed to a height of 7.5 cm twice a week, or as needed depending on growth. No supplemental irrigation was applied. At approximately two-week intervals after soil sampling, and continuing until November, turf canopy reflectance was measured using Spectrum CM1000 and TCM500 NDVI reflectance meters (Spectrum Technologies, Inc., Planfield, IL). Meter values for each sampling date were converted to a relative scale by dividing each value by the plateau value for each respective sampling date. When a plateau was not present, values were divided by the mean of the six highest meter readings for that respective sampling date. Relative values were pooled across the sampling dates and correlated with soil amino-sugar and active soil C concentrations.

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

## RESULTS

Readings from reflectance meters were significant, but weakly correlated to soil amino-sugar nitrogen concentrations (Figs. 1 and 2). For both species, a plateau response was observed for CM1000 and NDVI readings with critical values to optimize turf color between 250 to 265 mg $kg^{-1}$ for amino-sugar nitrogen. For active soil carbon, no plateau response was observed, but responses were linear (Figs. 5 and 6).

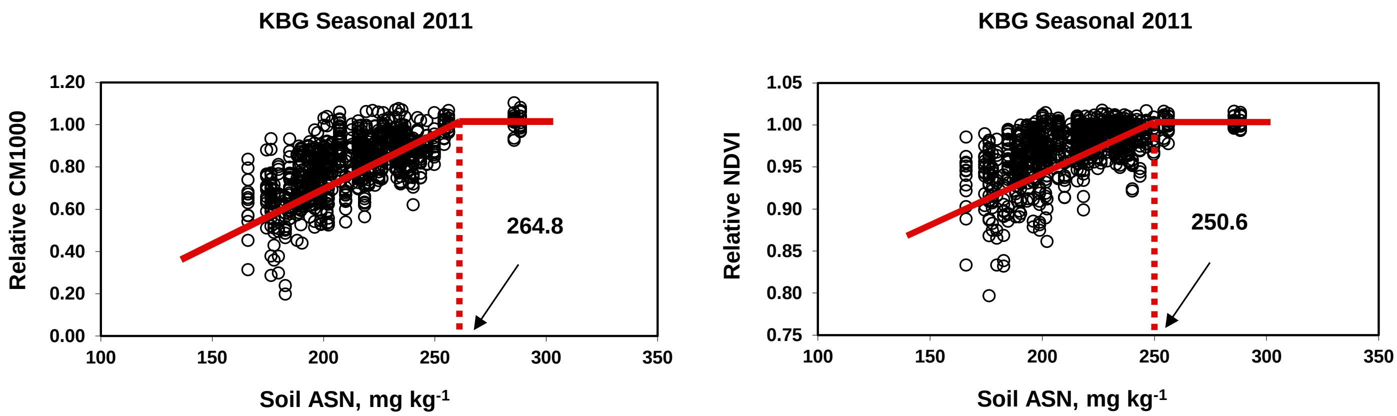


**Fig. 1.** **Relationship between relative CM1000 (left panel) and relative TCM500 NDVI (right panel) meter readings with soil amino-sugar N for Kentucky bluegrass lawn turf across 13 sampling dates during the 2011 growing season.**

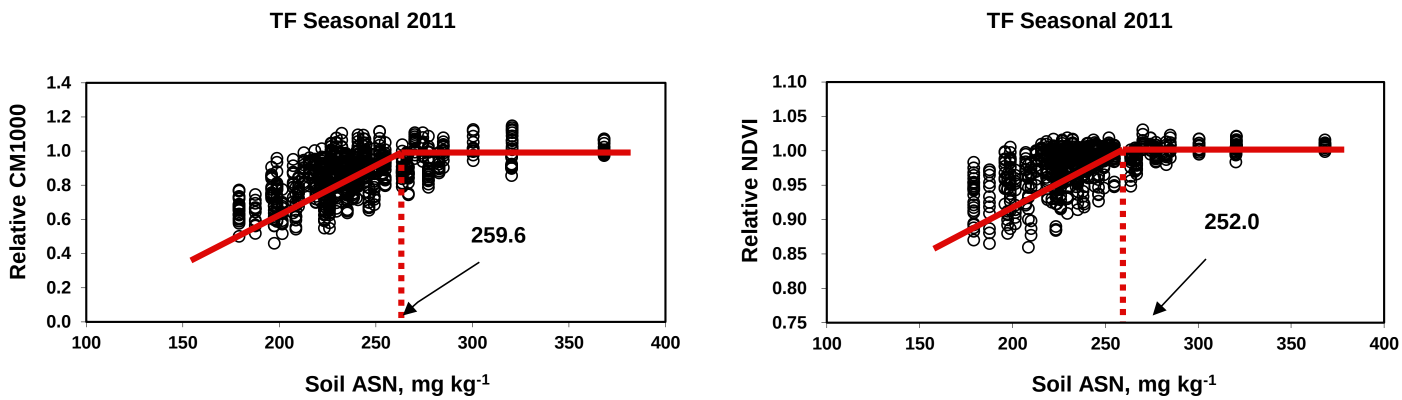


**Fig. 2.** **Relationship between relative CM1000 (left panel) and TCM500 NDVI (right panel) meter readings with soil amino-sugar N for tall fescue lawn turf across 13 sampling dates during the 2011 growing season.**

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

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



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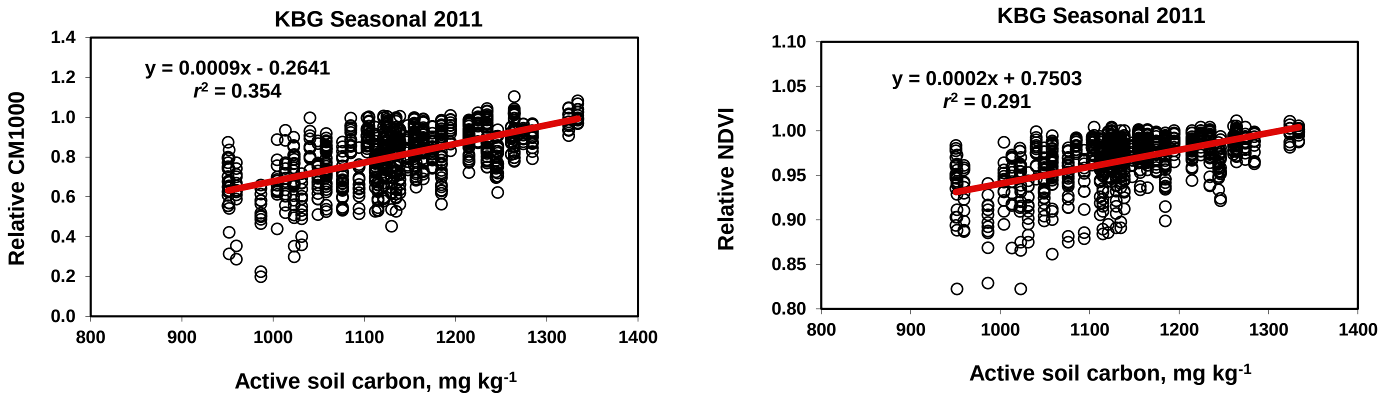


**Fig. 5. Relationship between relative CM1000 (left panel) and TCM500 NDVI (right panel) meter readings with soil active C for Kentucky bluegrass lawn turf across 13 sampling dates during the 2011 growing season.**

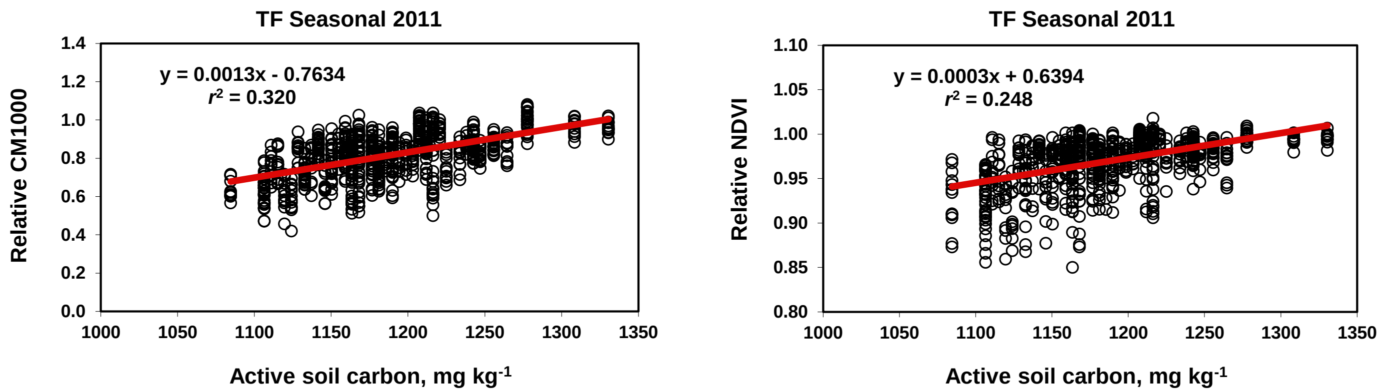


**Fig. 6. Relationship between relative CM1000 (left panel) and TCM500 NDVI (right panel) meter readings with soil active C for tall fescue lawn turf across 13 sampling dates during the 2011 growing season.**

## DISCUSSION

The fourth year's results of this study show positive, but weak relationships for Kentucky bluegrass and tall fescue color response to soil amino-sugar nitrogen and active soil C. We suspect that mineralization of the compost is increasing each year, providing increasingly higher soil amino-sugar nitrogen and active soil C concentrations with each passing year. Monitoring of the plots will continue through 2012.

# VERDURE SAP NITRATE-N CONCENTRATIONS AS A PREDICTOR OF TURF COLOR RESPONSE FALL 2011 – SPRING 2012

**Kevin Miele, Karl Guillard, and Thomas F. Morris**
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University of Connecticut

## INTRODUCTION

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

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

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

## MATERIALS & METHODS

This study was conducted in the autumn of 2012 on a three-year old turfgrass stand consisting of a mixture of 35% Kentucky bluegrass (*Poa pratensis*), 30% perennial ryegrass (*Lolium perenne*), and 35% creeping red fescue (*Festuca rubra*). The experiment was set out as two randomized complete block designs with three replicates. One experiment was fertilized in September and the other experiment was fertilized in October. Plot size was 5 × 5 feet. Treatments in each experiment were 13 N application rates (0, 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.5, 3.0, 3.5, and 4.0 lbs N/1000ft$^2$) applied as urea on September 15 for the first experiment and on October 16 for the second experiment. For the September-fertilized plots, turf color was measured with a Spectrum TCM500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Plainfield, IL) on October 10, 17, and 24 before plots were mowed to a height of 2¼ inches using a rotary hand mower with a bagger to collect the clippings (Fig. 1). For the October-fertilized plots, turf color was measured with the NDVI meter on November 7, 21, and 28. After mowing, verdure samples were removed from a small section (approximately 4 × 4-inch square) of each plot down to the soil surface using hand shears (Fig. 2). Fresh verdure samples were placed in a Spectrum hydraulic plant sap press and squeezed to expel the sap. The sap was placed into the sample well of a Cardy Nitrate Meter (Horiba B-343 Twin Nitrate Meter, Spectrum Technologies, Inc., Plainfield, IL; Fig. 9), and measurements were made for concentrations of nitrate-N. Measurements for all dates were taken between 1030 and 1600 hr. The sensor membrane in the sap nitrate meter was cleaned after each use with a mild dish-washing detergent to prevent the buildup of residue from the sap from interfering with the meter performance.

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

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

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

**Fig. 3. Fall color response of September fertilized plots on October 27, 2011.**

**Fig. 4. Fall color response of October fertilized plots on November 28, 2011.**

**Fig. 5. Spring color response of September 2011 fertilized plots on March 20, 2011.**

**Fig. 6. Spring color response of October 2011 fertilized plots on March 20, 2011.**

## RESULTS & DISCUSSION

### 2011 Fall Turf Color

Fall turf color response is presented in Figs. 3 and 4, and was highly correlated to fall verdure sap nitrate-N concentrations on Oct. 10, 17, 24, and Nov. 7, 21, 28. The relationship between fall verdure nitrate-N concentrations and fall NDVI readings for these dates are shown in Fig. 7.

When this study was conducted in previous years, higher critical levels were observed at the later sampling dates. This suggested that the turf plants were storing more nitrate in the verdure as top growth slowed with dormancy induced by the onset of colder weather. However, in Fall 2011, the weather was unseasonably warm and increasing concentrations of nitrate at the later sampling dates were not as pronounced as in years past.

LRP Model QRP Model

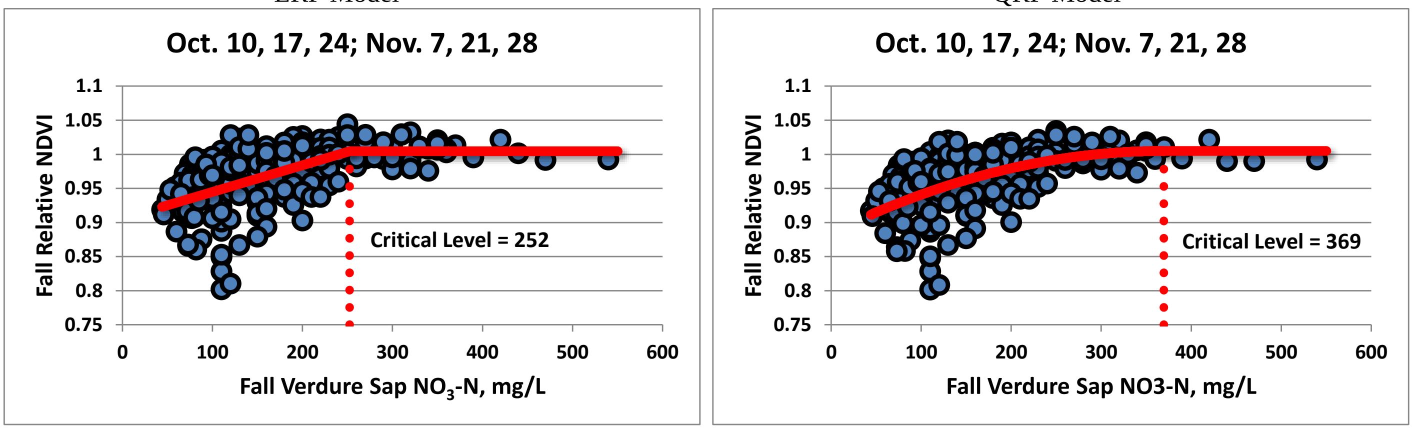


**Figure 7. Linear Response and Plateau (LRP) and Quadratic Response and Plateau (QRP) modeling of fall turf color, as indicated by relative NDVI, in response to fall verdure sap nitrate-N concentrations, 2011.**

### 2012 Spring Turf Color

Spring turf color response was highly correlated to the previous fall verdure sap nitrate-N concentrations from Oct. 10, 17, 24, and Nov. 7, 21, 28. Similar, albeit somewhat higher, critical levels were observed in Spring 2012 in comparison to those observed in Fall 2011.

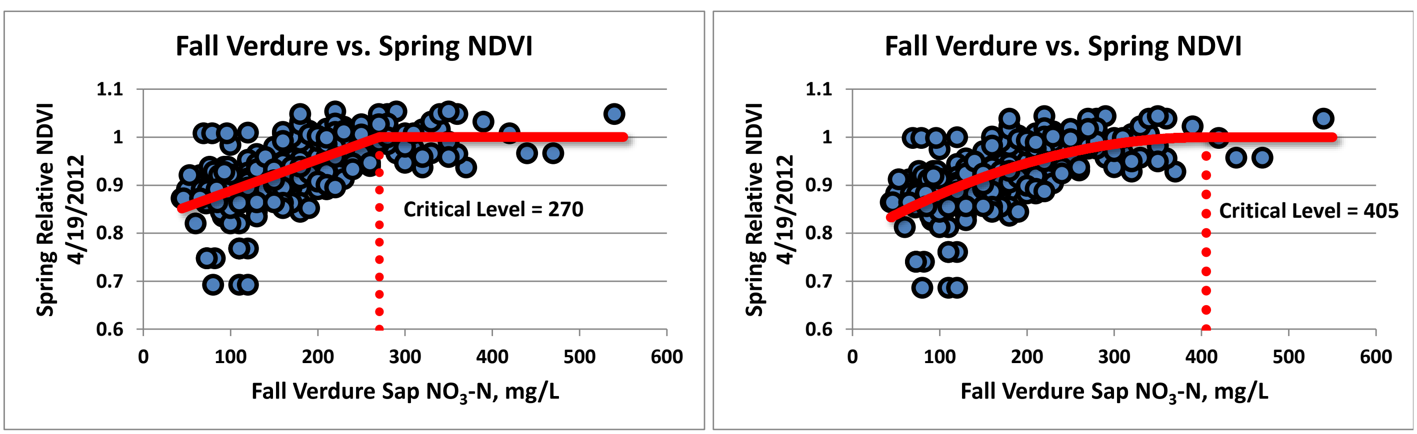


**Figure 8. Linear Response and Plateau (LRP) and Quadratic Response and Plateau (QRP) modeling of 2012 spring turf color, as indicated by relative NDVI, in response to 2011 fall verdure sap nitrate-N concentrations.**

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

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

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


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

# BENEFICIAL SOIL BACTERIAL AMENDMENT EFFECTS ON PERENNIAL RYEGRASS GROWTH AND QUALITY, AND SOIL PHOSPHORUS DURING THE YEAR AFTER ESTABLISHMENT, 2011

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## INTRODUCTION

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

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

## MATERIALS & METHODS

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

Treatments were repeated in 2011 as indicated above, beginning in June and monthly through October. Plots were mowed to a height of 31.75 mm (1.25 inches) using a Toro rotary hand mower. Weed control was accomplished using Dimension (May 6 at 10 oz/ac), Trimec Classic (June 3 at 1.5 oz/1000ft$^2$), and Tenacity (July 27 at 5 oz/ac). No fungicides or insecticides were applied in 2011. Turf color was measured with a Spectrum CM1000 Chlorophyll meter and a TCM500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Plainfield, IL) before mowing on June 20 and 30, July 20, August 10 and 25, September 17, October 9 and 26. Clipping yield was determined on July 12, August 18, September 17, and October 25 by collecting the central 20 × 48 inches of each plot with a Toro hand mower and recording the weights after drying the clipping in a paper bag at 70 °C for 48 hours. Clipping weights from each plot were summed to produce a total weight of clippings.

Soil samples were taken randomly from each plot at 4 to 5 different locations to a 10-cm depth on May 27 and December 4. Samples were air dried, then sieved to pass a 2-mm screen. Soil extractable P was determined for all soil samples by an ascorbic-acid colorimetric method after extraction with the modified-Morgan extractant.

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

## RESULTS & DISCUSSION

### Extractable Soil P

Phosphorus fertilizer treatments had the greatest effect on extractable soil P concentrations at both the May and December soil sampling dates (Table 1). As expected, increasing the rate of P from 0 to 30 kg/ha/month resulted in increasing extractable soil P concentrations at both dates. At the December sampling date, there was a significant BioPak × N interaction. However, no meaningful trend was evident.

Table 1. Source effects for extractable soil P analysis of variance

| | Date (mm/dd/yy) | |
|---|---|---|
| Source | 05/27/11 | 12/04/11 |
| BioPak | ns | ns |
| N | ns | ns |
| P | * | ** |
| BioPak*N | ns | ** |
| BioPak*P | ns | ns |
| N*P | ns | ns |
| BioPak*N*P | ns | ns |

ns, *,** Not significant ($p$ >0.05) and Significant at $p$ < 0.05 and 0.01, respectively.

### Turf Color

For each sampling date, N had the greatest and most consistent effect on CM1000 chlorophyll and NDVI values (Tables 2 and 3). Phosphorus addition improved CM1000 chlorophyll values in three of the six sampling dates. Increasing the rate of N, regardless of BioPak resulted in higher CM1000 and NDVI values, indicating more green turf. Overall effects of BioPak were not significant, but there was a significant BioPak × N interaction for mean NDVI values across the season. In this case, mean NDVI values averaged across the growing season were significantly higher at the no N treatment with BioPak addition, but no differences with or without BioPak were noted when N was applied at 10 to 30 kg/ha (Fig. 1). However, the zero N-BioPak treatment NDVI was still significantly lower than any treatment where N was applied.

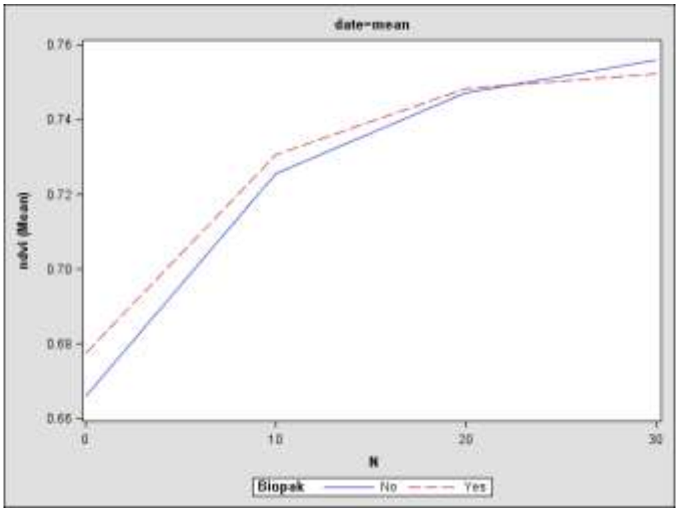


**Fig. 1. Mean NDVI values across all sampling dates for the BioPak × N interaction. Significant (*p*<0.05) differences were observed only at the zero N treatment. N applied at rates of kg/ha.**

Table 2 Source effects for CM1000 analysis of variance.

| Source | Date (mm/dd/yy) 06/20/11 | 06/30/11 | 07/20/11 | 08/10/11 | 08/25/11 | 09/17/11 | 10/09/11 | Mean |
|---|---|---|---|---|---|---|---|---|
| BioPak | ns | ns | ns | ns | ns | ns | ns | ns |
| N | ** | ** | ** | ** | ** | ** | ** | ** |
| P | * | * | ns | ns | ** | ns | ns | * |
| BioPak*N | ns | ns | ns | ns | ns | ns | * | ns |
| BioPak*P | ns | ns | ns | ns | ns | ns | ns | ns |
| N*P | ns | ns | ns | ns | ns | ns | ns | ns |
| BioPak*N*P | ns | ns | ns | ns | ns | ns | ns | ns |

ns, *,** Not significant (p >0.05) and Significant at p < 0.05 and 0.01, espectively.

Table 3 Source effects for NDVI analysis of variance.

| Source | Date (mm/dd/yy) 06/20/11 | 06/30/11 | 07/20/11 | 08/10/11 | 08/25/11 | 09/17/11 | 10/09/11 | 10/26/12 | Mean |
|---|---|---|---|---|---|---|---|---|---|
| BioPak | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| N | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| P | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| BioPak*N | ns | ns | ns | ns | ns | * | ns | ns | * |
| BioPak*P | ns | ns | ns | ns | ns | ns | ns | ns | ns |
| N*P | ns | ns | * | ns | * | ns | ns | ns | * |
| BioPak*N*P | ns | ns | ns | ns | ns | ns | ns | ns | ns |

ns, *,** Not significant (p >0.05) and Significant at p < 0.05 and 0.01, respectively.

## Clipping Yields

Significant effects on total clipping yields were attributable to primarily N and sometimes P fertilization (Table 4). Across all clipping dates, N showed the most consistent effect. As N rates increased from 0 to 30 kg/ha/month, clipping yields increased linearly from 227 to 901 kg/ha. As P rates increased from 0 to 30 kg/ha/month, clipping yields showed a quadratic response with peak yields at the 10 and 20 kg/ha treatments (646 kg/ha), then yields slightly decreased at the highest rate (610 kg/ha).

## Conclusions

During the year after establishment of a perennial ryegrass turf, BioPak was not effective in enhancing turf quality or growth at reduced inputs of N and P.

Table 4. Source effects for clipping yield analysis of variance.

| | Date (mm/dd/yy) | | | | |
|---|---|---|---|---|---|
| Source | 07/12/11 | 08/18/11 | 09/17/11 | 10/25/11 | Total |
| BioPak | ns | ns | ns | ns | ns |
| N | ** | ** | ** | ** | ** |
| P | ** | ns | ns | ns | ** |
| BioPak*N | ns | ns | ns | ns | ns |
| BioPak*P | ns | ns | ns | ns | ns |
| N*P | * | ns | ns | ns | ns |
| BioPak*N*P | ns | ns | ns | ns | ns |

ns, *,** Not significant ($p > 0.05$) and Significant at $p < 0.05$ and 0.01, respectively.

**SYSTEMIC RELEASE OF HERBIVORE-INDUCED PLANT VOLATILES BY COOL-SEASON TURFGRASSES INFESTED BY ROOT FEEDING LARVAE OF JAPANESE BEETLE (*Popillia japonica* Newman) AND ORIENTAL BEETLE (*Anomala orientalis*).**

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## INTRODUCTION

Species of white grubs are the most widespread and damaging turfgrass insect pests in the United States (Koppenhofer and Fuzy 2007). Of these, Japanese beetle, *Popillia japonica* Newman (Coleoptera: Scarabaeidae), and Oriental beetle, *Anomala orientalis* (Waterhouse) (Coleopltera: Scarabaeidae), have been reported as key pests of urban landscapes in the Northeast (Koppenhofer and Fuzy 2007). The damage posed by these species is significant. For example, yearly costs for management and mitigation of damage incurred by Japanese beetle are estimated at US$500 million (Gyeltshen and Hodges 2005).

*Tiphia vernalis* Rohwer and *Tiphia popilliavora* Rohwer were introduced as biocontrol agents against these beetles. Female *Tiphia* wasps, burrow into the soil and locate soil dwelling larval hosts using species-specific kairomones present in grub body odor trails and frass (Rogers and Potter 2002). Once a host is located, the wasp stings it, causing temporary paralysis. An egg is attached to the grub in a location that is species-specific (Rogers and Potter 2004, Clausen and King 1927).

White grubs tend to be patchily distributed in turf (Dalthorp et al., 2000; Rogers and Potter 2002) and it seems unlikely that *Tiphia* females search randomly for such patches. The cues that the flying wasps may use to guide them to areas where white grubs are abundant are still unknown. The knowledge on the blend of volatiles that turfgrass produce as a result of root herbivory is useful in understanding the attraction of Tiphiid wasps to patchily-distributed hosts in the soil. In a previous study we evaluated the responses of female *T. vernalis* and *T. popilliavora* to grub-infested and healthy plants using Y-tube olafactometer bioassays. *Tiphia* wasps were highly attracted to volatiles emitted by grub-infested tall fescue (*Festuca arundinacea* Schreb) and Kentucky bluegrass (*Poa pratensis* L.) over healthy grasses. In contrast, wasps did not exhibit a significant preference for grub-infested perennial ryegrass (*Lolium perenne* L.) as compared to the control plants. Thus the objective of the present study was to elucidate the volatile profiles of grub-infested vs. uninfested turfgrass species used in the bioassays to understand the wasps' response to herbivore-induced plant volatiles.

## MATERIALS & METHODS

### Volatile collection and analysis

Plant volatiles were collected from Kentucky bluegrass, tall fescue, and perennial ryegrass. These plants were grown in separate pots and grown in a plant growth chamber for 8 weeks. Third instar grubs of *P. japonica* and *A. orientalis* were introduced to half of the plants and allowed to feed on the roots for a week. The other plants were kept without grubs to serve as controls. Plant volatiles were collected by dynamic headspace sampling from the upper part of the plant by sealing the pots with Teflon bags in order to prevent contamination due to larval products and any other byproduct of larvae in the soil (Figure 1). For each grass species volatiles were collected simultaneously from a grub infested and a healthy plant. Plants were placed individually in glass volatile collection chambers and sealed with Qubitac sealant. Each collection apparatus was placed under 100W light bulb. The temperature inside the collection chambers was monitored to ensure a consistent temperature of 30±2ºC. Clean air was passed through each chamber at 200 mL min$^{-1}$ and was pulled at 100 mL min$^{-1}$ through a collection trap. The collection traps contained Tenax-GR absorbent. The volatiles were collected for 24-h period (including 12-h-photoperiod). Volatile analysis was done by gas-chromatography and mass spectrometry.

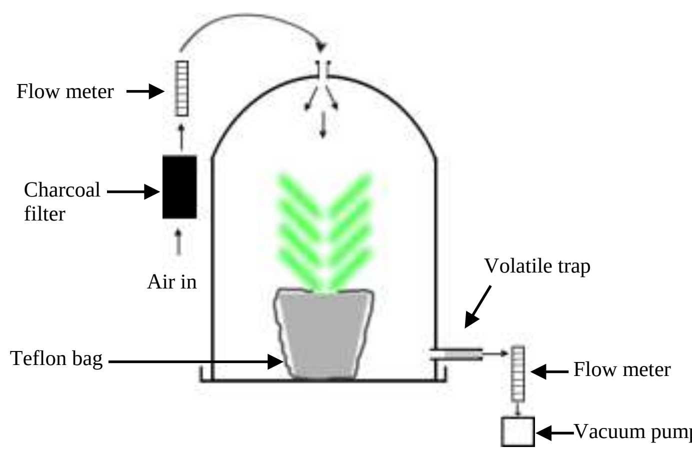


Figure 1. "Push-pull" head space collection chamber

### Collection and handling of grubs

Third- instar *P. japonica* and *A. orientalis* grubs were collected from late April to early May from stands of predominantly Kentucky bluegrass. Grubs were held in plastic containers (29 mL) containing autoclaved soil at room temperature (22-24ºC) until they were needed.

### Plant culture

Seeds of Kentucky bluegrass (*Poa pratensis* L.) cultivar "America", tall fescue (*Festuca arundinacea* Schreb) cultivar

"Daytona", and perennial ryegrass (*Lolium perenne* L.) cultivar "Quebec" were individually planted in regular potting soil (Canadian sphagnum peat (50%), processed pine bark, perlite and vermiculite) in 9 cm (diam.) x 9 cm (deep) plastic pots. The plants were kept in a growth chamber at 25°C, 70% relative humidity, and 16:8 light:dark regime for 8 weeks. The light intensity for the plants was 25,000 lux (Sylvania F72T12/CW/VHO) during the photophase. The plants were watered daily, and fertilized with Miracle-Gro® fertilizer 100 ppm in aqueous solution twice a week as part of the regular watering schedule.

## RESULTS & DISCUSSION

The compounds were tentatively identified using mass spectrum database search (NIST MS database, 2011). The area under an identified peak was integrated using a single *m/z* fragment from the total-ion spectrum for each compound. The *m/z* fragment 93, which is considered as a terpene-specific ion mass segment was used to illustrate the differences between test and control plants of each species. The compounds identified for both grub-infested and control plants of Kentucky bluegrass and tall fescue include, β-myrcene, trans-β-ocimene, α-ocimene, and D-limonene. The terpene levels emitted by grub-infested Kentucky bluegrass and tall fescue were greater than that of the control plants of the same species (Figures 2a, 2b, 3a, and 3b). The elevated levels of terpenes emitted by grub-infested Kentucky bluegrass and tall fescue coincided with the attractiveness to the Tiphiid wasps. However, compared to Kentucky bluegrass and tall fescue, relatively low levels of terpenes were observed for both grub-infested and control plants of perennial ryegrass (Figures 4a and 4b). Low levels of terpenes might explain why Tiphiid wasps did not show a preference for either infested or uninfested plants of perennial ryegrass. The results of this study concur with results from other studies where terpene production was induced by the application of jasmonic acid. Typically, the most obvious result of induction is a marked increase in the amount of terpenes produced by the plants, especially β-ocimene (Watkins et al., 2006; Tumlinson, 1999; Yue et al., 2001). Ocimene has been shown to attract parasitic wasps (Rose et al., 1998) aphid parasitoids (Du et al., 1998) and predatory mites (Watkins et al., 2006, Takabayashi et al., 1994). Further behavioral studies using Tiphiid wasps are needed to test electroantennogram responses to the compounds identified in this study.

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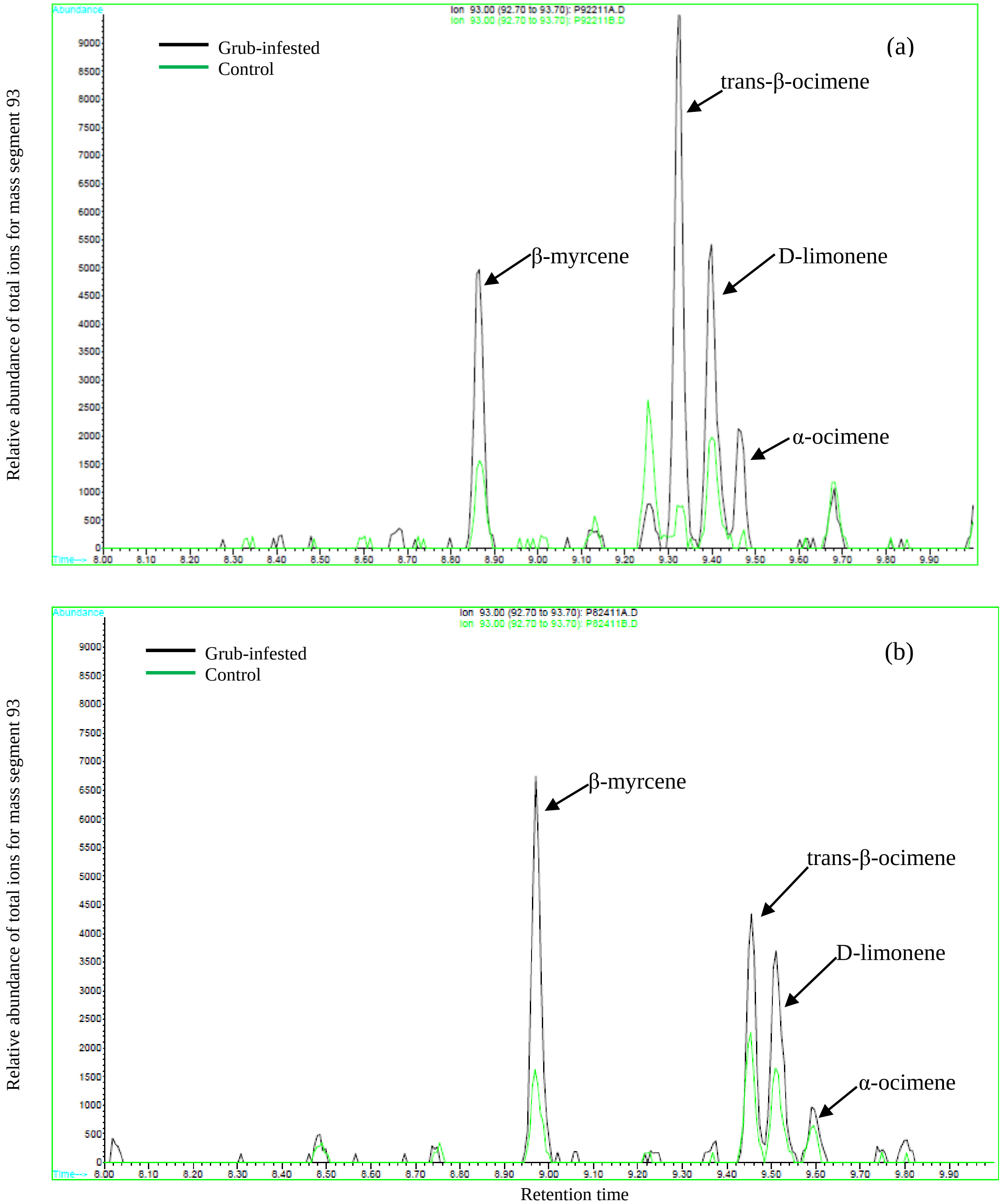



Figure 2. Overlapped chromatograms of (a) Kentucky bluegrass infested by Japanese beetle grubs and control, (b) Kentucky bluegrass infested by oriental beetle grubs and control.

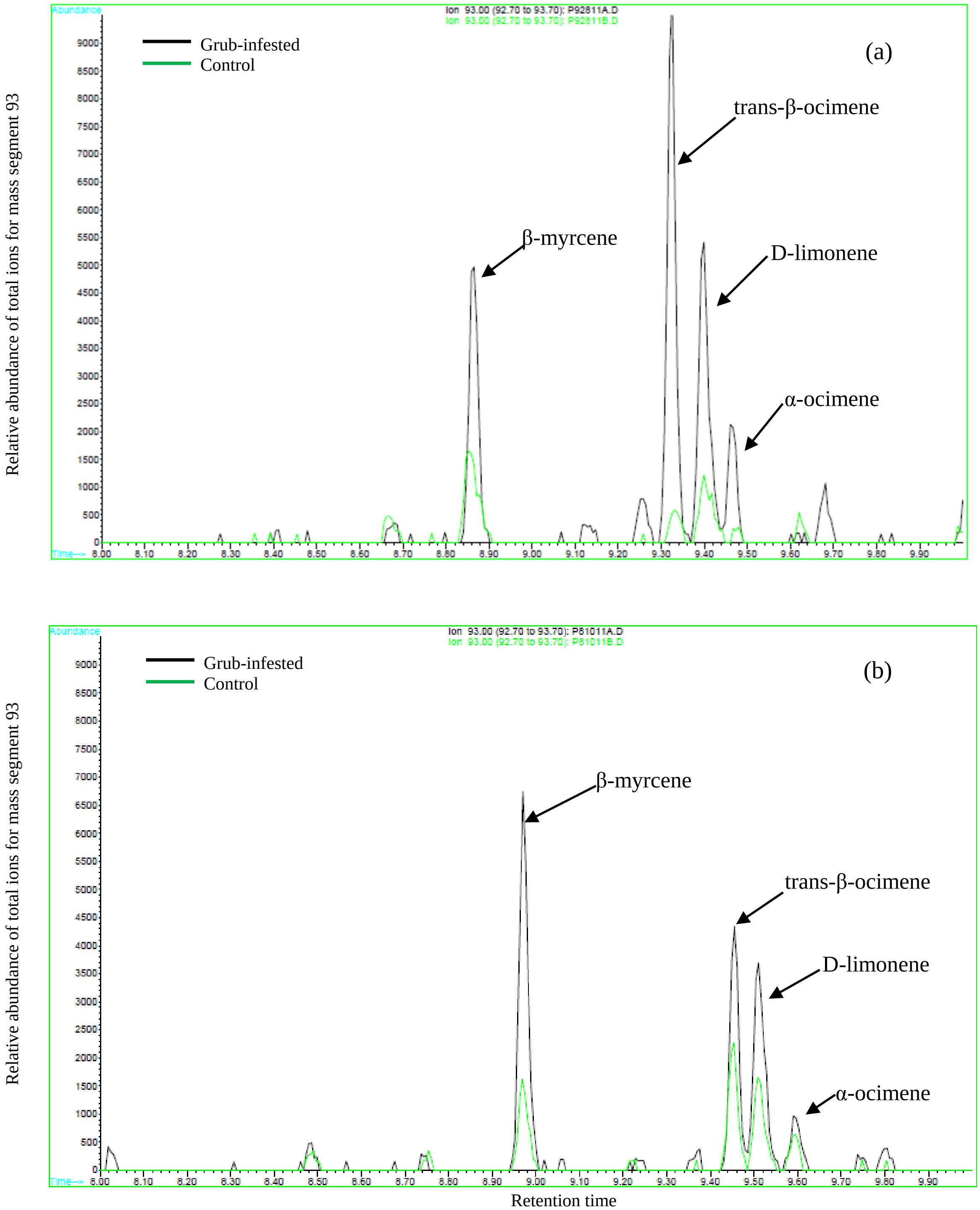
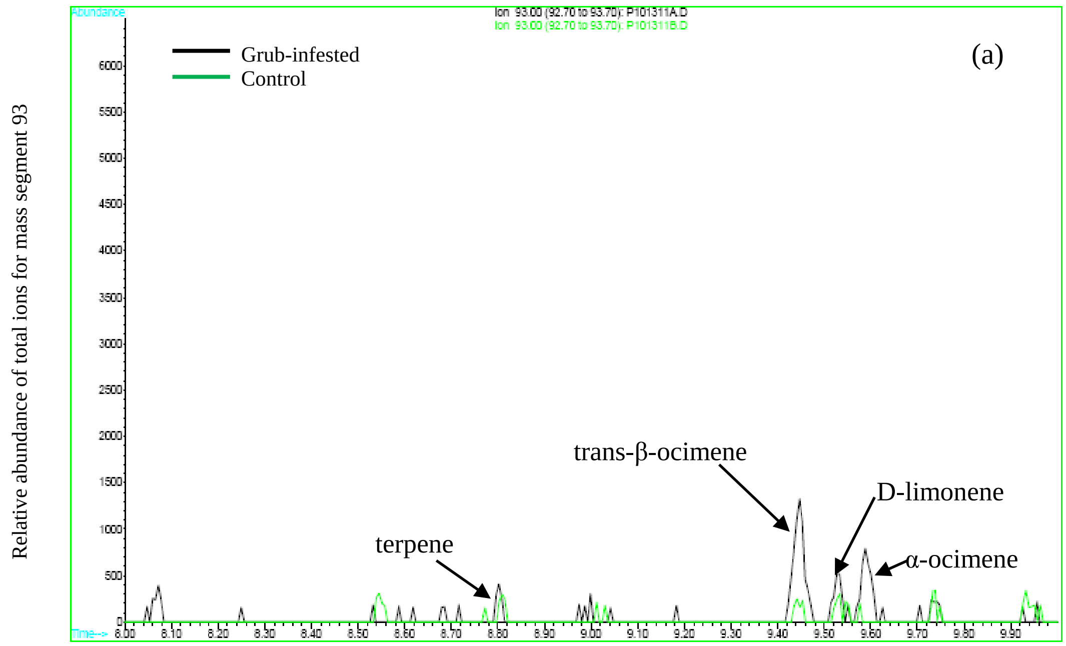



Figure 3. Overlapped chromatograms of (a) tall fescue infested by Japanese beetle grubs and corresponding control, (b) tall fescue infested by oriental beetle grubs and control.



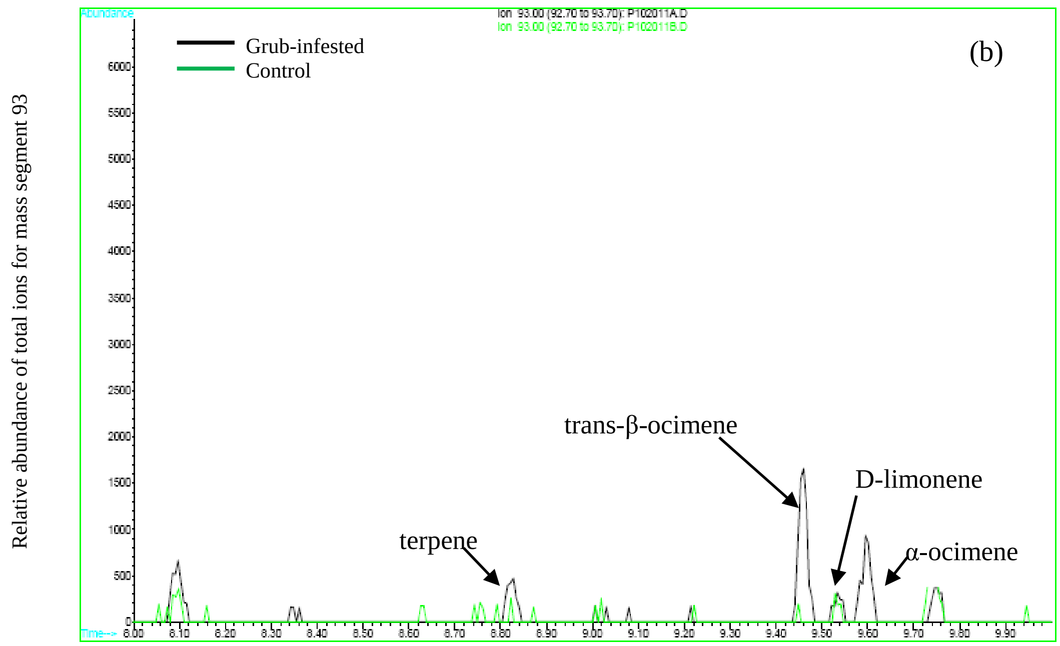




Figure 4. Overlapped chromatograms of (a) perennial ryegrass infested by Japanese beetle grubs and control, (b) perennial ryegrass infested by oriental beetle grubs and control.

# THE ABILITY OF TIPHIID WASPS TO DETECT KAIROMONES AND FRASS FROM SCARABAEID GRUBS AT SOME DISTANCE IN THE SOIL

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## INTRODUCTION

During the late 1920s and early 1930s, the US department of agriculture (USDA) introduced several parasitoid wasp species in order to control the outbreak of Japanese beetles, *Popillia japonica* (Ramoutar and Legrand 2007). Of these, two species of tiphiid wasps, *Tiphia vernalis* Rohwer and *Tiphia popilliavora* Rohwer were successfully established as biocontrol agents against Japanese beetle grubs (Ramoutar and Legrand 2007). *T. vernalis* and *T. popilliavora* are also parasitoids of oriental beetles (*Anomala orientalis*). These parasitic wasps burrow into the soil and search for grubs. When a host is found, the wasp paralyzes it momentarily and attaches an egg in a location that is specific for that species.

In order to implement effective pest management strategies, it is essential to understand the host location behaviors of parasitoids (Barbosa et al., 1982). Rogers and Potter (2002) suggested that once in the soil, *Tiphia* spp. locate their hosts using kairomones present in grub body odor trails and frass. However, it is still unclear, whether Tiphiid wasps can detect trails, including grub frass and body odor, at some distance, or whether they can perceive trails only when in direct contact with them. Moreover, the response to direct host-cue contact while in the soil has been described only for *T. vernalis* (Rogers and Potter 2002). Therefore, the objectives of this study were: (1) to examine whether female *T. popilliavora* can respond to direct host-cues; and (2) to examine whether female Tiphiid wasps can detect host cues, including grub frass and body odor, at some distance in the soil.

## MATERIALS & METHODS

Dual-choice tests were conducted to test whether or not *T. vernalis* and *T. popilliavora* can respond to cues at varying distances. The soil including the cues was buried at a depth of 0, 2, or 5 cm from the junction of the Y-tube, and wasps were tested for successful discrimination of the arm containing cues. The ability of *T. vernalis* to detect cues at 2 and 5cm (Figs. 1b and 1c) were examined whereas for *T. popilliavora*, cues at depth 0, 2, and 5 cm (Figs. 1a, 1b, and 1c) were examined. Third-instar grubs of *P. japonica* and *A. orientalis* were reared in separate cups for 2-7 days and the soil from those cups was used as the source of cues. The amount of soil packed at each depth was 12.5g and the soil containing cues was then covered with moist autoclaved soil up to the junction. Only the moist autoclaved soil (approx. 35.5g) was used to pack the other arm of the tube. Each parasitoid was tested by placing it on the Y-tube stem entrance and scoring its choice between two arms. The soil was collected from a field plot of UConn research farm. Choice was determined as the wasp reached 3 cm down one arm, irrespective of the depth at which the cues were placed. Tests were conducted separately for soil cues obtained from *P. japonica* and *A. orientalis* third-instar grubs. A total of 250 female Tiphiid wasps were tested. For these experiments, *T. vernalis* were collected during early May to mid June while *T. popilliavora* were collected during August to early September. Data were analyzed by Chi-square goodness-of-fit test using SAS.

### Y-tube & Host Cues Collection

The Y-tube was made of translucent glass (1.2 cm wide) and has a 6 cm stem and 12 cm arms extending at a 90$^o$angle of from the junction. The ends of the arms were covered with fine-mesh cloth to prevent the soil in the tube from pouring out.

To obtain grub cues for the tests, a grub was placed into a 29-mL plastic cup filled with moist autoclaved soil and 5 mg of Kentucky bluegrass seeds as a food source. Oriental and Japanese beetle grubs were reared for 2-7 days in these cups and the soil from the rearing cup was used as a source of cues (i.e. soil containing frass, body odor and some other stimuli associated with host).

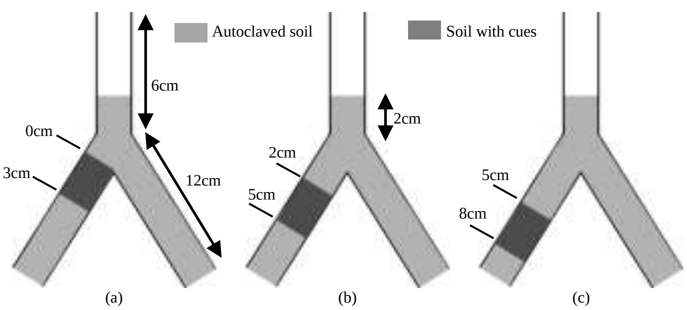


Figure 1. Experimental setup of the dual-choice test

## RESULTS & DISCUSSION

The wasps response to cues buried at different depths are shown in figures. 2, 3, and 5. The study showed that at a depth of 2 cm both *T. vernalis* and *T. popilliavora* chose the arm filled with cues more often than the opposite arm. When the cues of 3$^{rd}$ instar *P. japonica* were buried at 2 cm depth, both *Tiphia* spp. showed a significant preference for the arm with the cues (*T. vernalis*, $df = 1$, $\chi^2 = 8.53$, $P = 0.0035$, *T. popilliavora*, $df = 1$, $\chi^2 = 4.8$, $P = 0.0280$; Fig. 2a & 3a). When the cues were buried at 5cm, Tiphiid wasps did not show a preference for arm with cues or without cues (*T. vernalis*, $df = 1$, $\chi^2 = 0.20$, $P = 0.6547$ for *P. japonica* cues; $df = 1$, $\chi^2 = 0.80$, $P = 0.3711$; for *A. orientalis* cues; *T. popilliavora*, $df = 1$, $\chi^2 =$

0.20, $P$ = 0.6547 for *P. japonica*, $df$ = 1, $\chi^2$ = 0.00, $P$ = 1 for *A. orientalis*;  Fig. 2b. & 3b.). At depth of 0 cm, *T.popilliavora* chose the arm containing cues significantly more often than the opposite arm ($df$ = 1, $\chi^2$ = 9.80, $P$ = 0.0017, for both experiments, with *P. japonica* and *A. orientalis* cues; Fig. 4).

These results suggest that the distance from which Tiphiid wasps can detect their hosts by relying on direct host cues is relatively short. The wasps did not discriminate between test and control choices when the cues were buried at 5 cm. Moreover, it is noteworthy that Tiphiid wasps were better able to detect Japanese beetle host cues over Oriental beetle cues when buried at 2cm. This report is also the first account regarding the direct host cues employed by *T. popilliavora* in its host search.

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## ACKNOWLEDGEMENTS


We would like to thank UConn undergraduates Jason Bennett and Andrew Hirsbrunner for their assistance. This project was supported by a NE IPM Center Grant and NE-1032 project.

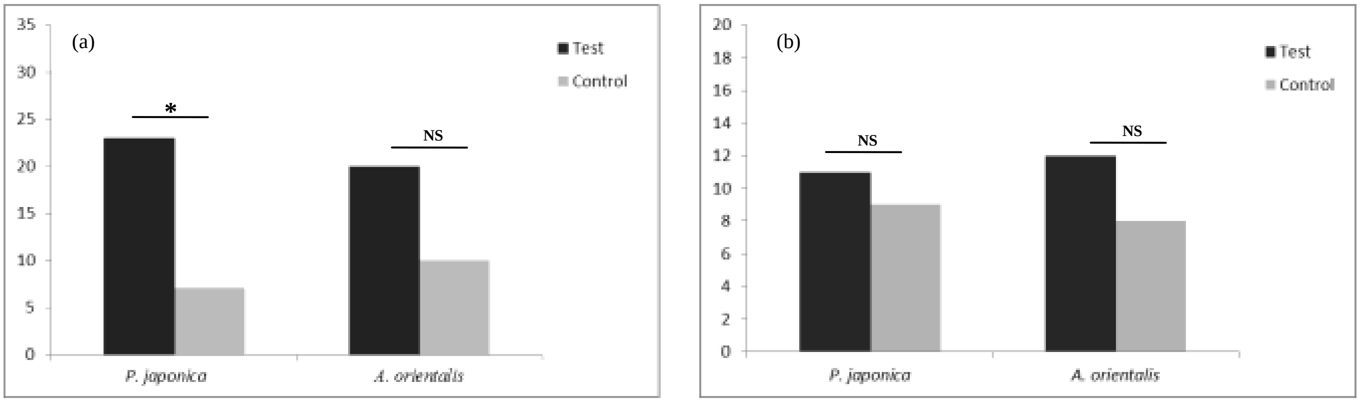


Figure 2. Response of female *T. vernalis* to (a) cues buried at a depth of 2cm, (b) cues buried at a depth of 5cm. $*P < 0.05$.

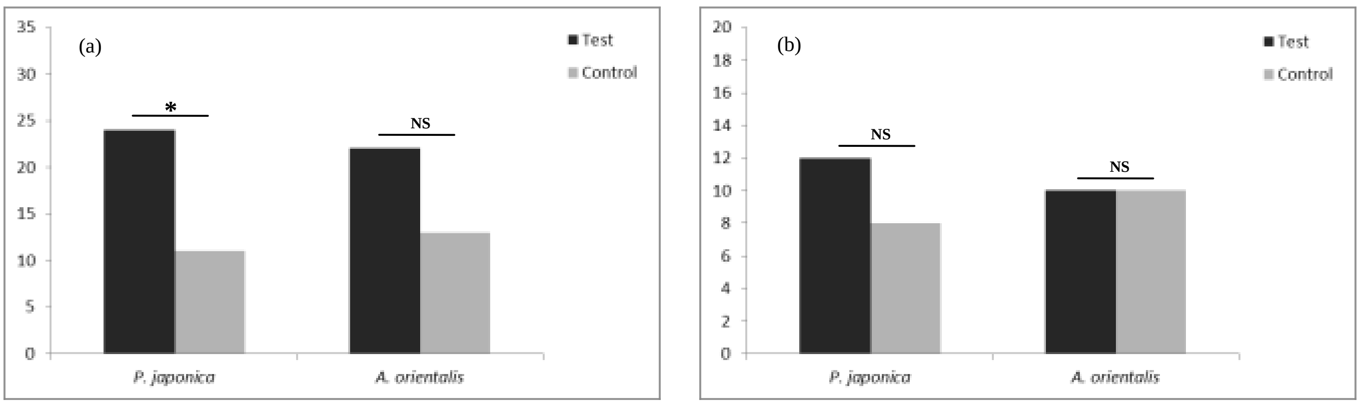


Figure 3. Response of female *T. popilliavora* to (a) cues buried at a depth of 2cm, (b) cues buried at a depth of 5cm. $*P < 0.05$.

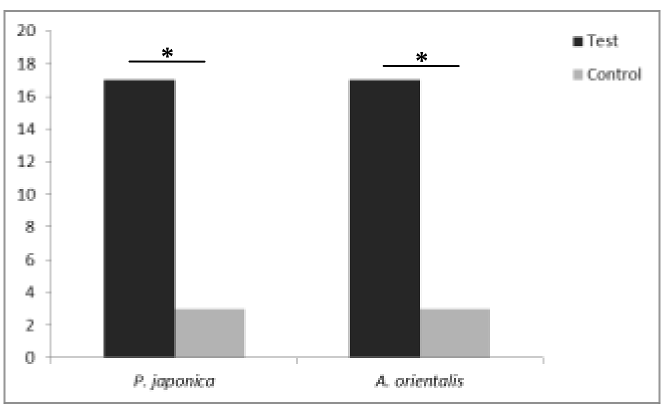


Figure 4. Response of female *T. popilliavora* to direct cue contact. $*P < 0.05$.

# ISOLATION AND EVALUATION OF PERENNIAL RYEGRASS DWARF MUTANTS INDUCED BY ETHYL METHANESULFONATE AND GAMMA-RAY IRRADIATION, 2011

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## INTRODUCTION

Perennial ryegrass (PRG; *Lolium perenne* L.) also known as English ryegrass is an important cool-season grass grown as a forage crop in pastures and as turfgrass in lawns, athletic fields and golf courses. PRG is poorly adapted to low mowing heights (e.g. 1.27-2.54 cm). However, it is commonly used in residential and commercial lawns and maintained at heights > 2.54 cm. Compact or dwarf PRG may be better adapted to high maintenance sites like fairways and tees where low mowing heights (i.e. ≤ 2.54 cm) are desirable. Moreover, dwarf PRG mutants may also reduce mowing frequency in higher cut applications (i.e. 2.54-5.08 cm). Water requirement of cool-season perennial ryegrass is also quite high. Therefore there is an increasing demand for dwarf turf with reduced mowing, irrigation and fertilizer requirements, due to increased energy costs and limited water resources. The main objectives of this study were to develop dwarf mutants of PRG from 'Fiesta 4' seeds, using EMS and gamma-ray radiation, and further characterize them under greenhouse and field conditions.

## MATERIALS & METHODS

Dwarf mutants were selected from EMS M2 and gamma M2 generation plants based on the growth rate or their responses to gibberellic acid ($GA_3$) (can germinate only when gibberellic acid is present). Out of them five dwarf mutants identified from EMS 2$^{nd}$ mutant generation seedlings were vegetatively propagated and evaluated for morphological characteristics in a greenhouse maintained at 20 ± 2 °C under natural light. Plants in all the experiments were fertilized with 49 g N 100-m$^2$ applied as 20-20-20 every 7 days and irrigated as per requirement.

*a). Tiller count.* Ten tillers from each mutant line and wild-type were transplanted individually into pots (10 cm in diameter) containing Promix. Tillers within each pot were counted weekly for 7 weeks.

*b). Leaf extension rate.* Ten tillers from each mutant line and the wild-type were separated out and transplanted individually into separate plug trays (plug size: 2 cm in diameter). Tillers were grown until each produced a daughter tiller. Extension of the third emerging leaf on the daughter tiller was measured as the length of the third leaf extending past the sheath of the second leaf. Measurements were taken daily with a vernier caliper until the leaf extension was < 1 mm for 3 consecutive days (i.e., fully expanded). Leaf extension rate was calculated as the total length divided by the number of days until leaves were fully expanded (mm/d).

*c). Root length.* Ten sets of tillers (each set containing 12 single tillers with 2.5 cm long roots) for each mutant line and the wild-type were transplanted into PVC tubes (5 cm in diameter × 60 cm in depth) filled with steam sterilized silica sand. Plants were maintained under a greenhouse mist system and misted 6 times per day for the initial 3 weeks and 3 times per day for the later 4 weeks. Nitrogen, phosphorous and potassium were applied in a solution containing 49 g N 100-m$^2$, 0.04 g P 100-m$^2$ and 0.08 g K 100-m$^2$, respectively as 20-20-20 every 7 days. After 7 weeks from the start date, the rooted plants were carefully removed from the tubes and sand was completely washed off. Total root length of each plant was measured. Tiller count, leaf extension rate and root length data were reported as mean of 10 replicates for each plant line.
*d). Turf quality assessment.* Four (7-month-old) plants were used to assess turf quality for each mutant line and the wild-type. All the plants were cut to 5 cm in height once per week and were maintained under these conditions for about 8 weeks. Turf quality observations were taken 4 days after cutting during the 9$^{th}$, 10$^{th}$ and the 11$^{th}$ weeks. Turf quality assessment was done both by visual observation and by using the Field Scout TCM 500 "NDVI" Turf Color Meter.

*Performance of dwarf mutants in the field.* Three replicates for each mutant line (both gamma and EMS mutants) and the wild-type 'Fiesta 4' were planted in the field in September, 2010. The spacing between two plants in a row and between 2 rows was 30 cm. All the plants were watered as per requirement until they were established in the field. In the last week of May 2011, 4 desirable dwarf mutants and 2 wild-type plants were carefully removed from the field and the soil was completely washed off. Observations on shoot length (canopy height), root length, turf color and tiller number were taken for the 4 mutants and the wild-type plants. Afterwards, the root system and shoots were separated from 3 replicates for each plant line, placed in envelopes, oven dried at 70 °C for 4 days and root/shoot biomass observations were taken. Data are presented as a mean of 3 replicates for each plant line.

*Statistical analysis.* Experimental units for the greenhouse evaluation (except for turf quality) were arranged in a completely randomized design. The mutants and the wild-type plants were arranged in randomized block design for turf quality assessment. Analysis of variance was performed on the data collected from the greenhouse and field-grown plants, using IBM SPSS software (Version 19.0; IBM Corporation, Somers, NY). Fisher's protected least significant difference test was used to separate treatment means at $\alpha = 0.05$.

## RESULTS

*Greenhouse evaluation of dwarf mutants.* After 7 weeks, no differences in tillering were observed among the 6 plant lines tested (Table 1). All the plant lines produced approximately 16-20 tillers during the 7 week period. Leaf extension rates of all the mutants were significantly different compared to the wild-type control (Table 2). The mutants GAD-1, EMS-18 and GAD-2 tended to have the shortest leaf growth of all the plant lines in this study. Total root lengths were significantly different among the plant lines evaluated. EMS-18 and GAD-2 mutants had approximately 15% longer roots compared to the wild-type control (Table 3). Among the 5 mutants evaluated, EMS-7 and EMS-18 mutants had significantly higher turf quality compared to the wild-type control (Table 4). NDVI data presented in this report also indicates that, EMS-7, EMS-18 and GAD-1 mutants had significantly higher NDVI values compared to the wild-type control on all the 3 sampling days (Table 5). NDVI ratings were consistent with the turf quality assessment by visual observation.

*Performance of dwarf mutants in the field.* The 2 EMS mutants, GAD-2 and EMS-19 displayed desirable turf characteristics compared to the wild-type 1. GAD-2 mutant had significantly higher NDVI color reading compared to the wild-type1 (Table 6). It also had 42.78% shorter shoots, 35.82% longer roots and 14.95% more tillers than the wild-type 1 (Table 6; Fig. 1). Dry root/shoot biomass ratio of GAD-2 mutant was 1.95 times higher than the control (Table 6; Fig 2). EMS-19 mutant had significantly lower NDVI color reading than the wild-type 1 (Table 6). This mutant also had reduced shoot length (43.50%) and 15.67% shorter roots compared to the control (Table 6; Fig 2). EMS-19 had 2.39 times higher dry root/shoot biomass ratio than the wild-type 1. However, it had the similar number of tillers as the control. Among the gamma mutants evaluated, Gamma-19 and Gamma-32 mutants had 36.72% to 38.36% longer shoots, 8.12% to 9.75% shorter roots and 7.97% to 11.82% less number of tillers compared to the wild-type 2 (Table 7; Fig. 3). Both these mutants had significantly lower root/shoot biomass ratio (1 to 1.3 times) than the wild-type2.

## DISCUSSION

We have generated several dwarf mutants of perennial ryegrass through EMS and gamma-ray induced mutations. Based on the greenhouse data, EMS-18 mutant with longer roots and low leaf extension rate looks promising as it also exhibited better turf quality characteristics like fine leaf structure, higher turf density and good leaf color compared to the wild-type control. However, based on the field evaluation, the EMS-19 and GAD-2 mutants displayed better turf characteristics than the wild-type and they could be ideal candidates for drought tolerance studies because of their higher dry root/shoot biomass. Further evaluation of the dwarf mutants under mowed conditions will be required to develop potential short-growth and drought tolerant cultivars.

Table 1. Tiller count of the EMS dwarf mutants in comparison to the wild-type 'Fiesta 4' perennial ryegrass. Data were collected in the greenhouse.

| Plant line[z] | Tiller count[y] (mean± SE) |
|---|---|
| Wild-type | 18.10 ± 0.78[x] |
| EMS-19 | 17.89 ± 1.21 |
| EMS-7 | 20.00 ± 1.02 |
| EMS-18 | 16.75 ± 0.36 |
| GAD-1 | 16.70 ± 0.87 |
| GAD-2 | 18.70 ± 0.67 |

SE = standard error.
[z]Each plant line had 10 replicates.
[y]Tiller counts were calculated based on the data collected after 7 weeks of culture.
[x]Tiller count was not significantly different among all the genotypes based on the Fisher's protected least significant difference test at $\alpha = 0.05$.

Table 2. Leaf extension rate of the EMS dwarf mutants in comparison to the wild-type ‘Fiesta 4’ perennial ryegrass. Data were collected in the greenhouse.

| Plant line[z] | Total length of the 3rd leaf (mm) (mean ± SE) | Leaf extension rate (mm/day) (mean ± SE) | Number of days for complete leaf extension (days) (mean ± SE) |
|---|---|---|---|
| Wild-type | 50.18 ± 3.24 a[y] | 5.49 ± 0.43 a[x] | 9.40 ± 0.60[w] |
| EMS-19 | 40.05 ± 1.78 b | 4.47 ± 0.25 b | 9.17 ± 0.49 |
| EMS-7 | 37.28 ± 1.08 bc | 4.18 ± 0.16 b | 9.00 ± 0.30 |
| EMS-18 | 33.46 ± 1.66 cd | 3.74 ± 0.26 b | 9.16 ± 0.40 |
| GAD-1 | 31.07 ± 1.16 d | 3.89 ± 0.21 b | 8.18 ± 0.48 |
| GAD-2 | 34.67 ± 1.71 cd | 3.98 ± 0.28 b | 8.92 ± 0.43 |

SE = standard error.

[z]Each plant line had 10 replicates.

[xy]Means in a column not followed by the same letter were significantly different based on the Fisher’s protected least significant difference test at $\alpha = 0.05$.

[w]Number of days required for complete leaf extension was not significantly different among the 6 genotypes, based on the Fisher’s protected least significant difference test at $\alpha = 0.05$.

Table 3. Root length of the EMS dwarf mutants in comparison to the wild-type ‘Fiesta 4’ perennial ryegrass. Data were collected in the greenhouse.

| Plant line[z] | Root length (mm)[y] (mean± SE) |
|---|---|
| Wild-type | 517.05 ± 13.05 b[x] |
| EMS-19 | 437.03 ± 8.27 c |
| EMS-7 | 431.32 ± 11.73 c |
| EMS-18 | 595.63 ± 9.45 a |
| GAD-1 | 400.05 ± 10.97 c |
| GAD-2 | 594.44 ± 12.85 a |

SE = standard error.

[z]Each plant line had 10 replicates.

[y]Root length data were recorded after the 7th week of experiment.

[x]Means in a column not followed by the same letter were significantly different based on the Fisher’s protected least significant difference test at $\alpha = 0.05$.

Table 4. Turf quality rating of the EMS dwarf mutants in comparison to the wild-type ‘Fiesta 4’ perennial ryegrass. Data were collected in the greenhouse.

| Plant line[z] | Turf quality rating (mean ± SE) | | |
|---|---|---|---|
| | 22nd Feb. | 1st March | 8th March |
| Wild-type | 5.50 ± 0.29 b[y] | 5.50 ± 0.29 bc[y] | 5.00 ± 0.41bc[y] |
| EMS-19 | 6.25 ± 0.25 ab | 6.25 ± 0.25 abc | 6.00 ± 0.41abc |
| EMS-7 | 7.75 ± 0.25 a | 7.75 ± 0.25 a | 7.25 ± 0.47 a |
| EMS-18 | 7.50 ± 0.29 a | 7.75 ± 0.25 a | 7.50 ± 0.29 a |
| GAD-1 | 7.00 ± 0 ab | 7.25 ± 0.25 ab | 7.00 ± 0.41ab |
| GAD-2 | 5.75 ± 1.10 b | 4.75 ± 1.37 c | 4.25 ± 1.37 c |

SE = standard error.

Turf quality is a composite score determined by the collective contribution of shoot density, leaf texture, smoothness and color. Turf quality rating 1.0 = poorest possible turf quality; 9.0 = best possible turf quality; 5.0 = minimum acceptable value for turf quality.

[z]Each plant line had 4 replicates.

[y]Means in a column not followed by the same letter were significantly different based on the Fisher’s protected least significant difference test at $\alpha = 0.05$.



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Table 5. NDVI color reading of the EMS dwarf mutants in comparison to the wild-type 'Fiesta 4' perennial ryegrass. Data were collected in the greenhouse.

| Plant line[z] | NDVI color reading (mean ± SE) | | |
|---|---|---|---|
| | 22nd Feb. | 1st March | 8th March |
| Wild-type | 0.625 ± 0.03 b[y] | 0.637 ± 0.02 bc[y] | 0.633 ± 0.02 bc[y] |
| EMS-19 | 0.686 ± 0.01 ab | 0.684 ± 0.01 ab | 0.669 ± 0.02 ab |
| EMS-7 | 0.735 ± 0.01 a | 0.734 ± 0.01 a | 0.733 ± 0.01 a |
| EMS-18 | 0.699 ± 0.02 a | 0.699 ± 0.02 ab | 0.709 ± 0.01 a |
| GAD-1 | 0.718 ± 0.01 a | 0.714 ± 0.01 a | 0.716 ± 0.01 a |
| GAD-2 | 0.621 ± 0.04 b | 0.604 ± 0.05 c | 0.576 ± 0.05 c |

SE = standard error.

NDVI = Normalized Difference Vegetative Index is an alternative evaluation technique to assess turf quality. NDVI Turf Color Meter measures the reflected light from turf grass. NDVI values are interpreted as, the higher the value the better the turf quality and vice versa.

[z]Each plant line had 4 replicates.

[y]Means in a column not followed by the same letter were significantly different based on the Fisher's protected least significant difference test at $\alpha = 0.05$.

Table 6. Observations for field-grown EMS mutants and the wild-type 'Fiesta 4' perennial ryegrass.

| Plant line[z] | NDVI color reading[y] (mean ± SE) | Shoot length (cm)[y] (mean ± SE) | Root length (cm)[y] (mean ± SE) | Tiller count[y] (mean ± SE) | Dry root/shoot biomass[x] (mean ± SE) |
|---|---|---|---|---|---|
| Wild-type1 | 0.705 ± 0.04 b[w] | 51.33 ± 0.88 a[w] | 22.33 ± 0.88 c[w] | 354.33 ± 3.48 b[w] | 0.23 ± 0.02 c[w] |
| GAD-2 | 0.743 ± 0.01 a | 29.37 ± 0.85 b | 30.33 ± 0.33 a | 407.33 ± 3.17 a | 0.45 ± 0.09 b |
| EMS-19 | 0.681 ± 0.01 c | 29.00 ± 1.00 b | 25.83 ± 1.17 b | 363.67 ± 3.67 b | 0.55 ± 0.07 a |

SE = standard error.

[z]Each plant line had 3 replicates.

[y]Data were collected on May 25, 2011.

[x]Dry biomass data were collected on May 29, 2011

[w]Means in a column not followed by the same letter were significantly different based on the Fisher's protected least significant difference test at $\alpha = 0.05$.

Table 7. Observations for field-grown gamma mutants and the wild-type 'Fiesta 4' perennial ryegrass.

| Plant line[z] | NDVI color reading[y] (mean ± SE) | Shoot length (cm)[y] (mean ± SE) | Root length (cm)[y] (mean ± SE) | Tiller count[y] (mean ± SE) | Dry root/shoot biomass[x] (mean ± SE) |
|---|---|---|---|---|---|
| Wild-type2 | 0.813 ± 0.04 a[w] | 50.83 ± 1.01 a[w] | 30.66 ± 0.88 a[w] | 476.67 ± 4.70 a[w] | 0.38 ± 0.05 a[w] |
| Gamma-19 | 0.739 ± 0.03 b | 31.33 ± 1.20 b | 27.67 ± 0.33 b | 438.67 ± 0.88 b | 0.29 ± 0.03 c |
| Gamma-32 | 0.811 ± 0.02 a | 32.67 ± 0.33 b | 28.17 ± 0.60 b | 420.33 ± 1.33 c | 0.36 ± 0.04 b |

SE = standard error.

[z]Each plant line had 3 replicates.

[y]Data were collected on May 25, 2011.

[x]Dry biomass data were collected on May 29, 2011

[w]Means in a column not followed by the same letter were significantly different based on the Fisher's protected least significant difference test at $\alpha = 0.05$.

Fig. 1. GAD-2 mutant (left) and wild-type1 'Fiesta 4' perennial ryegrass (right) in the field.

Fig. 2. Comparison of root and shoot lengths of field-grown EMS-19 mutant (left) wild-type1 'Fiesta 4' perennial ryegrass (center) and GAD-2 mutant (right).

Fig. 3. Comparison of root and shoot lengths of field-grown Gamma-19 mutant (left), wild-type2 'Fiesta 4' perennial ryegrass (center) and Gamma-32 mutant (right).

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

Obeysekara, P. and A. Legrand. 2010. Do tiphiid wasps use herbivore-induced plant volatiles for finding white grubs?. Entomological Society of America, Eastern Branch 83rd Annual Meeting, Hartford, CT. March 24th, 2012.

Japanese beetle (*Popillia japonica*) and Oriental beetle (*Anomala orientalis*) are considered invasive species and have been reported as key pests of urban landscapes in the Northeast. *Tiphia vernalis* Rohwer and *Tiphia popilliavora* Rohwer were introduced as biocontrol agents against these beetles. These parasitic wasps burrow into the soil and search for grubs. When a host is found, the wasp paralyzes it momentarily and attaches an egg in a location that is specific for that species. It is unknown if these wasps can detect patches of concealed hosts from a distance above ground and what role, if any, herbivore-induced plant volatiles play in their host location. The work reported here increases our understanding of *Tiphia* wasp host location in turfgrass systems. This study evaluated the responses of female *T. vernalis* and *T. popilliavora* to grub-infested and healthy plants in Y-tube olfactometer bioassays. Also the effect of root-herbivory on the composition of turfgrass volatile profiles was investigated by collecting volatiles from healthy and grub-infested grasses. *Tiphia* wasps were highly attracted to volatiles emitted by grub-infested tall fescue (TF) and Kentucky bluegrass (KBG) over healthy grasses. In contrast, wasps did not exhibit a significant preference for grub-infested perennial ryegrass (PR) as compared to the control plants. Monoterpene levels emitted by grub-infested KBG and TF were greater than that of control plants. Low levels of monoterpenes were observed for both test and control perennial ryegrass. The elevated levels of monoterpenes emitted by grub-infested TF and KBG coincided with attractiveness to the Tiphiid wasps. These results suggest that *Tiphia* spp. use herbivore-induced plant volatiles to locate white grubs in turfgrass systems.

## ORGANIC MANAGEMENT PRACTICES ON ATHLETIC FIELDS: PART 1: THE EFFECTS ON COLOR, QUALITY, COVER, AND WEED POPULATIONS

Miller, N. A., and J. J. Henderson. 2012. Organic management practices on athletic fields: Part 1: The effects on color, quality, cover, and weed populations. Crop Sci. 52(2):p. 890-903.

Many organic products have been used effectively in turfgrass management programs, but their exclusive use in athletic field maintenance and effect on playing surface quality has not been extensively researched. The objectives were to determine the effects of management regimes and overseeding during simulated traffic on: (i) turfgrass color and quality; (ii) percent cover; and (iii) weed populations. The experimental design was a 2 x 6 factorial, with two overseeding levels (overseeded and not overseeded) of a perennial ryegrass (Lolium perenne L.) blend during traffic and six management regimes: 1) Conventional 2) Organic Manure (OMan) 3) Organic Protein (OPro) 4) Organic Manure + Compost Tea (OMan + CT) 5) Organic Protein + Compost Tea (OPro + CT) 6) None, or the control. This research was conducted over two years on a mature stand of 'Langara' Kentucky bluegrass (Poa pratensis L.) on a Paxton sandy loam soil. Fall traffic was simulated with a Cady Traffic Simulator. The conventional treatment consistently produced higher quality turfgrass, lower weed counts and better mid to late fall color. Weed populations were significantly less with the conventional regime. Overseeding increased cover at the end of the traffic periods by 32% in the first year, and by 103% in the second year. Overseeding was also beneficial to turfgrass color and quality, and in reducing weeds. The conventional treatment also retained significantly higher turfgrass cover than the organic regimes under trafficked conditions late into the fall in 2008. However, no difference in late fall cover between the conventional and organic management regimes was observed in late fall 2009. Compost tea applications showed no enhancement of turfgrass color, quality, or cover over the entire duration of the study.

## CORRELATING PARTICLE SHAPE PARAMETERS TO BULK PROPERTIES AND LOAD STRESSES AT TWO WATER CONTENTS

Miller N.A., and J.J. Henderson. 2011. Correlating particle shape parameters to bulk properties and load stresses at two water contents. Agron. J. 103:1514-1523.

Particle shape of prospective root-zone sands is evaluated qualitatively, but a quantitative shape determination may be more useful for sand selection. The objectives of this research were to: determine how particle shape complexity relates to bulk density, total porosity, and mechanical behavior (resistance to displacement given a vertical load); correlate quantitative shape parameters to these properties; determine how water content influences these relationships; and establish if quantitative shape parameters can be used to predict mechanical behavior in the absence of turfgrass roots. Seven materials of various shapes were separated into the medium size class (0.25 to 0.50 mm) to limit variability introduced by particle size distribution. A dynamic, digital imaging machine was used to quantify particle sphericity, symmetry, and aspect ratio. Bulk density, total porosity, and stress at multiple displacements were determined for the materials at two water contents, oven-dry and 5% gravimetric water content. As sphericity, symmetry and aspect ratio increased, bulk density increased and total porosity decreased. Sphericity, symmetry, and aspect ratio were negatively correlated with stress under a vertical load. The addition of water at compaction did not affect the correlations of the shape parameters with either bulk density or porosity; correlations of symmetry and sphericity with these were stronger at 5% water content for some displacements. Multiple regression analysis indicated that sphericity can be used to predict stress characteristics of sands compacted at 5% water content for specific testing conditions. These data indicate that particle shape complexity is related to bulk properties and has potential for predicting the stress characteristics of prospective root zone materials prior to construction.

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

Tencza, B.J., and J.J. Henderson. 2011. Portable roadway systems evaluated using simulated traffic on playing surfaces for non-sporting events. Annu. Meet. Abstr. American Society of Agronomy Abstracts. Madison, WI.

Many current sports venues routinely host non-sporting events that require vehicular traffic over playing surfaces to set up stages, seating and other event specific equipment. This presents a tremendous challenge to athletic field managers to protect the integrity of the playing surface often times during the season of play. The objectives of this research were to: 1) determine the impact of each cover system on turfgrass color and percent cover when used for multiple cover periods, 2) document changes in playing surface characteristics (surface hardness, traction, and displacement) following each cover period, and 3) evaluate the effects of roadway systems on soil physical properties. This experiment was arranged in a 6 x 3 (cover type x cover period) factorial in a strip plot design with three replications on a mixed stand of Kentucky bluegrass (Poa pratensis L.) and perennial ryegrass (Lolium perenne L.). The main plots (cover period) were split by cover type. The five turf protection systems evaluated were 1) ¾" Plywood only (2 layers), 2) Enkamat Plus (1 layer) and ¾" Plywood (2 layers), 3) Enkamat Flatback (1 layer) and ¾" Plywood (2 layers), 4) Supa-TracTM (Rola-Trak North America), 5) TerraTrak PlusTM (Terraplas USA, Inc.), and 6) and an uncovered treatment. The second factor, cover period, had three levels: 3, 6, and 9 days. An uncovered/untrafficked control was also included. Treatments were subjected to two traffic events; each consisted of 10 passes with a loaded dump truck (gross vehicle weight of rating of 9,072 kg. There were no differences between cover types for turfgrass color and percent cover when the covers were utilized for a three day period. As the cover duration increased, TerraTrak and Supa-Trac retained better color and cover than most of the treatments. No considerable differences in surface hardness or traction existed between cover types and cover periods. The plywood treatments provided the best protection against displacement given the load range tested. All the plywood treatments and the uncovered/untrafficked control had lower bulk density values compared to Supa-Trac, TerraTrak Plus, and the uncovered/trafficked treatment following traffic. The uncovered/untrafficked control had the greatest hydraulic conductivity compared to all other treatments, while the plywood only treatment had greater hydraulic conductivity than Supa-Trac, TerraTrak Plus, and the uncovered/trafficked treatment.

**IRRIGATION QUANTITY EFFECTS ON ANTHRACNOSE DISEASE OF ANNUAL BLUEGRASS**

Roberts, J.A., Inguagiato, J.C., Clarke, B.B., Murphy, J.A. 2011. Irrigation quantity effects on anthracnose disease of annual bluegrass. *Crop Sci*. 51:1244-1252.

Irrigation can influence both turf vigor and playability of putting greens. Anthracnose (*Colletotrichum cereale* Manns sensu lato Crouch, Clarke, and Hillman) has become an increasingly destructive disease of annual bluegrass (ABG) [*Poa annua* L. f. *reptans* (Hausskn.) T. Koyama] putting greens, particularly when turf is under stress. This 3-yr field study evaluated the effects of irrigation quantity (100, 80, 60, and 40% of reference evapotranspiration [ETo]) on anthracnose severity of ABG mowed daily to 3.2 mm. Severe drought stress (40% ETo) increased anthracnose severity in 2006, 2007, and 2008. Anthracnose was less severe under 60% ETo irrigation, and irrigating at 80% ETo reduced severity compared to 60% ETo Irrigating at 100% ETo initially reduced anthracnose severity compared to 40% ETo; however, 100% ETo resulted in similar disease severity later in the 2006 and 2008 seasons. While this response was not observed late in the 2007 season, plots maintained at 100% ETo had turf quality similar to plots irrigated at 40% ETo later in each year due in part to increased algal development. Irrigation to replace 80% ETo typically resulted in the least amount of disease and the best turf quality throughout the trial. Thus, irrigation to minimize drought stress while also avoiding continuous high soil water content is beneficial in reducing anthracnose and maintaining acceptable turf performance.



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

Inguagiato, J., Kaminski, J. 2011. Comparison of phosphonate materials and application rate on algae development in putting green turf. *2011 International Annual Meetings: [Abstracts][ASA-CSSA-SSSA]*. p. 68544.

Algae infestations in putting green turf often require repeat fungicide applications to control. A field study was conducted in 2009 and 2010 on 'L-93' creeping bentgrass (*Agrostis stolonifera*) turf in Storrs, CT to identify alternative options for algae control. Turf was maintained at 4.0 mm and lightly irrigated two to three times day$^{-1}$ between 1100 and 1600 hrs from July through September to encourage algae development. Phosphonate materials and application rate were evaluated as a 4 by 6 factorial within a randomized complete block design with four blocks. Phosphonate materials included a phosphite fungicide, phosphite fertilizer, and $H_3PO_3$/KOH each containing mono- and di-potassium salts of phosphorous acid, or $H_3PO_4$/KOH. Phosphorous acid or phosphoric acid ($H_3PO_x$) was applied at 2.69, 5.43, 8.15, 10.86, 13.58, and 16.29 kg ha$^{-1}$ every 14 days from 16 Jun to 24 Sep 2009 and 20 May to 26 Aug 2010. Under limited pressure, algae was least severe in phosphite fertilizer treated turf and most severe where $H_3PO_4$/KOH was applied throughout 2009. Phosphite fungicide and $H_3PO_3$/KOH treated turf were similar to turf treated with phosphite fertilizer. In 2010 algae development was more severe. All phosphites reduced algae 4 – 24% compared to phosphate, but did not differ from each other. Algae decreased linearly with increasing application rate of various phosphonates. However, turf quality was reduced in August 2010 at phosphonate rates greater than 10.9 kg ha$^{-1}$. These data suggest that phosphites can suppress algae development regardless of formulation, although repeat applications at high rates may reduce turf quality during the summer.

## IMPLICATION OF EARLY-SEASON FUNGICIDE APPLICATION ON SEASON LONG DOLLAR SPOT CONTROL

Inguagiato, J.C. and Kaminski, J.E. 2011. Implication of early-season fungicide application on season long dollar spot control. Phytopathology. June Supplement. 101:S79.

Extended control of dollar spot (DS), caused by *Sclerotinia homoeocarpa* F.T. Bennett, has been reported with fungicides applied weeks before traditional preventive applications. Field studies were conducted on *Agrostis stolonifera* L. maintained at 1.3 cm in Connecticut (CT) and Pennsylvania (PA) to assess the effect of an early season fungicide application on DS control programs during 2010. Main effects included preventive fungicide timing (mid-April or late-May application of vinclozolin), summer applied fungicides (chlorothalonil, vinclozolin, or boscalid), and application interval of summer fungicides (14-, 21-, or 28-d). Dollar spot severity in the study areas increased in CT and PA during early- and mid-July, respectively, although results varied by location. In CT, DS was less severe in chlorothalonil and boscalid treated turf receiving a preventive application in mid-April compared to late-May during July and August, and August respectively. Mid-April preventive application reduced DS severity in turf treated every 21 d compared to turf receiving a late-May application. However, no difference was observed in 14 d treated turf in CT and PA. Additional significant preventive timing effects were not observed in PA. These data suggest early season fungicide applications can improve DS control throughout the season; however this effect appears to be inconsistent among locations.

## INFLUENCE OF FUNGICIDE TIMING AND POST APPLICATION IRRIGATION ON DOLLAR SPOT SEVERITY

Kaminski, J.E., Inguagiato, J.C., and Putman, A.I. 2011. Influence of fungicide timing and post application irrigation on dollar spot severity. Phytopathology. June Supplement. 101:S87.

Dollar spot, caused by the pathogen *Sclerotinia homoeocarpa* F.T. Bennett, is a common disease of golf course turf. Our study was conducted to compare early versus traditional preventive applications of different fungicides and the influence of post application irrigation on disease suppression. A total of seven evaluations were conducted between 2008 and 2010 in Connecticut and Pennsylvania. All studies were designed as a 2 × 2 × 4 factorial and arranged as a randomized complete block with 4 replications. The main treatments included timing (mid-April or mid to late May), irrigation (none or 2.5 mm), and fungicide (none, propiconazole, boscalid or vinclozolin). All treatments decreased dollar spot when compared to the untreated control plots, but few differences were observed among the main effects. Of 50 rating dates assessed across all studies, dollar spot was reduced on only 5 and 4 dates in plots treated at early or traditional timings, respectively. Irrigation was only significant on 3 of 50 rating dates and in all cases, the application of post application irrigation resulted in an increase in dollar spot severity when compared to plots receiving no irrigation after application. Results of this study indicate that while early season fungicide applications may suppress dollar spot infection centers, they may offer little benefit over properly timed preventive fungicide applications.