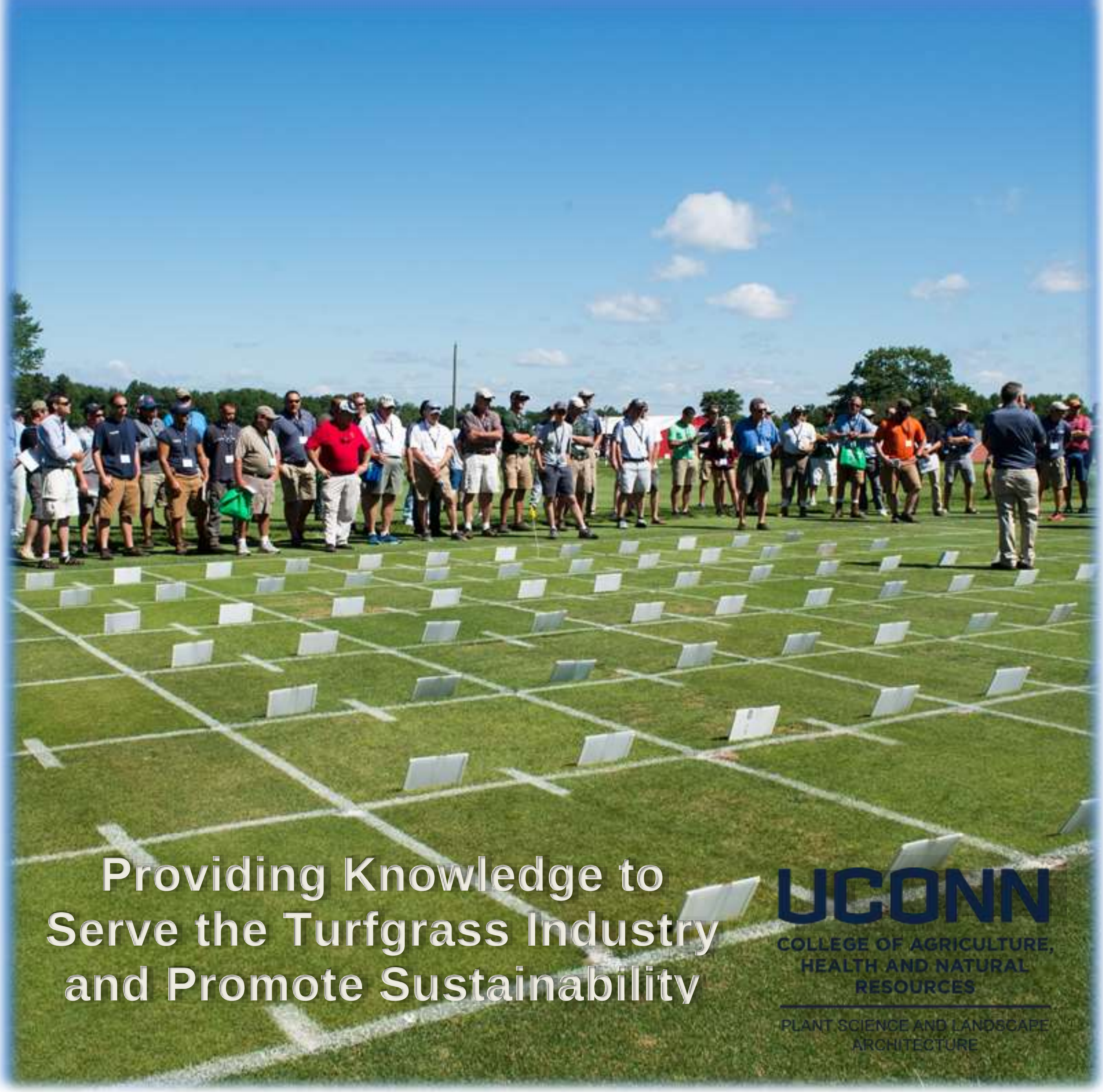
University of Connecticut

College of Agriculture, Health and Natural Resources

2016 Annual Turfgrass Research Report



Providing Knowledge to Serve the Turfgrass Industry and Promote Sustainability

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

Cover photo: Turfgrass cultivar evaualtion study being discussed at the 2016 UConn Turfgrass Field Day. (Photo credits: Kim Bova, Kim Bova Photography, www.kimbova.com)

UCONN | COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES

PLANT SCIENCE AND LANDSCAPE ARCHITECTURE

2016 Annual Turfgrass Research Report Summary

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

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

This report is divided into various sections and includes original research results in turf pathology, athletic field and golf turf maintenance, fertility and nutrient management, and cultivar evaluation and improvement. Additionally, abstracts and citations of scientific publications and presentations published in calendar year 2016 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

University of Connecticut
College of Agriculture, Health and Natural Resources
Dept. of Plant Science & Landscape Architecture
Unit 4067, 1376 Storrs Road,
Storrs, CT 06269-4067 USA
karl.guillard@uconn.edu
(860) 486-6309

University of Connecticut Turfgrass Science Program

ADMINISTRATION

Gregory J. Weidemann, Dean and Director, College of Agriculture, Health and Natural Resources
Michael P. O'Neill, Associate Dean & Associate Director, Cooperative Extension System
Cameron Faustman, Associate Dean for Research and
Associate Director, Storrs Agricultural Experiment Station; Associate Dean for Academic Programs
Richard McAvoy, Department Head and Professor, Plant Science and Landscape Architecture

RESEARCH, TEACHING, EXTENSION FACULTY AND EDUCATORS

Karl Guillard, Professor, Agronomy
Jason Henderson, Associate Professor, Turfgrass and Soil Sciences
John Inguagiato, Assistant Professor, Turfgrass Pathology
Ana Legrand, Assistant Extension Professor, IPM/Entomology
Yi Li, Professor, Horticultural Biotechnology
Thomas Morris, Professor, Soil Fertility
Steven Rackliffe, Associate Extension Professor, Turfgrass Science
Cristian Schulthess, Associate Professor, Soil Chemistry
Victoria Wallace, Extension Educator, Sustainable Turf & Landscape

STAFF

Nicole Gableman, Administrative Services Asstistant 3
Kevin Miele, Research Assistant II
Stephen Olsen, Farm Manager
Cristina Osbourne, Financial Assistant 2
Christine Strand, Secretary 1
Mark Oliver, Research Lab Aide
Geoffrey Scott Vose, Agricultural Worker 2

GRADUATE RESEARCH ASSISTANTS

Julie Campbell
Rania El Tanbouly
Xuan Chen
Lorenzo Katin-Grazzini
Rahul Kumar
Wei Li
Garrett Maxey
David Moore
Huseyin Yer

UNDERGRADUATE RESEARCH ASSISTANTS

Jesse Dunnack
Zoë Esponda
Derek Lockwood
Andrew Redlund

2016 Financial Support

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

Allen's Seed
AMVAC Environmental Products
A-OK Turf Equipment
Aquatrols
Argesource Inc.
Artscape Organic Care LLC.
Atlantic Golf and Turf
Barenbrug, USA
BASF Corp.
Bayer Environmental Science
BioWorks Inc.
Cardinals Inc.
Connecticut Association of Golf Course Superintendents
Connecticut Department of Energy and Environmental Protection
Connecticut Grounds Keepers Associaton
Crop Production Services
CTEC/CICA
DeLea Sod Farms
DGM Systems
Executive Turf Products
Franklin Paint
Golf Course Superintendents Association of Cape Cod
Green Earth Ag & Turf
Grigg Brothers
Harrells LLC
Helena
Lebanon Turf
Metropolotain Golf Course Superintendents Association
National Turfgrass Evaluation Program
New England Regional Turfgrass Foundation
New England Specialty Soils
New England Sports Turf Manager's Assoc.
Nufarm, Ltd.
PBI Gordon Corp.
Pennington Seed
Pioneer Athletics
PJC Organic
Plant Food Company, Inc.
Read Custom Soils
Residex
Savage Farms Inc.
SiteOne Landscape Supply
Slater Farms LLC
Sodco Inc.
Steven Willand Inc.
Storrs Agricultural Experiment Station
Sustane Natural Fertilizer
Syngenta Professional Products
The Chas. C. Hart Seed Co.
The Lawn Institute
Tom Irwin, Inc.
Tuckahoe Turf Farms, Inc.
Turf Products, LLC
UCONN Extension
United States Environmental Protection Agency
United States Golf Association
USDA NIFA Hatch Multistate Project NE-1046
Valley Green, Inc.
Warner Turf Equipment
Winding Brook Turf Farm Inc.
Winfield
Winterberry Irrigation

We regret that some individuals may have been inadvertently left off of this list. If you or your company has provided financial support for turfgrass research at the University of Connecticut and were not included on the above list, please contact us to ensure that you are included in future reports.

The University of Connecticut Turfgrass Science Program

2016 In-Kind Support

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

A-List Turf
Allens Seed
Atlantic Golf and Turf
BASF Corp.
Bayer Environmental Science
Championship Turf Services
DLF/Seed Research of Oregon
Green Earth Ag. & Turf, LLC
F.M. Brown, Sons, Inc.
Holliston Sand Company, Inc.
Indian Hill Country Club
Landmark Turf & Native Seed
MAS Golf Course Renovation & Construction
PBI Gordon Corp.
ProSeeds Marketing, Inc.
Pure Seed Testing, Inc.
Shelter Harbor Golf Club
Suståne/Natural Fertilizer of America, Inc.
Syngenta Professional Products
Tartan Farms, LLC
The Chas. C. Hart Seed Co.
The Toro Company
Turf Merchants, Inc.
Turf Products Corp.

We regret that some individuals may have been inadvertently left off of this list. If you or your company has provided material support for turfgrass research at the University of Connecticut and were not included on the above list, please contact us to ensure that you are included in future reports.

The University of Connecticut Turfgrass Science Program

2016 TURFGRASS FIELD DAY SPONSORS

2016 TURFGRASS FIELD DAY EXHIBITORS

Allen's Seed
A-OK Turf Equipment
Argesource Inc.
Artscape Organic Care LLC.
Atlantic Golf and Turf
BASF Corporation
BioWorks Inc.
Cardinals Inc.
Chas. C. Hart Seed Co.
Connecticut Assoc. of Golf Course Superintendents
Connecticut Grounds Keepers Assoc.
Crop Production Services
CTEC/CICA
DeLea Sod Farms
DGM Systems
Executive Turf Products
Franklin Paint
Green Earth Ag & Turf
Harrells LLC
Lebanon Turf
New England Specialty Soils
Nufarm
PBI Gordon
Pennington Seed
Pioneer Athletics
PJC Organic
Read Custom Soils
Residex
Savage Farms Inc.
SiteOne Landscape Supply
Slater Farms LLC
Sodco Inc.
Steven Willand Inc.
Sustane Natural Fertilizer
Tom Irwin, Inc.
Tuckahoe Turf Farms, Inc.
Turf Products
Valley Green, Inc.
Warner Turf Equipment
Winding Brook Turf Farm Inc.
Winfield
Winterberry Irrigation

We regret that some individuals may have been inadvertently left off of this list. If you or your company were exhibitors for the 2016 UConn Turfgrass Field Day and were not listed above, please contact us to ensure that you are included in future reports.

The University of Connecticut Turfgrass Science Program

DISCLAIMER

Do not duplicate, reprint, or publish information within this report without the expressed written consent of the author(s).

The information in this material is for educational purposes. This publication reports pesticide use in research trials and these may not conform to the pesticide label. Results described in these reports are not provided as recommendations. It is the responsibility of the pesticide applicator to follow current label directions for the specific pesticide being used. Any reference to commercial products, trade or brand names is for information only, and no endorsement or approval is intended. The Cooperative Extension System does not guarantee or warrant the standard of any product referenced or imply approval of the product to the exclusion of others which also may be available. If the information does not agree with current labeling, follow the label instructions. **The label is the law**. Read and follow all instructions and safety precautions on labels. Carefully handle and store agrochemicals/pesticides in originally labeled containers in a safe manner and place. Contact the Connecticut Department of Environmental Protection for current regulations. The user of this information assumes all risks for personal injury or property damage.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Gregory J. Weidemann, Dean, Cooperative Extension System, University of Connecticut, Storrs. An equal opportunity program provider and employer. To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 326-W, Whitten Building, Stop Code 9410, 1400 Independence Avenue, SW, Washington, DC 20250-8410 or call (202) 720-5964.

Table of Contents Page No.

PREVENTIVE ANTHRACNOSE CONTROL WITH VARIOUS FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2016

J. Inguagiato, K. Miele, J. Dunnack, Z. Esponda, and S. Vose

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

INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. An integrated disease control program including cultural management and fungicides is required to minimize turf loss due to this disease. Rotational fungicide programs utilizing different chemical modes of action and multi-site fungicides have been found to be most effective in providing season-long anthracnose control. Identifying new fungicides with unique modes of action effective against anthracnose is important to continued control of this disease and resistance management. The objective of this study was to examine the efficacy of experimental and commonly used fungicides for anthracnose control on an annual bluegrass putting green turf.

MATERIALS & METHODS

A field study was conducted on an annual bluegrass (*Poa annua*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Minimal nitrogen was applied to the study area to encourage anthracnose development. A total of 1.6 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from March through 19 August. Overhead irrigation and hand-watering was applied as needed to prevent drought stress. A rotation of Xzemplar (0.26 fl.oz.), Curalan (1.0 oz.), and Emerald (0.18 oz.) was applied every 14-d between 26 May and 15 August to prevent dollar spot development; ProStar (1.5 oz.) was applied preventively for brown patch on 18 June and 15 July. Dylox 80WP (3.75 oz.) was applied on 27 May for control of annual bluegrass weevil. Wetting agents Dispatch (0.55 fl.oz.) and Revolution (6 fl.oz.) were applied on 18 Jun and 23 Jul.

Treatments consisted of tank mixes and rotational programs of commercially available and developmental fungicides. Initial applications were made on 18 May prior to disease developing in the trial area, except UC16-15 and UC16-16 which were applied preventively on 31 May. Subsequent applications were made every 14-d through 9 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose was determined visually as the percent area blighted by *C. cereale* from 13 June through 19 August. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best possible quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. Normalized difference vegetative index (NDVI) was calculated as the mean of 10 subsamples taken randomly throughout the plot area (NDVI 500, Spectrum Technologies). Algae severity was visually assessed on a 0 to 5 scale, where 0 was equal to no surface algae and 2 represented the maximum acceptable level of algae colonization. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Anthracnose severity data were log-transformed as necessary for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS AND DISCUSSION

Anthracnose Severity

Anthracnose pressure was low throughout most of this trial. Symptoms developed from a natural infestation on 13 Jun and increased slightly to 8 to 12% plot area blighted in untreated control plots throughout July before increasing to 43% plot area blighted by 19 Aug (Tables 1a & 1b).

Most treatments significantly reduced anthracnose compared to untreated control throughout the trial (Tables 1 & 2). Among those fungicides which provided anthracnose control, few differences were observed. Anthracnose severity among the top performing fungicides was less than or equal to 3% plot area blighted, which was considered a good level of disease control in this trial. Treatments which consistently provided good anthracnose control in this trial included: rotational programs containing Appear, Primo MAXX, and Daconil Action, with Velista, or Medallion SC, Rotation Program, Fame+T, and Daconil Ultrex tank mixed with Signature, Signature XTRA, or Appear.

Kabuto + TebuStar tank mixes regardless of rate or application interval, except Kabuto (0.5 fl.oz.) + TebuStar (0.68 fl.oz.) every 28-d, Medallion SC + Appear, and UC16-16 generally provided good control during mid-July through August, but were not different from untreated control during June and early-July. However, initial application of UC16-16 was not until 31 May, 2 weeks after all other treatments began.

The Plant Food program, which included only nutrient and biostimulant based products with no fungicide, provided good anthracnose control through 15 Jul, but was no different than untreated control thereafter. UC16-15 did not differ from untreated control on all but one observation date in this trial.

Transfilm did not influence efficacy of Kabuto + TebuStar tank mixes. Kabuto (0.5 fl.oz.) + TebuStar (0.68 fl.oz.) every 28-d and UC16-15 were consistently no different than untreated control.

Turf Quality, Phytotoxicity, NDVI and Algae Severity

Turf quality of treatments transitioned throughout the trial as growth regulation effects and anthracnose severity changed. Generally, treatments which provided good anthracnose control throughout the trial also had the greatest turf quality including: rotations of Appear, Primo MAXX, and Daconil Action, with Velista, or Medallion SC, Rotation Program, and Daconil Ultrex tank mixed with Signature, Signature XTRA, or Appear (Tables 2a & 2b).

Turf quality of plots treated with Fame+T, Kabuto + TebuStar (regardless of rate or interval), and UC16-16 was unacceptable (< 6.0) from June through mid-July (15 Jul). Leaf texture of turf in these plots was course, surface uniformity appeared poor, and density was reduced. These effects were most pronounced where TebuStar was applied every 14-d at 1.1 or 0.7 fl.oz. with Kabuto, Fame+T, and UC16-16 which was apparent in the unacceptable phytotoxicity ratings (i.e., > 2.0) on 24 Jun and 1 Jul (Table 3). This turf response to tebuconazole is not uncommon when DMI fungicides are applied repeatedly, or at high rates. TebuStar applied with Kabuto every 28-d generally had better turf quality than equivalent rates applied every 14-d. However, despite poor turf quality during June and early-July, all treatments containing tebuconazole (i.e., TebuStar, Fame+T) provided acceptable turf quality (≥ 6.0) during late-July and early-August.

Algae developed uniformly throughout the study area following a period of thunderstorms and overcast conditions on 8 Jul. All treatments containing chlorothalonil applied as Daconil Action and Daconil Ultrex had less algae than untreated control plots (Table 4). Similarly, plots treated with phosphite (i.e., Appear, Phosphite 30) or fosetyl-Al (i.e., Signature, Signature Xtra). All other treatments increased algae compared to untreated control, except phosphate and the Plant Food Program.

Table 1a. Effect of various fungicides on preventative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft[2]	Int[x]	13 Jun	17 Jun	24 Jun	1 Jul	8 Jul
			Anthracnose Severity				
			% plot area blighted				
Appear	6.0 fl.oz.	14-d	0.0[t] h[s]	0.2 hi	0.2 fgh	0.1 h	0.2 ef
+ Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[w]					
- Velista	0.5 oz.						
Appear	6.0 fl.oz.	14-d	0.6 fgh	0.3 ghi	0.8 d-h	0.9 e-h	1.2 b-f
+Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[v]					
- Medallion SC	1.0 fl.oz.						
Appear	6.0 fl.oz.	14-d	0.0 h	0.2 hi	0.0 h	0.3 fgh	0.2 f
+Primo Maxx	0.125 fl.oz.	14-d					
+Daconil Action	3.5 fl.oz.	14-d					
- Medallion SC	1.0 fl.oz.	pgm[u]					
- Velista	0.5 oz.						
Kabuto	0.4 fl.oz.	14-d	3.9 a-f	2.2 d-g	1.1 c-h	6.2 b-f	2.1 b-f
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	2.9 a-g	3.0 b-f	1.4 c-h	5.7 b-f	1.8 b-f
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	1.7 b-h	1.8 d-h	0.0 h	5.5 b-f	1.9 b-f
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	0.9 d-h	1.1 e-i	0.0 h	0.8 e-h	0.3 ef
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	3.4 a-f	2.9 c-f	0.3 fgh	3.5 c-h	0.9 def
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	3.0 a-g	3.7 a-e	2.5 b-h	5.1 b-g	2.0 b-f
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.5 fl.oz.	14-d	2.5 a-g	2.0 d-h	1.3 c-h	3.2 c-h	1.1 b-f
+ TebuStar	0.68 fl.oz.						
Kabuto	0.5 fl.oz.	28-d	4.7 a-e	5.1 a-d	4.1 b-e	12.3 abc	5.1 abc
+ TebuStar	0.68 fl.oz.						
Fame+T	0.9 fl.oz.	28-d	1.2 c-h	1.2 e-i	0.2 fgh	4.2 c-h	1.1 b-f
Phosphate	34.6 fl.oz.	14-d	7.0 ab	9.9 a	8.0 ab	11.9 abc	5.0 a-d
+ Phosphite 30	5.6 fl.oz.						
Phosphate	34.6 fl.oz.	14-d	9.0 a	9.5 ab	19.1 a	20.6 a	17.3 a
Phosphite 30	5.6 fl.oz.	14-d	2.1 a-h	2.3 d-g	0.6 e-h	5.7 b-f	2.4 b-f
UC16-15	0.5 fl.oz.	14-d	5.4 a-d	5.2 a-d	6.1 abc	8.8 a-d	2.7 b-f
UC16-16	1.5 fl.oz.	14-d	8.7 a	9.0 abc	2.8 b-g	16.5 ab	5.7 ab
Daconil Ultrex	3.2 oz.	14-d	1.2 c-h	1.9 d-h	0.7 d-h	4.7 b-h	2.3 b-f
+ Signature	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	0.2 gh	0.0 i	0.0 h	0.1 gh	0.2 ef
+ Signature XTRA	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	0.0 h	0.8 e-i	0.1 gh	3.7 c-h	1.9 b-f
+ Appear	4.0 fl.oz.						
Medallion SC	1.0 fl.oz.	14-d	3.8 a-f	2.4 d-g	5.2 a-d	8.2 a-e	3.0 b-e
+ Appear	4.0 fl.oz.						
Rotational Program[z]		14-d	0.2 gh	0.0 i	0.3 fgh	2.5 c-h	0.9 c-f
Plant Food Program[y]		7-d	0.7 e-h	0.7 f-i	0.6 e-h	1.0 d-h	0.9 c-f
Untreated			5.4 abc	5.1 a-d	3.3 b-f	8.9 abc	4.2 bcd
ANOVA: Treatment (P > F)			0.0004	0.0001	0.0001	0.0010	0.0042
Days after treatment		7-d	6	2	3	2	2
		14-d	13	2	9	2	10
		28-d	26	2	9	16	24

[z]Rotational Program consisted of Signature XTRA (4.0 oz.), tank-mixed with the following treatments listed by application date. 18 May: Insignia SC (0.7 fl.oz.) + Chipco 26019 (4.0 fl.oz.), 31 May: Autilus (5.0 fl.oz) + Affirm (0.88 oz.), 15 June: Mirage (1.5 fl.oz.) + Medallion SC (1.0 fl.oz.), 28 June: Velista (0.5 oz.) + Daconil Action (2.0 fl.oz.), 12 July: Briskway (0.6 fl.oz.) + Segway (0.6 fl.oz.), 26 July: Medallion SC (1.0 fl.oz.) + Velista (0.5 oz.), 9 August: Affirm (0.88 oz.) + Daconil Action (2.0 fl.oz.). All rates are per 1000ft^2.

[y]The Plant Foods Program consisted of Kelp Iron (3.0 fl.oz.) tank-mixed with the following treatments on an alternating weekly basis. Week 1: 16-2-7 (6.0 fl.oz.) + Adams Earth (3.0 fl.oz.) + Phosphite 30 (3.0 fl.oz.). Week 2: Sugar Cal (3.0 fl.oz.) + Mg Nitrate (6.0 fl.oz.) + Omega (6.0 fl.oz.). All rates are per 1000ft2.

[x]Treatments were initiated on 18 May, prior to disease development in the trial area. Treatments were reapplied on either a 7-d, 14-d , or 28-d basis.

[w]Daconil Action and Velista were alternately tank-mixed with Appear + Primo Maxx

[v]Daconil Action and Medallion SC were alternately tank-mixed with Appear + Primo Maxx

[u]Medallion SC and Velista were alternately tank-mixed with Appear + Primo Maxx + Daconil Action

[t]Anthracnose data were log transformed. Means are detransformed for presentation.

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

Table of Contents

Table 1b. Effect of various fungicides on preventative anthracnose control in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[x]	15 Jul	28 Jul	4 Aug	12 Aug	19 Aug
			Anthracnose Severity				
			% plot area blighted				
Appear	6.0 fl.oz.	14-d	0.0[t] g[s]	0.0 g	0.0 e[x]	0.0 g	0.8 hi
+ Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[w]					
- Velista	0.5 oz.						
Appear	6.0 fl.oz.	14-d	0.4 efg	0.4 fg	0.6 de	0.0 g	1.7 hi
+Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[v]					
- Medallion SC	1.0 fl.oz.						
Appear	6.0 fl.oz.	14-d	0.1 g	0.2 fg	0.0 e	0.2 fg	0.0 i
+Primo Maxx	0.125 fl.oz.	14-d					
+Daconil Action	3.5 fl.oz.	14-d					
- Medallion SC	1.0 fl.oz.	pgm[u]					
- Velista	0.5 oz.						
Kabuto	0.4 fl.oz.	14-d	0.6 d-g	0.7 efg	0.4 de	0.3 fg	0.0 i
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	1.2 b-g	1.3 d-g	0.6 de	0.4 fg	1.9 hi
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	1.0 b-g	0.7 efg	0.3 de	0.0 g	0.4 hi
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	0.2 fg	0.0 g	0.0 e	0.0 g	0.4 hi
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	0.4 efg	0.8 efg	0.3 de	0.7 fg	3.8 fgh
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	1.3 b-g	0.7 efg	0.4 de	1.5 def	9.7 ef
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.5 fl.oz.	14-d	1.0 b-g	0.0 g	0.7 de	0.6 fg	1.3 hi
+ TebuStar	0.68 fl.oz.						
Kabuto	0.5 fl.oz.	28-d	3.8 abc	4.1 b-e	1.5 cde	3.3 de	13.3 de
+ TebuStar	0.68 fl.oz.						
Fame+T	0.9 fl.oz.	28-d	0.5 d-g	1.0 efg	0.5 de	1.3 d-g	1.4 hi
Phosphate	34.6 fl.oz.	14-d	4.9 ab	6.8 bc	4.4 bc	12.6 ab	21.2 cd
+ Phosphite 30	5.6 fl.oz.						
Phosphate	34.6 fl.oz.	14-d	9.0 a	25.4 a	23.0 a	30.4 a	54.3 a
Phosphite 30	5.6 fl.oz.	14-d	3.1 a-e	2.4 c-f	1.7 cd	4.3 cd	12.1 de
UC16-15	0.5 fl.oz.	14-d	3.3 a-d	12.0 ab	9.7 ab	17.4 ab	32.4 bc
UC16-16	1.5 fl.oz.	14-d	3.8 abc	2.0 c-g	0.9 de	0.9 efg	1.0 hi
Daconil Ultrex	3.2 oz.	14-d	0.6 d-g	0.5 fg	0.2 de	0.2 fg	1.5 hi
+ Signature	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	0.00 g	0.3 fg	0.2 de	0.1 fg	2.1 ghi
+ Signature XTRA	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	1.1 b-g	1.4 d-g	0.5 de	0.3 fg	0.4 hi
+ Appear	4.0 fl.oz.						
Medallion SC	1.0 fl.oz.	14-d	2.4 b-f	1.3 d-g	1.7 cd	1.2 efg	7.8 efg
+ Appear	4.0 fl.oz.						
Rotational Program[z]		14-d	0.7 c-g	0.6 fg	0.3 de	0.0 g	0.9 hi
Plant Food Program[y]		7-d	1.1 b-g	5.8 bcd	6.3 b	9.9 bc	38.2 ab
Untreated			4.7 ab	12.5 ab	10.4 ab	18.8 ab	42.5 ab
ANOVA: Treatment (P > F)			0.0007	0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	3	2	0	3	10
		14-d	3	2	9	3	10
		28-d	3	16	23	3	10

[z] Rotational Program consisted of Signature XTRA (4.0 oz.), tank-mixed with the following treatments listed by application date. 18 May: Insignia SC (0.7 fl.oz.) + Chipco 26019 (4.0 fl.oz.), 31 May: Autilus (5.0 fl.oz.) + Affirm (0.88 oz.), 15 June: Mirage (1.5 fl.oz.) + Medallion SC (1.0 fl.oz.), 28 June: Velista (0.5 oz.) + Daconil Action (2.0 fl.oz.), 12 July: Briskway (0.6 fl.oz.) + Segway (0.6 fl.oz.), 26 July: Medallion SC (1.0 fl.oz.) + Velista (0.5 oz.), 9 August: Affirm (0.88 oz.) + Daconil Action (2.0 fl.oz.). All rates are per 1000ft².

[y] The Plant Foods Program consisted of Kelp Iron (3.0 fl.oz.) tank-mixed with the following treatments on an alternating weekly basis. Week 1: 16-2-7 (6.0 fl.oz.) + Adams Earth (3.0 fl.oz.) + Phosphite 30 (3.0 fl.oz.). Week 2: Sugar Cal (3.0 fl.oz.) + Mg Nitrate (6.0 fl.oz.) + Omega (6.0 fl.oz.). All rates are per 1000ft2.

[x] Treatments were initiated on 18 May, prior to disease development in the trial area. Treatments were reapplied on either a 7-d, 14-d , or 28-d basis.

[w] Daconil Action and Velista were alternately tank-mixed with Appear + Primo Maxx

[v] Daconil Action and Medallion SC were alternately tank-mixed with Appear + Primo Maxx

[u] Medallion SC and Velista were alternately tank-mixed with Appear + Primo Maxx + Daconil Action

[t] Anthracnose data were log transformed. Means are detransformed for presentation.

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

Table of Contents

Table 2a. Effect of various fungicides on turf quality in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[x]	Turf Quality 6 Jun	10 Jun	17 Jun	24 Jun	1 Jul
			----------------------1-9, 6=min acceptable--------------------				
Appear	6.0 fl.oz.	14-d	7.5 a[t]	7.0 ab	7.7 a	6.5 a-e	7.2 ab
+ Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[w]					
- Velista	0.5 oz.						
Appear	6.0 fl.oz.	14-d	7.5 a	6.8 ab	7.2 ab	6.5 a-e	6.4 a-d
+Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[v]					
- Medallion SC	1.0 fl.oz.						
Appear	6.0 fl.oz.	14-d	7.0 ab	7.0 ab	7.7 a	7.5 ab	6.7 abc
+Primo Maxx	0.125 fl.oz.	14-d					
+Daconil Action	3.5 fl.oz.	14-d					
- Medallion SC	1.0 fl.oz.	pgm[u]					
- Velista	0.5 oz.						
Kabuto	0.4 fl.oz.	14-d	5.3 def	5.3 de	5.0 de	5.3 e-h	4.5 f
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	5.0 ef	5.3 de	5.2 de	5.0 fgh	5.0 def
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	5.0 ef	5.0 def	5.0 de	5.0 fgh	4.5 f
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	5.8 cde	5.8 cd	5.7 cd	6.0 c-f	5.7 b-f
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	6.0 cd	5.3 de	5.2 de	5.2 fgh	5.8 b-f
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	5.8 cde	5.3 de	5.2 de	5.5 d-g	5.5 c-f
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.5 fl.oz.	14-d	5.5 de	5.3 de	5.2 de	5.5 d-g	5.2 c-f
+ TebuStar	0.68 fl.oz.						
Kabuto	0.5 fl.oz.	28-d	5.3 def	5.0 def	4.5 ef	4.5 gh	4.5 f
+ TebuStar	0.68 fl.oz.						
Fame+T	0.9 fl.oz.	28-d	6.0 cd	5.3 de	5.0 de	5.0 fgh	4.7 ef
Phosphate	34.6 fl.oz.	14-d	5.3 def	5.0 def	5.0 de	5.0 fgh	5.2 c-f
+ Phosphite 30	5.6 fl.oz.						
Phosphate	34.6 fl.oz.	14-d	5.0 ef	4.3 f	3.9 f	4.5 gh	4.7 ef
Phosphite 30	5.6 fl.oz.	14-d	5.7 de	5.3 de	4.8 def	5.9 c-f	6.1 a-e
UC16-15	0.5 fl.oz.	14-d	5.0 ef	5.3 de	4.9 de	5.0 fgh	5.0 def
UC16-16	1.5 fl.oz.	14-d	5.0 ef	4.6 ef	4.5 ef	4.2 h	5.2 c-f
Daconil Ultrex	3.2 oz.	14-d	6.5 bc	6.3 bc	5.7 cd	5.8 c-g	5.4 c-f
+ Signature	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	7.8 a	7.5 a	8.0 a	7.8 a	7.7 a
+ Signature XTRA	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	7.0 ab	6.8 ab	6.5 bc	6.3 b-f	5.7 b-f
+ Appear	4.0 fl.oz.						
Medallion SC	1.0 fl.oz.	14-d	5.7 de	5.3 de	5.2 de	5.2 fgh	6.1 a-e
+ Appear	4.0 fl.oz.						
Rotational Program[z]		14-d	7.8 a	6.8 ab	8.0 a	7.0 abc	5.9 b-e
Plant Food Program[y]		7-d	6.5 bc	6.3 bc	6.2 bc	6.8 a-d	6.0 a-e
Untreated			4.5 f	5.0 def	5.0 de	5.3 e-h	5.0 def
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		7-d	6	3	2	3	3
		14-d	6	10	2	10	3
		28-d	20	24	2	10	17

[z]Rotational Program consisted of Signature XTRA (4.0 oz.), tank-mixed with the following treatments listed by application date. 18 May: Insignia SC (0.7 fl.oz.) + Chipco 26019 (4.0 fl.oz.), 31 May: Autilus (5.0 fl.oz) + Affirm (0.88 oz.), 15 June: Mirage (1.5 fl.oz.) + Medallion SC (1.0 fl.oz.), 28 June: Velista (0.5 oz.) + Daconil Action (2.0 fl.oz.), 12 July: Briskway (0.6 fl.oz.) + Segway (0.6 fl.oz.), 26 July: Medallion SC (1.0 fl.oz.) + Velista (0.5 oz.), 9 August: Affirm (0.88 oz.) + Daconil Action (2.0 fl.oz.). All rates are per 1000ft^2.

[y]The Plant Foods Program consisted of Kelp Iron (3.0 fl.oz.) tank-mixed with the following treatments on an alternating weekly basis. Week 1: 16-2-7 (6.0 fl.oz.) + Adams Earth (3.0 fl.oz.) + Phosphite 30 (3.0 fl.oz.). Week 2: Sugar Cal (3.0 fl.oz.) + Mg Nitrate (6.0 fl.oz.) + Omega (6.0 fl.oz.). All rates are per 1000ft2.

[x]Treatments were initiated on 18 May, prior to disease development in the trial area. Treatments were reapplied on either a 7-d, 14-d , or 28-d basis.

[w]Daconil Action and Velista were alternately tank-mixed with Appear + Primo Maxx

[v]Daconil Action and Medallion SC were alternately tank-mixed with Appear + Primo Maxx

[u]Medallion SC and Velista were alternately tank-mixed with Appear + Primo Maxx + Daconil Action

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

Table of Contents

Table 2b. Effect of various fungicides on turf quality in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment / Rate per 1000ft²	Int[x]	Turf Quality 8 Jul	15 Jul	28 Jul	4 Aug	19 Aug
		-1-9, 6=min acceptable-				
Appear ....6.0 fl.oz.	14-d	7.0 ab[t]	7.7 ab	8.5 ab	8.0 abc	8.0 ab
+ Primo Maxx.......0.125 fl.oz.	14-d					
- Daconil Action ....3.5 fl.oz.	pgm[w]					
- Velista........................0.5 oz.						
Appear ....6.0 fl.oz.	14-d	7.3 ab	7.7 ab	8.8 a	7.5 a-e	6.8 b-e
+Primo Maxx........0.125 fl.oz.	14-d					
- Daconil Action ....3.5 fl.oz.	pgm[v]					
- Medallion SC..........1.0 fl.oz.						
Appear ....6.0 fl.oz.	14-d	7.5 a	7.3 abc	8.3 abc	8.5 ab	8.3 a
+Primo Maxx........0.125 fl.oz.	14-d					
+Daconil Action........3.5 fl.oz.	14-d					
- Medallion SC..........1.0 fl.oz.	pgm[u]					
- Velista........................0.5 oz.						
Kabuto ....0.4 fl.oz.	14-d	3.3 hi	5.3 fgh	6.0 ghi	6.5 def	7.8 abc
+ TebuStar ....1.1 fl.oz.						
Kabuto ....0.4 fl.oz.	28-d	4.0 f-i	6.7 b-e	6.0 ghi	7.3 b-e	6.3 def
+ TebuStar ....1.1 fl.oz.						
Kabuto ....0.4 fl.oz.	14-d	3.3 hi	5.3 fgh	6.0 ghi	7.5 a-e	8.0 ab
+ TebuStar ....0.7 fl.oz.						
Kabuto ....0.4 fl.oz.	28-d	4.8 d-g	6.7 b-e	7.8 a-d	8.0 abc	6.8 b-e
+ TebuStar ....0.7 fl.oz.						
Kabuto ....0.4 fl.oz.	14-d	2.9 i	4.9 gh	6.0 ghi	7.0 cde	6.5 cde
+ TebuStar ....0.7 fl.oz.						
+ Transfilm ....2.83 fl.oz.						
Kabuto ....0.4 fl.oz.	28-d	4.0 f-i	5.7 efg	6.3 fgh	7.8 a-d	5.0 fgh
+ TebuStar ....0.7 fl.oz.						
+ Transfilm ....2.83 fl.oz.						
Kabuto ....0.5 fl.oz.	14-d	3.5 hi	6.0 d-g	8.0 abc	7.5 a-e	7.0 a-d
+ TebuStar ....0.68 fl.oz.						
Kabuto ....0.5 fl.oz.	28-d	4.3 e-h	5.7 efg	6.0 ghi	6.5 def	4.5 gh
+ TebuStar ....0.68 fl.oz.						
Fame+T.......................0.9 fl.oz.	28-d	4.3 e-h	6.3 c-f	6.8 d-g	7.3 b-e	6.0 def
Phosphate..................34.6 fl.oz.	14-d	5.0 def	5.0 gh	5.0 ijk	5.5 fg	4.5 gh
+ Phosphite 30 ....5.6 fl.oz.						
Phosphate..................34.6 fl.oz.	14-d	3.8 ghi	4.3 h	4.0 k	4.3 g	3.0 i
Phosphite 30 ....5.6 fl.oz.	14-d	5.3 cde	5.4 fgh	5.3 hij	6.3 ef	5.5 efg
UC16-15 ....0.5 fl.oz.	14-d	4.8 d-g	5.3 fgh	4.8 jk	4.8 g	3.8 hi
UC16-16 ....1.5 fl.oz.	14-d	3.9 f-i	5.9 d-g	6.3 e-h	6.4 ef	6.9 a-e
Daconil Ultrex ....3.2 oz.	14-d	7.0 ab	7.0 a-d	7.5 b-e	7.8 a-d	7.3 a-d
+ Signature...................4.0 oz.						
Daconil Ultrex ....3.2 oz.	14-d	8.0 a	8.0 a	8.5 ab	8.8 a	6.8 b-e
+ Signature XTRA.......4.0 oz.						
Daconil Ultrex ....3.2 oz.	14-d	7.0 ab	6.7 b-e	7.3 c-f	7.5 a-e	7.0 a-d
+ Appear ....4.0 fl.oz.						
Medallion SC.............1.0 fl.oz.	14-d	5.6 cd	5.4 fgh	7.3 b-f	7.5 a-e	6.3 def
+ Appear ....4.0 fl.oz.						
Rotational Program[z]	14-d	6.3 bc	6.7 b-e	8.3 abc	8.0 abc	7.8 abc
Plant Food Program[y]	7-d	5.5 cd	5.4 fgh	6.3 fgh	5.3 fg	3.0 i
Untreated		4.8 d-g	5.0 gh	4.8 jk	4.8 g	3.0 i
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment	7-d	2	2	2	0	10
	14-d	9	2	2	9	10
	18-d	23	2	16	23	10

Rotational Program consisted of Signature XTRA (4.0 oz.), tank-mixed with the following treatments listed by application date. 18 May: Insignia SC (0.7 fl.oz.) + Chipco 26019 (4.0 fl.oz.), 31 May: Autilus (5.0 fl.oz) + Affirm (0.88 oz.), 15 June: Mirage (1.5 fl.oz.) + Medallion SC (1.0 fl.oz.), 28 June: Velista (0.5 oz.) + Daconil Action (2.0 fl.oz.), 12 July: Briskway (0.6 fl.oz.) + Segway (0.6 fl.oz.), 26 July: Medallion SC (1.0 fl.oz.) + Velista (0.5 oz.), 9 August: Affirm (0.88 oz.) + Daconil Action (2.0 fl.oz.). All rates are per 1000ft².

[y]The Plant Foods Program consisted of Kelp Iron (3.0 fl.oz.) tank-mixed with the following treatments on an alternating weekly basis. Week 1: 16-2-7 (6.0 fl.oz.) + Adams Earth (3.0 fl.oz.) + Phosphite 30 (3.0 fl.oz.), Week 2: Sugar Cal (3.0 fl.oz.) + Mg Nitrate (6.0 fl.oz.) + Omega (6.0 fl.oz.). All rates are per 1000ft2.

[x]Treatments were initiated on 18 May, prior to disease development in the trial area. Treatments were reapplied on either a 7-d, 14-d , or 28-d basis.

[w]Daconil Action and Velista were alternately tank-mixed with Appear + Primo Maxx

[v]Daconil Action and Medallion SC were alternately tank-mixed with Appear + Primo Maxx

[u]Medallion SC and Velista were alternately tank-mixed with Appear + Primo Maxx + Daconil Action

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

Table of Contents

Table 3. Effect of various fungicides on phytotoxicity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[x]	Phytotoxicity 10 Jun	17 Jun	24 Jun	1 Jul	28 Jul	4 Aug	19 Aug
			-------- 0-5; 2 = max acceptable --------						
Appear	6.0 fl.oz.	14-d	0.0 e[t]	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
+ Primo Maxx	0.125 fl.oz.	14-d							
- Daconil Action	3.5 fl.oz.	pgm[w]							
- Velista	0.5 oz.								
Appear	6.0 fl.oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
+Primo Maxx	0.125 fl.oz.	14-d							
- Daconil Action	3.5 fl.oz.	pgm[v]							
- Medallion SC	1.0 fl.oz.								
Appear	6.0 fl.oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
+Primo Maxx	0.125 fl.oz.	14-d							
+Daconil Action	3.5 fl.oz.	14-d							
- Medallion SC	1.0 fl.oz.	pgm[u]							
- Velista	0.5 oz.								
Kabuto	0.4 fl.oz.	14-d	0.9 ab	0.5b	2.5 ab	2.3 a	0.7 a-d	0.0	0.0
+ TebuStar	1.1 fl.oz.								
Kabuto	0.4 fl.oz.	28-d	0.6 bc	0.3bc	1.8 abc	1.5 bcd	1.0 ab	0.0	0.0
+ TebuStar	1.1 fl.oz.								
Kabuto	0.4 fl.oz.	14-d	1.6 a	1.0a	2.8 a	2.0 ab	0.4 b-e	0.0	0.0
+ TebuStar	0.7 fl.oz.								
Kabuto	0.4 fl.oz.	28-d	0.1 cde	0.0c	1.5 bcd	0.8 ef	0.4 b-e	0.0	0.0
+ TebuStar	0.7 fl.oz.								
Kabuto	0.4 fl.oz.	14-d	0.3 bcd	0.3b	1.3 cd	1.6 a-d	1.3 a	0.0	0.0
+ TebuStar	0.7 fl.oz.								
+ Transfilm	2.83 fl.oz.								
Kabuto	0.4 fl.oz.	28-d	0.1 cde	0.0c	0.5 de	1.0 de	0.2 de	0.0	0.0
+ TebuStar	0.7 fl.oz.								
+ Transfilm	2.83 fl.oz.								
Kabuto	0.5 fl.oz.	14-d	0.3 bcd	0.0c	1.8 abc	1.0 de	0.6 a-d	0.0	0.0
+ TebuStar	0.68 fl.oz.								
Kabuto	0.5 fl.oz.	28-d	0.1 de	0.0c	1.0 cde	1.3 cde	0.2 de	0.0	0.0
+ TebuStar	0.68 fl.oz.								
Fame+T	0.9 fl.oz.	28-d	0.2 cde	0.3bc	2.0 abc	1.8 abc	0.9 abc	0.0	0.0
Phosphate	34.6 fl.oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
+ Phosphite 30	5.6 fl.oz.								
Phosphate	34.6 fl.oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
Phosphite 30	5.6 fl.oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
UC16-15	0.5 fl.oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
UC16-16	1.5 fl.oz.	14-d	0.1 cde	0.0c	1.7 abc	1.0 de	0.2 cde	0.0	0.0
Daconil Ultrex	3.2 oz.	14-d	0.0 e	0.0c	0.5 de	0.3 fg	0.0 e	0.0	0.0
+ Signature	4.0 oz.								
Daconil Ultrex	3.2 oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
+ Signature XTRA	4.0 oz.								
Daconil Ultrex	3.2 oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
+ Appear	4.0 fl.oz.								
Medallion SC	1.0 fl.oz.	14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
+ Appear	4.0 fl.oz.								
Rotational Program[z]		14-d	0.0 e	0.0c	0.0 e	0.0 g	0.0 e	0.0	0.0
Plant Food Program[y]		7-d	0.0 e	0.0 c	0.5 de	0.0 g	0.0 e	0.0	0.0
Untreated			0.0 e	0.0 c	0.0 e	0.0 g	0.3 cde	0.0	0.0
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	1.0000	1.0000
Days after treatment		7-d	3	2	3	2	2	0	10
		14-d	10	2	9	2	2	9	10
		28-d	23	2	9	16	16	23	10

Rotational Program consisted of Signature XTRA (4.0 oz.), tank-mixed with the following treatments listed by application date. 18 May: Insignia SC (0.7 fl.oz.) + Chipco 26019 (4.0 fl.oz.), 31 May: Autilus (5.0 fl.oz) + Affirm (0.88 oz.), 15 June: Mirage (1.5 fl.oz.) + Medallion SC (1.0 fl.oz.), 28 June: Velista (0.5 oz.) + Daconil Action (2.0 fl.oz.), 12 July: Briskway (0.6 fl.oz.) + Segway (0.6 fl.oz.), 26 July: Medallion SC (1.0 fl.oz.) + Velista (0.5 oz.), 9 August: Affirm (0.88 oz.) + Daconil Action (2.0 fl.oz.). All rates are per 1000ft^2.

[y]The Plant Foods Program consisted of Kelp Iron (3.0 fl.oz.) tank-mixed with the following treatments on an alternating weekly basis. Week 1: 16-2-7 (6.0 fl.oz.) + Adams Earth (3.0 fl.oz.) + Phosphite 30 (3.0 fl.oz.). Week 2: Sugar Cal (3.0 fl.oz.) + Mg Nitrate (6.0 fl.oz.) + Omega (6.0 fl.oz.). All rates are per 1000ft2.

[x]Treatments were initiated on 18 May, prior to disease development in the trial area. Treatments were reapplied on either a 7-d, 14-d , or 28-d basis.

[w]Daconil Action and Velista were alternately tank-mixed with Appear + Primo Maxx

[v]Daconil Action and Medallion SC were alternately tank-mixed with Appear + Primo Maxx

[u]Medallion SC and Velista were alternately tank-mixed with Appear + Primo Maxx + Daconil Action

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

Table of Contents

Table 4. Effect of various fungicides on NDVI and algae severity in an annual bluegrass putting turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[x]	NDVI 1 Jul	NDVI 8 Jul	NDVI 27 Jul	NDVI 12 Aug	Algae Severity 8 July
			------------------ Vegetation Index	------------------			--0-5; 2=max--
Appear	6.0 fl.oz.	14-d	0.762	0.765	0.756 ab[t]	0.769	1.0 gh
+ Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[w]					
- Velista	0.5 oz.						
Appear	6.0 fl.oz.	14-d	0.768	0.765	0.756 ab	0.784	0.5 hi
+Primo Maxx	0.125 fl.oz.	14-d					
- Daconil Action	3.5 fl.oz.	pgm[v]					
- Medallion SC	1.0 fl.oz.						
Appear	6.0 fl.oz.	14-d	0.752	0.764	0.742 a-f	0.788	0.3 hi
+Primo Maxx	0.125 fl.oz.	14-d					
+Daconil Action	3.5 fl.oz.	14-d					
- Medallion SC	1.0 fl.oz.	pgm[u]					
- Velista	0.5 oz.						
Kabuto	0.4 fl.oz.	14-d	0.754	0.769	0.740 a-f	0.777	4.5 ab
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	0.758	0.765	0.747 a-d	0.761	4.3 ab
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	0.726	0.767	0.75 abc	0.767	4.3 ab
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	0.769	0.782	0.75 abc	0.767	3.8 bc
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	0.755	0.775	0.745 a-e	0.758	4.9 a
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	0.758	0.767	0.753 abc	0.785	3.8 bc
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.5 fl.oz.	14-d	0.748	0.777	0.753 abc	0.786	4.3 ab
+ TebuStar	0.68 fl.oz.						
Kabuto	0.5 fl.oz.	28-d	0.744	0.753	0.735 b-g	0.743	3.8 bc
+ TebuStar	0.68 fl.oz.						
Fame+T	0.9 fl.oz.	28-d	0.754	0.774	0.739 a-f	0.784	4.5 ab
Phosphate	34.6 fl.oz.	14-d	0.752	0.759	0.726 def	0.748	1.5 fg
+ Phosphite 30	5.6 fl.oz.						
Phosphate	34.6 fl.oz.	14-d	0.748	0.754	0.711 g	0.737	3.3 cd
Phosphite 30	5.6 fl.oz.	14-d	0.751	0.759	0.721 eg	0.750	1.6 fg
UC16-15	0.5 fl.oz.	14-d	0.745	0.757	0.729 c-g	0.750	3.0 cd
UC16-16	1.5 fl.oz.	14-d	0.745	0.757	0.719 fg	0.760	4.3 ab
Daconil Ultrex	3.2 oz.	14-d	0.741	0.761	0.744 a-e	0.767	0.0 i
+ Signature	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	0.763	0.763	0.755 abc	0.757	0.0 i
+ Signature XTRA	4.0 oz.						
Daconil Ultrex	3.2 oz.	14-d	0.748	0.760	0.751 abc	0.784	0.0 i
+ Appear	4.0 fl.oz.						
Medallion SC	1.0 fl.oz.	14-d	0.751	0.754	0.737 a-f	0.749	1.6 fg
+ Appear	4.0 fl.oz.						
Rotational Program[z]		14-d	0.759	0.763	0.760 a	0.746	0.8 ghi
Plant Food Program[y]		7-d	0.774	0.757	0.753 ab	0.761	2.0 ef
Untreated			0.754	0.762	0.718 f	0.750	2.8 de
ANOVA: Treatment (P > F)			0.3076	0.4405	0.0020	0.0592	0.0001
Days after treatment		7-d	2	2	1	3	2
		14-d	2	10	1	3	9
		28-d	6	24	15	3	23

[z]Rotational Program consisted of Signature XTRA (4.0 oz.), tank-mixed with the following treatments listed by application date. 18 May: Insignia SC (0.7 fl.oz.) + Chipco 26019 (4.0 fl.oz.), 31 May: Autilus (5.0 fl.oz) + Affirm (0.88 oz.), 15 June: Mirage (1.5 fl.oz.) + Medallion SC (1.0 fl.oz.), 28 June: Velista (0.5 oz.) + Daconil Action (2.0 fl.oz.), 12 July: Briskway (0.6 fl.oz.) + Segway (0.6 fl.oz.), 26 July: Medallion SC (1.0 fl.oz.) + Velista (0.5 oz.), 9 August: Affirm (0.88 oz.) + Daconil Action (2.0 fl.oz.). All rates are per 1000ft².

[y]The Plant Foods Program consisted of Kelp Iron (3.0 fl.oz.) tank-mixed with the following treatments on an alternating weekly basis. Week 1: 16-2-7 (6.0 fl.oz.) + Adams Earth (3.0 fl.oz.) + Phosphite 30 (3.0 fl.oz.). Week 2: Sugar Cal (3.0 fl.oz.) + Mg Nitrate (6.0 fl.oz.) + Omega (6.0 fl.oz.). All rates are per 1000ft2.

[x]Treatments were initiated on 18 May, prior to disease development in the trial area. Treatments were reapplied on either a 7-d, 14-d , or 28-d basis.

[w]Daconil Action and Velista were alternately tank-mixed with Appear + Primo Maxx

[v]Daconil Action and Medallion SC were alternately tank-mixed with Appear + Primo Maxx

[u]Medallion SC and Velista were alternately tank-mixed with Appear + Primo Maxx + Daconil Action

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

Table of Contents

PREVENTIVE ANTHRACNOSE CONTROL WITH OREON AND AUTILUS FUNGICIDES ON AN ANNUAL BLUEGRASS PUTTING GREEN TURF, 2016

J. Inguagiato, K. Miele, J. Dunnack, Z. Esponda, and S. Vose

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

INTRODUCTION

Anthracnose (caused by *Colletotrichum cereale*) is a devastating disease of annual bluegrass putting green turf. An integrated disease control program including cultural management and fungicides is required to minimize turf loss due to this disease. Rotational fungicide programs utilizing different chemical modes of action and multi-site fungicides have been found to be most effective in providing season-long anthracnose control. Identifying new fungicides with unique modes of action effective against anthracnose is important to continued control of this disease and resistance management. The objective of this study was to examine the efficacy of experimental and commonly used fungicides for anthracnose control on an annual bluegrass putting green turf.

MATERIALS & METHODS

A field study was conducted on an annual bluegrass (*Poa annua*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Minimal nitrogen was applied to the study area to encourage anthracnose development. A total of 1.6 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources from March through 19 August. Overhead irrigation and hand-watering was applied as needed to prevent drought stress. A rotation of Xzemplar (0.26 fl.oz.), Curalan (1.0 oz.), and Emerald (0.18 oz.) was applied every 14-d between 26 May and 15 August to prevent dollar spot development; ProStar (1.5 oz.) was applied preventively for brown patch on 18 June and 15 July. Dylox 80WP (3.75 oz.) was applied on 27 May for control of annual bluegrass weevil. Wetting agents Dispatch (0.55 fl.oz.) and Revolution (6 fl.oz.) were applied on 18 Jun and 23 Jul.

Treatments consisted of OREON, Autilus, or UC16-14 tank mixed with various commercially available fungicides. UC16-13 was also evaluated at various application rates. Initial applications were made on 18 May prior to disease developing in the trial area, except UC16-15 and UC16-16 which were applied preventively on 31 May. Subsequent applications were made every 14-d through 9 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Anthracnose was determined visually as the percent area blighted by *C. cereale* from 13 June through 19 August. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best possible quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. Normalized difference vegetative index (NDVI) was calculated as the mean of 10 subsamples taken randomly throughout the plot area (NDVI 500, Spectrum Technologies). Algae severity was visually assessed on a 0 to 5 scale, where 0 was equal to no surface algae and 2 represented the maximum acceptable level of algae colonization. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test. Anthracnose severity data were arc-sin or log-transformed as necessary for ANOVA and mean separation tests, means were de-transformed for presentation.

RESULTS AND DISCUSSION

Anthracnose Severity

Anthracnose pressure was moderate throughout most of this trial. Symptoms developed from a natural infestation on 13 June and increased to a sustained, moderate level of disease (~ 30% plot area blighted) in untreated control plots throughout June, July, and August (Tables 1a & 1b).

OREON tank-mixed with PAR generally provided excellent to good anthracnose control throughout the duration of the trial (Tables 1a + 1b). No differences in anthracnose control were observed among rates of OREON ranging from 4.0 to 8.0 fl.oz. Autilus or UC16-14 were also evaluated as tank-mixes with PAR, and provided excellent anthracnose control, comparable to OREON.

UC16-14 was evaluated as a tank-mix partner with several commonly applied fungicides. Results varied among tank-mix combinations. The most consistent differences in anthracnose control occurred between Insignia SC, Heritage TL, and Medallion SC applied alone compared to tank mixes of each of these with UC16-14. In each of these cases, the tank mix reduced anthracnose compared to the former fungicides applied alone. Tank-mixing fungicides is typically more effective for controlling anthracnose than applying single products, as is apparent in Medallion SC plots. However, in this study the benefit of tank-mixing UC16-14 with Insignia SC or Heritage TL was particularly evident since, these fungicides have previously been observed to be ineffective at controlling anthracnose at this particular site; likely due to resistance of the pathogen to strobilurin fungicides. Differences between tank-mixes of UC16-14 and Velista or Signature XTRA were also apparent, albeit observed less frequently. These tank mixes reduced anthracnose 4 to 13% or 2 to 9% compared to Velista or Signature XTRA, respectively. Tank-mixing UC16-14 with Civitas One generally was no different than Civitas One alone; although the tank mix appeared to reduce the efficacy of UC16-14. UC16-14 applied in the absence of Civitas One generally contained 2 to 9% less anthracnose than UC16-14 + Civitas One.

Applications of UC16-13 consistently reduced anthracnose compared to untreated control, although failed to provide acceptable disease control during mid- to late-June. Anthracnose control improved during July and August with all rates reducing disease to ≤ 5% disease.

Turf Quality, Phytotoxicity, NDVI and Algae Severity

Turf quality of treatments transitioned throughout the trial as growth regulation effects and anthracnose severity changed. Generally, treatments which provided good anthracnose control throughout the trial and contained a green pigment also had the greatest turf quality including: Autilus + PAR, UC16-14 + PAR, Velista + UC16-14 + PAR, Insignia SC + UC16-14 + PAR, Medallion SC + UC16-14 + PAR, and Signature XTRA + UC16-14 (Tables 2a & 2b).

Plots treated with Civitas One + UC16-14 contained slight, albeit acceptable, phytotoxicity symptoms (slight chlorosis) on 1 July (Table 4). However, symptoms were more pronounced on 28 July, increasing to an unacceptable yellow discoloration. The tank mix increased phytotoxicity compared to either material applied individually. It may be possible that the mineral oil in Civitas One enhanced uptake of the active ingredient in UC16-14 resulting in phytotoxicity and reduced anthracnose control.

Table 1a. Effect of new and experimental AMVAC fungicides tank-mixed with various fungicides on anthracnose on an annual bluegrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[z]	Anthracnose Severity 13 Jun	17 Jun	24 Jun	1 Jul	8 Jul
			---------------------- % plot area blighted				-----------------------
OREON	4.0 fl.oz.	14-d	0.1[y] gh[x]	0.1[y] hi	3.4 [y] f-j	3.5 [y] e-i	2.0 [y] d-g
+ Harrell's Par	0.37 fl.oz.						
OREON	6.0 fl.oz.	14-d	0.0 h	0.0 i	0.3 j	0.6 hi	0.1 g
+ Harrell's Par	0.37 fl.oz.						
OREON	8.0 fl.oz.	14-d	0.0 h	0.1 hi	2.0 g-j	5.9 d-h	0.1 g
+ Harrell's Par	0.37 fl.oz.						
Autilus	6.0 fl.oz.	14-d	0.0 h	0.1 hi	1.5 hij	1.1 hi	0.4 fg
+ Harrell's Par	0.37 fl.oz.						
UC16-14	6.0 fl.oz.	14-d	0.1 gh	0.1 hi	1.1 ij	0.5 i	0.1 g
+ Harrell's Par	0.37 fl.oz.						
Velista	0.5 oz.	14-d	4.7 b-e	11.6 bcd	15.2 b-e	13.4 bcd	6.8 cd
Velista	0.5 oz.	14-d	0.0 h	0.0 i	2.4 f-j	2.8 f-i	1.8 d-g
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Insignia SC	0.5 fl.oz.	14-d	9.4 bc	9.0 cde	23.6 a-d	18.5 abc	21.6 ab
Insignia SC	0.5 fl.oz.	14-d	0.0 h	0.1 hi	1.7 hij	0.7 hi	0.1 g
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Heritage TL	1.0 fl.oz.	14-d	26.3 a	22.2 a	30.9 ab	30.6 a	23.5 ab
Heritage TL	1.0 fl.oz.	14-d	0.0 h	0.0 i	0.7 hij	2.5 f-i	0.7 efg
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Medallion SC	1.5 fl.oz.	14-d	6.1 bcd	11.1 b-e	27.3 abc	8.8 b-g	5.3 cde
Medallion SC	1.5 fl.oz.	14-d	0.0 h	0.0 i	0.6 j	0.5 i	0.1 g
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Signature Xtra	4.0 oz.	14-d	0.9 e-h	1.8 gh	8.1 e-i	11.2 b-e	6.1 cd
Signature Xtra	4.0 oz.	14-d	0.0 h	0.1 hi	5.4 e-j	1.8 ghi	0.7 efg
+ UC16-14	6.0 fl.oz.						
Civitas One	8.5 fl.oz.	14-d	0.6 fgh	3.6 fg	12.1 c-f	12.9 bcd	8.0 cd
Civitas One	8.5 fl.oz.	14-d	1.4 d-h	3.6 fg	10.2 d-h	8.3 c-f	4.0 def
+ UC16-14	6.0 fl.oz.						
UC16-13	0.8 fl.oz.	21-d	10.4 bc	13.4 bc	22.9 a-d	20.3 ab	13.5 bc
UC16-13	1.0 fl.oz.	21-d	3.7 c-f	5.1 efg	11.6 c-g	10.5 b-f	5.6 cde
UC16-13	1.2 fl.oz.	21-d	10.9 b	7.9 c-f	24.2 a-d	12.3 b-e	4.8 cde
Mirage	1.0 fl.oz.	14-d	2.2 d-g	5.8 d-g	17.1 b-e	17.2 abc	6.8 cd
Untreated			25.3 a	17.4 ab	35.9 a	29.3 a	25.8 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	13	2	9	2	9
		21-d	6	10	17	2	9

[z]Treatments were initiated on 18 May, prior to disease development. Subsequent 14-d treatments were made on 31 May, 15 June, 29 June, 12 July, and 28 July. Subsequent 21-d treatments were made on 7 June, 29 June, and 20 July.

[y]Data were automatically arc-sin square root transformed. Means are de-transformed for presentation.

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

Table 1b. Effect of new and experimental AMVAC fungicides tank-mixed with various fungicides on anthracnose on an annual bluegrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per $1000ft^2$	Int[z]	Anthracnose Severity 15 Jul	28 Jul	4 Aug	12 Aug
			----------------- % plot area blighted -----------------			
OREON	4.0 fl.oz.	14-d	0.8[y] c-g[x]	1.1[y] def	0.0[y] e[z]	0.0[y] h
+ Harrell's Par	0.37 fl.oz.					
OREON	6.0 fl.oz.	14-d	0.2 fg	0.2 ef	0.2 de	0.2 fgh
+ Harrell's Par	0.37 fl.oz.					
OREON	8.0 fl.oz.	14-d	0.0 g	2.1 b-f	0.1 de	1.2 d-h
+ Harrell's Par	0.37 fl.oz.					
Autilus	6.0 fl.oz.	14-d	0.1 g	0.0 f	0.2 de	0.3 e-h
+ Harrell's Par	0.37 fl.oz.					
UC16-14	6.0 fl.oz.	14-d	0.2 fg	0.6 ef	0.0 e	0.0 h
+ Harrell's Par	0.37 fl.oz.					
Velista	0.5 oz.	14-d	2.1 b-e	1.4 c-f	0.3 de	0.3 e-h
Velista	0.5 oz.	14-d	0.3 efg	0.3 ef	0.1 de	0.5 e-h
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Insignia SC	0.5 fl.oz.	14-d	16.3 a	38.6 a	22.0 a	26.7 a
Insignia SC	0.5 fl.oz.	14-d	0.2 fg	0.00 f	0.0 e	0.1 gh
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Heritage TL	1.0 fl.oz.	14-d	19.9 a	42.2 a	18.4 a	35.0 a
Heritage TL	1.0 fl.oz.	14-d	0.7 d-g	0.9 def	0.4 de	0.9 e-h
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Medallion SC	1.5 fl.oz.	14-d	2.5 bcd	5.8 bc	0.8 cde	6.5 bc
Medallion SC	1.5 fl.oz.	14-d	0.2 fg	0.3 ef	0.2 de	0.0 h
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Signature Xtra	4.0 oz.	14-d	1.5 b-g	1.2 c-f	0.5 de	2.2 cde
Signature Xtra	4.0 oz.	14-d	0.1 g	0.8 ef	0.0 e	0.2 fgh
+ UC16-14	6.0 fl.oz.					
Civitas One	8.5 fl.oz.	14-d	3.1 bc	8.2 b	4.9 b	20.9 a
Civitas One	8.5 fl.oz.	14-d	1.4 b-g	2.2 b-e	1.0 cde	1.7 def
+ UC16-14	6.0 fl.oz.					
UC16-13	0.8 fl.oz.	21-d	4.7 b	4.5 bcd	1.3 cd	4.2 bcd
UC16-13	1.0 fl.oz.	21-d	1.8 b-f	2.5 b-e	2.3 bc	7.4 b
UC16-13	1.2 fl.oz.	21-d	2.1 b-e	2.4 b-e	1.0 cde	1.7 d-g
Mirage	1.0 fl.oz.	14-d	1.1 c-g	0.9 def	0.0 e	0.3 e-h
Untreated			18.1 a	30.4 a	12.8 a	30.3 a
ANOVA: Treatment ($P > F$)			0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	3	0	7	3
		21-d	16	0	15	3

[z]Treatments were initiated on 18 May, prior to disease development. Subsequent 14-d treatments were made on 31 May, 15 June, 29 June, 12 July, and 28 July. Subsequent 21-d treatments were made on 7 June, 29 June, and 20 July.

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

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

Table 2a. Effect of new and experimental AMVAC fungicides tank-mixed with various fungicides on Turf Quality on an annual bluegrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[z]	Turf Quality 6 Jun	10 Jun	17 Jun	24 Jun
			-------------- 1-9; 6=min acceptable	--------------		
OREON	4.0 fl.oz.	14-d	6.8 bcd[y]	6.5 cde	7.0 ab	6.4[x] abc
+ Harrell's Par	0.37 fl.oz.					
OREON	6.0 fl.oz.	14-d	7.3 ab	7.5 ab	7.5 a	7.0 ab
+ Harrell's Par	0.37 fl.oz.					
OREON	8.0 fl.oz.	14-d	7.0 abc	6.8 bcd	7.0 ab	6.4 abc
+ Harrell's Par	0.37 fl.oz.					
Autilus	6.0 fl.oz.	14-d	7.0 abc	7.5 ab	7.0 ab	7.2 a
+ Harrell's Par	0.37 fl.oz.					
UC16-14	6.0 fl.oz.	14-d	6.5 cde	7.3 abc	7.5 a	7.2 a
+ Harrell's Par	0.37 fl.oz.					
Velista	0.5 oz.	14-d	5.8 fgh	5.5 fg	4.3 def	4.7 efg
Velista	0.5 oz.	14-d	7.0 abc	7.3 abc	7.3 a	6.9 ab
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Insignia SC	0.5 fl.oz.	14-d	5.5 gh	5.3 gh	4.5 de	4.5 fg
Insignia SC	0.5 fl.oz.	14-d	7.5 a	7.3 abc	7.5 a	6.7 ab
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Heritage TL	1.0 fl.oz.	14-d	5.3 h	4.5 hi	3.5 ef	4.0 g
Heritage TL	1.0 fl.oz.	14-d	6.8 bcd	6.8 bcd	7.0 ab	6.5 abc
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Medallion SC	1.5 fl.oz.	14-d	5.8 fgh	5.5 fg	4.3 def	4.7 efg
Medallion SC	1.5 fl.oz.	14-d	7.0 abc	7.8 a	7.3 a	6.9 ab
+ UC16-14	6.0 fl.oz.					
+ Harrell's Par	0.37 fl.oz.					
Signature Xtra	4.0 oz.	14-d	6.3 def	6.3 def	6.0 bc	5.5 cde
Signature Xtra	4.0 oz.	14-d	6.8 bcd	7.0 a-d	6.5 ab	6.0 bcd
+ UC16-14	6.0 fl.oz.					
Civitas One	8.5 fl.oz.	14-d	6.0 efg	5.8 efg	5.3 cd	5.2 def
Civitas One	8.5 fl.oz.	14-d	5.8 fgh	5.5 fg	4.8 d	5.0 def
+ UC16-14	6.0 fl.oz.					
UC16-13	0.8 fl.oz.	21-d	5.8 fgh	5.0 ghi	4.5 de	5.0 def
UC16-13	1.0 fl.oz.	21-d	5.8 fgh	5.3 gh	4.8 d	5.2 def
UC16-13	1.2 fl.oz.	21-d	5.3 h	5.0 ghi	4.5 de	5.2 def
Mirage	1.0 fl.oz.	14-d	6.0 efg	5.5 fg	5.0 cd	4.7 efg
Untreated			4.5 i	4.3 i	3.3 f	3.9 g
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	6	10	2	9
		21-d	19	3	10	17

[z]Treatments were initiated on 18 May, prior to disease development. Subsequent 14-d treatments were made on 31 May, 15 June, 29 June, 12 July, and 28 July. Subsequent 21-d treatments were made on 7 June, 29 June, and 20 July.

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

[x]Data were automatically log transformed. Means are de-transformed for presentation.

Table 2b. Effect of new and experimental AMVAC fungicides tank-mixed with various fungicides on Turf Quality on an annual bluegrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft[2]	Int[z]	Turf Quality 1 Jul	8 Jul	15 Jul	28 Jul	4 Aug
			------------------------- 1-9; 6=min acceptable -------------------------				
OREON	4.0 fl.oz.	14-d	5.7[y] b-e[x]	5.5 c-f	6.3 a-d	7.0 a-d	8.3 a
+ Harrell's Par	0.37 fl.oz.						
OREON	6.0 fl.oz.	14-d	6.2 a-d	5.8 b-e	6.8 ab	7.8 a	8.0 ab
+ Harrell's Par	0.37 fl.oz.						
OREON	8.0 fl.oz.	14-d	5.7 b-e	5.8 b-e	5.5 cde	6.8 a-d	6.5 def
+ Harrell's Par	0.37 fl.oz.						
Autilus	6.0 fl.oz.	14-d	7.0 ab	6.0 a-d	6.3 a-d	7.5 ab	7.5 a-d
+ Harrell's Par	0.37 fl.oz.						
UC16-14	6.0 fl.oz.	14-d	7.2 a	6.5 abc	6.5 abc	7.8 a	8.0 ab
+ Harrell's Par	0.37 fl.oz.						
Velista	0.5 oz.	14-d	5.0 ef	4.8 efg	5.8 b-e	6.0 cde	7.5 a-d
Velista	0.5 oz.	14-d	6.3 a-d	5.5 c-f	6.5 abc	8.0 a	8.0 ab
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Insignia SC	0.5 fl.oz.	14-d	4.2 fg	3.8 gh	4.0 fg	3.8 f	4.0 i
Insignia SC	0.5 fl.oz.	14-d	6.2 a-d	5.5 c-f	6.5 abc	7.5 ab	7.8 abc
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Heritage TL	1.0 fl.oz.	14-d	3.7 g	3.3 h	3.8 g	3.8 f	4.3 hi
Heritage TL	1.0 fl.oz.	14-d	6.2 a-d	6.0 a-d	5.8 b-e	7.0 a-d	7.8 abc
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Medallion SC	1.5 fl.oz.	14-d	5.2 def	5.8 b-e	6.0 a-e	5.8 de	6.8 c-f
Medallion SC	1.5 fl.oz.	14-d	7.4 a	6.8 ab	6.8 ab	7.8 a	8.0 ab
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Signature Xtra	4.0 oz.	14-d	5.2 c-f	5.5 c-f	6.3 a-d	7.3 abc	7.0 b-e
Signature Xtra	4.0 oz.	14-d	6.4 abc	7.0 a	7.0 a	7.3 abc	8.0 ab
+ UC16-14	6.0 fl.oz.						
Civitas One	8.5 fl.oz.	14-d	5.0 ef	4.8 efg	5.3 de	5.3 e	5.3 gh
Civitas One	8.5 fl.oz.	14-d	5.2 c-f	5.3 def	5.5 cde	5.0 ef	5.8 fg
+ UC16-14	6.0 fl.oz.						
UC16-13	0.8 fl.oz.	21-d	4.5 fg	4.8 efg	5.0 ef	5.3 e	6.0 efg
UC16-13	1.0 fl.oz.	21-d	5.0 ef	4.5 fg	5.3 de	5.8 de	6.0 efg
UC16-13	1.2 fl.oz.	21-d	4.5 fg	4.8 efg	5.5 cde	6.3 b-e	7.0 b-e
Mirage	1.0 fl.oz.	14-d	5.0 ef	4.5 fg	5.5 cde	5.8 de	6.8 c-f
Untreated			4.2 fg	3.8 gh	3.8 g	3.8 f	4.5 hi
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	2	9	3	0	7
		21-d	2	9	16	0	15

[z]Treatments were initiated on 18 May, prior to disease development. Subsequent 14-d treatments were made on 31 May, 15 June, 29 June, 12 July, and 28 July. Subsequent 21-d treatments were made on 7 June, 29 June, and 20 July.

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

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

Table 3. Effect of new and experimental AMVAC fungicides tank-mixed with various fungicides on NDVI vegetation index on an annual bluegrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000 ft^2	Int[z]	NDVI				
			17 Jun	1 Jul	8 Jul	27 Jul	12 Aug
			---------------------------- Vegetation Index				---------------------------------
OREON	4.0 fl.oz.	14-d	0.700 a-d[y]	0.736 c-g	0.739	0.781	0.773
+ Harrell's Par	0.37 fl.oz.						
OREON	6.0 fl.oz.	14-d	0.714 a	0.746 a-e	0.741	0.769	0.756
+ Harrell's Par	0.37 fl.oz.						
OREON	8.0 fl.oz.	14-d	0.711 ab	0.725 fg	0.743	0.753	0.758
+ Harrell's Par	0.37 fl.oz.						
Autilus	6.0 fl.oz.	14-d	0.709 ab	0.736 c-g	0.741	0.774	0.748
+ Harrell's Par	0.37 fl.oz.						
UC16-14	6.0 fl.oz.	14-d	0.709 ab	0.742 a-f	0.734	0.809	0.748
+ Harrell's Par	0.37 fl.oz.						
Velista	0.5 oz.	14-d	0.700 a-d	0.758 ab	0.735	0.777	0.748
Velista	0.5 oz.	14-d	0.703 a-d	0.743 a-f	0.737	0.774	0.772
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Insignia SC	0.5 fl.oz.	14-d	0.703 a-d	0.736 c-g	0.726	0.736	0.751
Insignia SC	0.5 fl.oz.	14-d	0.718 a	0.744 a-f	0.742	0.766	0.751
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Heritage TL	1.0 fl.oz.	14-d	0.680 cde	0.726 efg	0.739	0.732	0.747
Heritage TL	1.0 fl.oz.	14-d	0.692 a-e	0.736 c-g	0.738	0.773	0.766
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Medallion SC	1.5 fl.oz.	14-d	0.699 a-d	0.743 abc	0.743	0.752	0.750
Medallion SC	1.5 fl.oz.	14-d	0.714 a	0.745	0.729	0.780	0.750
+ UC16-14	6.0 fl.oz.						
+ Harrell's Par	0.37 fl.oz.						
Signature Xtra	4.0 oz.	14-d	0.708 ab	0.738 a-e	0.727	0.765	0.757
Signature Xtra	4.0 oz.	14-d	0.708 ab	0.737 b-g	0.730	0.781	0.754
+ UC16-14	6.0 fl.oz.						
Civitas One	8.5 fl.oz.	14-d	0.695 a-e	0.750 c-g	0.740	0.751	0.756
Civitas One	8.5 fl.oz.	14-d	0.678 de	0.720 g	0.735	0.760	0.754
+ UC16-14	6.0 fl.oz.						
UC16-13	0.8 fl.oz.	21-d	0.685 b-e	0.742 a-f	0.736	0.758	0.746
UC16-13	1.0 fl.oz.	21-d	0.713 a	0.759 a	0.751	0.768	0.753
UC16-13	1.2 fl.oz.	21-d	0.705 abc	0.739 b-g	0.746	0.760	0.734
Mirage	1.0 fl.oz.	14-d	0.708 ab	0.747 a-d	0.744	0.759	0.756
Untreated			0.666 e	0.727 d-g	0.723	0.720	0.739
ANOVA: Treatment (P > F)			0.0251	0.0164	0.6211	0.0641	0.3110
Days after treatment		14-d	2	2	9	15	3
		21-d	10	2	9	7	3

[z]Treatments were initiated on 18 May, prior to disease development. Subsequent 14-d treatments were made on 31 May, 15 June, 29 June, 12 July, and 28 July. Subsequent 21-d treatments were made on 7 June, 29 June, and 20 July.

[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. Effect of new and experimental AMVAC fungicides tank-mixed with various fungicides on phytotoxicity on an annual bluegrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[z]	Phytotoxicity					
			10 Jun	17 Jun	24 Jun	1 Jul	28 Jul	4 Aug
			0-5; 2 = max acceptable					
OREON + Harrell's Par	4.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.0 d[y]	0.0 b	0.0
OREON + Harrell's Par	6.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.0 b	0.0
OREON + Harrell's Par	8.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.0 b	0.0
Autilus + Harrell's Par	6.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.0 b	0.0
UC16-14 + Harrell's Par	6.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.0 b	0.0
Velista	0.5 oz.	14-d	0.0	0.0	0.0	0.0 d	0.0 b	0.0
Velista + UC16-14 + Harrell's Par	0.5 oz. + 6.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.5 abc	0.0 b	0.0
Insignia SC	0.5 fl.oz.	14-d	0.0	0.0	0.0	0.3 bc	0.3 b	0.0
Insignia SC + UC16-14 + Harrell's Par	0.5 fl.oz. + 6.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.5	0.0 d	0.0 b	0.0
Heritage TL	1.0 fl.oz.	14-d	0.0	0.0	0.0	0.1 cd	0.0 b	0.0
Heritage TL + UC16-14 + Harrell's Par	1.0 fl.oz. + 6.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.0 b	0.0
Medallion SC	1.5 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.5 b	0.0
Medallion SC + UC16-14 + Harrell's Par	1.5 fl.oz. + 6.0 fl.oz. + 0.37 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.0 b	0.0
Signature Xtra	4.0 oz.	14-d	0.0	0.0	0.5	0.0 d	0.0 b	0.0
Signature Xtra + UC16-14	4.0 oz. + 6.0 fl.oz.	14-d	0.0	0.0	0.0	0.0 d	0.3 b	0.0
Civitas One	8.5 fl.oz.	14-d	0.0	0.0	0.0	0.1 cd	0.5 b	0.0
Civitas One + UC16-14	8.5 fl.oz. + 6.0 fl.oz.	14-d	0.0	0.0	0.3	0.7 ab	2.3 a	0.0
UC16-13	0.8 fl.oz.	21-d	0.0	0.0	0.0	0.1 cd	0.0 b	0.0
UC16-13	1.0 fl.oz.	21-d	0.0	0.0	0.5	1.0 a	0.0 b	0.0
UC16-13	1.2 fl.oz.	21-d	0.0	0.0	0.5	0.3 bc	0.3 b	0.0
Mirage	1.0 fl.oz.	14-d	0.0	0.0	0.8	1.0 a	0.0 b	0.0
Untreated			0.0	0.0	0.0	0.0 d	0.0 b	0.0
ANOVA: Treatment (P > F)			1.0000	1.0000	0.1837	0.0001	0.0001	1.0000
Days after treatment		14-d	10	2	9	2	0	7
		21-d	3	10	17	2	0	15

[z]Treatments were initiated on 18 May, prior to disease development. Subsequent 14-d treatments were made on 31 May, 15 June, 29 June, 12 July, and 28 July. Subsequent 21-d treatments were made on 7 June, 29 June, and 20 July.

[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 5. Effect of new and experimental AMVAC fungicides tank-mixed with various fungicides on algae intensity on an annual bluegrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[z]	Algae Intensity 8 July
			-- 0-5; 2 = max acceptable --
OREON	4.0 fl.oz.	14-d	2.0 b-e[y]
+ Harrell's Par	0.37 fl.oz.		
OREON	6.0 fl.oz.	14-d	2.3 a-d
+ Harrell's Par	0.37 fl.oz.		
OREON	8.0 fl.oz.	14-d	2.3 a-d
+ Harrell's Par	0.37 fl.oz.		
Autilus	6.0 fl.oz.	14-d	2.0 b-e
+ Harrell's Par	0.37 fl.oz.		
UC16-14	6.0 fl.oz.	14-d	1.5 cde
+ Harrell's Par	0.37 fl.oz.		
Velista	0.5 oz.	14-d	2.8 abc
Velista	0.5 oz.	14-d	1.5 cde
+ UC16-14	6.0 fl.oz.		
+ Harrell's Par	0.37 fl.oz.		
Insignia SC	0.5 fl.oz.	14-d	1.8 b-e
Insignia SC	0.5 fl.oz.	14-d	2.0 b-e
+ UC16-14	6.0 fl.oz.		
+ Harrell's Par	0.37 fl.oz.		
Heritage TL	1.0 fl.oz.	14-d	2.8 abc
Heritage TL	1.0 fl.oz.	14-d	2.3 a-d
+ UC16-14	6.0 fl.oz.		
+ Harrell's Par	0.37 fl.oz.		
Medallion SC	1.5 fl.oz.	14-d	1.3 def
Medallion SC	1.5 fl.oz.	14-d	1.3 def
+ UC16-14	6.0 fl.oz.		
+ Harrell's Par	0.37 fl.oz.		
Signature Xtra	4.0 oz.	14-d	0.8 ef
Signature Xtra	4.0 oz.	14-d	0.0 f
+ UC16-14	6.0 fl.oz.		
Civitas One	8.5 fl.oz.	14-d	3.0 ab
Civitas One	8.5 fl.oz.	14-d	2.3 a-d
+ UC16-14	6.0 fl.oz.		
UC16-13	0.8 fl.oz.	21-d	2.0 b-e
UC16-13	1.0 fl.oz.	21-d	3.0 ab
UC16-13	1.2 fl.oz.	21-d	3.0 ab
Mirage	1.0 fl.oz.	14-d	3.5 a
Untreated			2.0 b-e
ANOVA: Treatment (P > F)			0.0005
Days after treatment		14-d	9
		21-d	9

[z]Treatments were initiated on 18 May, prior to disease development. Subsequent 14-d treatments were made on 31 May, 15 June, 29 June, 12 July, and 28 July. Subsequent 21-d treatments were made on 7 June, 29 June, and 20 July.

[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).

PREVENTIVE BROWN PATCH CONTROL WITH FUNGICIDES ON A COLONIAL BENTGRASS FAIRWAY TURF, 2016

K. Miele, J. Dunnack, Z. Esponda, S. Vose, and J. Inguagiato

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

INTRODUCTION

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

MATERIALS & METHODS

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

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

Brown patch was assessed visually as a percentage of the plot area blighted by *Rhizoctonia solani*. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS AND DISCUSSION

Brown Patch Incidence

Conditions conducive to disease development first occurred in mid-July, and by 28-July the brown patch epidemic was quite severe in untreated plots, averaging 35% blighted area (Table 1a + 1b). Most treatments provided good to excellent levels of disease control as of this date. Kabuto + TebuStar (all rates and intervals), performed very well. Kabuto applied alone was less effective than when tank-mixed with TebuStar. The addition of Transfilm, a surfactant, to this mix did not have any impact on efficacy. When applied alone, Transfilm showed moderate (>10%) levels of disease. Fame+T, Heritage WG, Heritage Action, Affirm, Compass, Exteris Stressgard, and Interface also controlled disease well as of this date. There was no difference in control between the different formulations of Heritage.

Disease continued to progress, and as of 16 August, untreated plots reached almost 40% plot area blighted. Most treatments continued to provide good disease control, with the exception of Kabuto or Transfilm applied alone, which were largely no different than the untreated control. Kabuto is a new SDHI fungicide, and like many SDHI fungicides has a relatively narrow spectrum of disease control activity. Kabuto is currently only labeled for dollar spot control.

Turf Quality and Phytotoxicity

Turf quality (Table 2) was primarily affected by disease severity. In general, the trial area was well fertilized and conducive to high-quality turf, leading to high turf quality ratings for most treatments. Poor turf quality (<6) was observed on Kabuto and Transfilm (applied alone) treated plots, as well as untreated plots at the height of the epidemic on 16 August.

There was little to no phytotoxicity caused by any of the treatments for the duration of the trial (Table 3.)

Table 1a. Effect of various fungicides on preventative brown patch control on a colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[z]	24 Jun	8 Jul	15 Jul	22 Jul	28 Jul
			Brown Patch Severity				
			% plot area blighted				
Kabuto + TebuStar	0.4 fl.oz. + 1.1 fl.oz.	14-d	0.0	0.0	0.2[y] cd[x]	1.7 b-e	2.3 b-e
Kabuto + TebuStar	0.4 fl.oz. + 1.1 fl.oz.	28-d	0.0	0.0	0.0 d	1.5 b-e	3.5 b-e
Kabuto + TebuStar	0.4 fl.oz. + 0.7 fl.oz.	14-d	0.0	0.0	0.0 d	0.9 b-e	0.0 e
Kabuto + TebuStar	0.4 fl.oz. + 0.7 fl.oz.	28-d	0.0	0.0	0.0 d	0.3 de	0.0 e
Kabuto + TebuStar + Transfilm	0.4 fl.oz. + 0.7 fl.oz. + 2.83 fl.oz.	14-d	0.0	0.0	0.0 d	1.3 b-e	0.7 e
Kabuto + TebuStar + Transfilm	0.4 fl.oz. + 0.7 fl.oz. + 2.83 fl.oz.	28-d	0.0	0.0	2.1 bc	1.5 b-e	0.6 e
Kabuto + TebuStar	0.5 fl.oz. + 0.68 fl.oz.	14-d	0.0	0.0	0.0 d	0.3 de	0.0 e
Kabuto + TebuStar	0.5 fl.oz. + 0.68 fl.oz.	28-d	0.0	0.0	0.0 d	0.3 de	0.0 e
Fame+T	0.9 fl.oz.	28-d	0.0	0.0	0.0 d	0.6 cde	0.6 e
Heritage WG	0.2 oz.	21-d	0.0	0.0	0.0 d	0.0 e	0.7 e
Heritage Action	0.2 oz.	21-d	0.0	0.0	0.0 d	0.7 cde	0.6 e
Heritage WG	0.3 oz.	21-d	0.0	0.0	0.0 d	0.0 e	0.7 e
Heritage Action	0.3 oz.	28-d	0.0	0.0	0.0 d	0.6 cde	2.3 b-e
Affirm	0.88 oz.	14-d	0.0	0.0	0.0 d	0.6 cde	0.6 e
Kabuto	0.4 fl.oz.	14-d	0.0	0.0	4.3 ab	10.8 a	12.8 ab
Kabuto	0.4 fl.oz.	21-d	0.0	0.0	5.1 ab	9.5 a	3.5 b-e
Kabuto	0.5 fl.oz.	21-d	0.0	0.0	1.5 bcd	5.1 ab	9.3 a-d
+ Transfilm	7.35 fl.oz.	21-d	0.0	0.0	3.6 ab	3.7 abc	11.0 abc
Compass 50WG	0.2 oz.	21-d	0.0	0.0	0.2 cd	1.7 b-e	2.0 cde
Exteris Stressgard	2.94 fl.oz.	21-d	0.0	0.0	0.0 d	1.1 b-e	1.4 de
Interface	3.9 fl.oz.	21-d	0.0	0.0	0.6 cd	2.7 a-d	0.8 e
Untreated			0.0	0.0	8.3 a	11.4 a	35.2 a
ANOVA: Treatment (P > F)			1.0000	1.0000	0.0001	0.0005	0.0002
Days after treatment		14-d	3	8	9	2	8
		21-d	16	9	17	2	8
		28-d	16	2	9	14	22

[z]Treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals.
[y]Brown patch data were automatically log-transformed. Means are de-transformed for presentation.
[x]Means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$)

Table 1b. Effect of various fungicides on preventative brown patch control on a colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[z]	Brown Patch Severity			
			1 Aug	5 Aug	16 Aug	19 Aug
			------------------- % plot area blighted ------------------			
Kabuto	0.4 fl.oz.	14-d	0.0[y] d[x]	1.8 bcd	0.0 c	0.0 e
+ TebuStar	1.1 fl.oz.					
Kabuto	0.4 fl.oz.	28-d	1.6 bcd	1.6 bcd	0.0 c	0.7 de
+ TebuStar	1.1 fl.oz.					
Kabuto	0.4 fl.oz.	14-d	0.0 d	0.6 cd	0.0 c	0.0 e
+ TebuStar	0.7 fl.oz.					
Kabuto	0.4 fl.oz.	28-d	0.0 d	0.7 cd	0.0 c	0.0 e
+ TebuStar	0.7 fl.oz.					
Kabuto	0.4 fl.oz.	14-d	0.0 d	0.0 d	0.0 c	0.0 e
+ TebuStar	0.7 fl.oz.					
+ Transfilm	2.83 fl.oz.					
Kabuto	0.4 fl.oz.	28-d	0.0 d	0.6 cd	1.1 c	0.5 e
+ TebuStar	0.7 fl.oz.					
+ Transfilm	2.83 fl.oz.					
Kabuto	0.5 fl.oz.	14-d	0.0 d	0.0 d	0.0 c	0.0 e
+ TebuStar	0.68 fl.oz.					
Kabuto	0.5 fl.oz.	28-d	0.0 d	0.0 d	0.0 c	0.0 e
+ TebuStar	0.68 fl.oz.					
Fame+T	0.9 fl.oz.	28-d	0.0 d	0.0 d	0.0 c	0.0 e
Heritage WG	0.2 oz.	21-d	0.0 d	0.0 d	0.0 c	0.0 e
Heritage Action	0.2 oz.	21-d	0.0 d	0.0 d	0.0 c	0.0 e
Heritage WG	0.3 oz.	21-d	0.0 d	0.0 d	0.0 c	0.0 e
Heritage Action	0.3 oz.	28-d	0.0 d	0.0 d	0.0 c	0.7 de
Affirm	0.88 oz.	14-d	0.7 cd	1.2 bcd	0.0 c	0.0 e
Kabuto	0.4 fl.oz.	14-d	27.9 a	32.4 a	49.9 a	56.1 ab
Kabuto	0.4 fl.oz.	21-d	5.0 b	0.6 cd	15.8 b	27.6 c
Kabuto	0.5 fl.oz.	21-d	22.8 a	30.2 a	39.9 a	53.2 ab
+ Transfilm	7.35 fl.oz.	21-d	28.6 a	35.7 a	54.4 a	67.1 a
Compass 50WG	0.2 oz.	21-d	0.4 d	0.0 d	0.0 c	0.0 e
Exteris Stressgard	2.94 fl.oz.	21-d	1.2 bcd	2.2 bc	1.3 c	1.8 de
Interface	3.9 fl.oz.	21-d	3.8 bc	5.3 b	1.8 c	5.6 d
Untreated			43.8 a	40.3 a	39.4 a	43.4 bc
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	0	4	0	3
		21-d	12	16	7	10
		28-d	0	4	14	17

[z]Treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals.
[y]Brown patch data were automatically log-transformed. Means are de-transformed for presentation.
[x]Means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05)

Table of Contents

Table 2. Effect of various fungicides on turf quality on a colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[z]	Turf Quality 24 Jun	8 Jul	22 Jul	5 Aug	16 Aug
			-------------------- 1-9; 6=min acceptable --------------------				
Kabuto	0.4 fl.oz.	14-d	7.5	7.5	6.5 c-f[y]	7.8 abc	7.3 b
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	7.5	7.8	7.5 abc	8.0 abc	7.3 b
+ TebuStar	1.1 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	7.5	8.0	7.8 abc	8.3 abc	8.3 ab
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	7.5	7.8	7.8 abc	8.3 abc	7.8 ab
+ TebuStar	0.7 fl.oz.						
Kabuto	0.4 fl.oz.	14-d	7.3	7.8	7.3 a-d	8.3 abc	7.3 b
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.4 fl.oz.	28-d	7.0	7.5	7.5 abc	7.8 abc	7.8 ab
+ TebuStar	0.7 fl.oz.						
+ Transfilm	2.83 fl.oz.						
Kabuto	0.5 fl.oz.	14-d	7.8	8.0	8.0 ab	8.5 ab	7.3 b
+ TebuStar	0.68 fl.oz.						
Kabuto	0.5 fl.oz.	28-d	7.5	8.0	7.8 abc	8.0 abc	7.5 ab
+ TebuStar	0.68 fl.oz.						
Fame+T.......................	0.9 fl.oz.	28-d	7.0	7.8	7.5 abc	8.3 abc	7.8 ab
Heritage WG..................	0.2 oz.	21-d	7.3	8.0	7.8 abc	9.0 a	8.3 ab
Heritage Action.............	0.2 oz.	21-d	7.0	7.8	7.5 abc	8.5 ab	8.5 a
Heritage WG..................	0.3 oz.	21-d	7.5	8.0	8.5 a	8.5 ab	8.5 a
Heritage Action.............	0.3 oz.	28-d	7.8	8.0	7.0 b-e	8.3 abc	8.5 a
Affirm..........................	0.88 oz.	14-d	7.5	8.0	8.0 ab	8.3 abc	8.3 ab
Kabuto	0.4 fl.oz.	14-d	8.0	8.0	5.8 ef	4.3 d	4.0 d
Kabuto	0.4 fl.oz.	21-d	7.3	7.3	5.8 ef	8.0 abc	5.5 c
Kabuto	0.5 fl.oz.	21-d	7.8	7.8	6.0 def	4.3 d	4.0 d
+ Transfilm	7.35 fl.oz.	21-d	7.5	7.5	6.5 c-f	4.5 d	3.3 d
Compass 50WG.............	0.2 oz.	21-d	7.8	7.8	7.5 abc	9.0 a	8.0 ab
Exteris Stressgard	2.94 fl.oz.	21-d	8.3	8.0	8.0 ab	6.8 c	7.8 ab
Interface......................	3.9 fl.oz.	21-d	7.5	7.8	7.8 abc	7.0 bc	7.3 b
Untreated			8.3	7.3	5.3 f	4.3 d	3.8 d
ANOVA: Treatment (P > F)			0.3521	0.3851	0.0010	0.0001	0.0001
Days after treatment		14-d	3	8	2	4	0
		21-d	16	2	2	16	7
		28-d	16	2	14	4	14

[z]Treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals.
[y]Means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test (α = 0.05)

Table 3. Effect of various fungicides on phytotoxicity on a colonial bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[z]	Phytotoxicity 24 Jun	8 Jul
			- 0-5; 2=max acceptable -	
Kabuto	0.4 fl.oz.	14-d	0.3	0.0
+ TebuStar	1.1 fl.oz.			
Kabuto	0.4 fl.oz.	28-d	0.0	0.0
+ TebuStar	1.1 fl.oz.			
Kabuto	0.4 fl.oz.	14-d	0.0	0.0
+ TebuStar	0.7 fl.oz.			
Kabuto	0.4 fl.oz.	28-d	0.0	0.0
+ TebuStar	0.7 fl.oz.			
Kabuto	0.4 fl.oz.	14-d	0.0	0.0
+ TebuStar	0.7 fl.oz.			
+ Transfilm	2.83 fl.oz.			
Kabuto	0.4 fl.oz.	28-d	0.0	0.0
+ TebuStar	0.7 fl.oz.			
+ Transfilm	2.83 fl.oz.			
Kabuto	0.5 fl.oz.	14-d	0.0	0.0
+ TebuStar	0.68 fl.oz.			
Kabuto	0.5 fl.oz.	28-d	0.0	0.0
+ TebuStar	0.68 fl.oz.			
Fame+T	0.9 fl.oz.	28-d	0.0	0.0
Heritage WG	0.2 oz.	21-d	0.3	0.0
Heritage Action	0.2 oz.	21-d	0.3	0.0
Heritage WG	0.3 oz.	21-d	0.0	0.0
Heritage Action	0.3 oz.	28-d	0.0	0.0
Affirm	0.88 oz.	14-d	0.0	0.0
Kabuto	0.4 fl.oz.	14-d	0.0	0.0
Kabuto	0.4 fl.oz.	21-d	0.0	0.0
Kabuto	0.5 fl.oz.	21-d	0.0	0.0
+ Transfilm	7.35 fl.oz.	21-d	0.0	0.0
Compass 50WG	0.2 oz.	21-d	0.0	0.0
Exteris Stressgard	2.94 fl.oz.	21-d	0.0	0.0
Interface	3.9 fl.oz.	21-d	0.0	0.0
Untreated			0.0	0.0
ANOVA: Treatment (P > F)			0.4773	1.0000
Days after treatment		14-d	3	8
		21-d	16	2
		28-d	16	2

[z]Treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals.

PREVENTIVE BROWN PATCH CONTROL WITH FUNGICIDES ON A TALL FESCUE LAWN TURF, 2016

K. Miele, J. Dunnack, Z. Esponda, S. Vose, and J. Inguagiato

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

INTRODUCTION

Brown patch of turfgrass, caused by *Rhizoctonia solani* is characterized by round patches of diffusely-blighted, thinned turf. It is a summer disease that is most active under warm (nighttime temperatures ≥ 65° F) and humid conditions. It is commonly controlled using cultural practices such as avoiding excess nitrogen and improving air movement, as well as through the use of preventative fungicides. In residential turf maintenance granular fungicide formulations are sometimes preferable over sprayable formulations for their ease of use. However, questions arise as to whether disease control between fungicide formulations is equivalent based on the differences in converage that may result during the application. The objectives of this study was to compare efficacy of various formulations of commonly used residential turf fungicides and to evaluate the effectiveness of new and existing fungicides at controlling brown patch in a tall fescue lawn turf.

MATERIALS & METHODS

A field study was conducted on a 'Crossfire 3' tall fescue (*Lolium arundinaceum*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed two days wk^{-1} at a cutting height of 3-inches. Nitrogen was applied to the study area to encourage brown patch development. A total of 1.25 lb N 1000-ft^{-2} was applied as water soluble sources from April through July. Overhead irrigation was applied daily each evening during the trial to extend leaf wetness period and encourage disease development.

Treatments consisted of granular or sprayable fungicides. Initial applications were made on 16 June prior to disease developing in the trial area. Subsequent applications were made at specified treatment intervals through 16 August. Liquid treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft^{-2} at 40 psi. Granular treatments were applied using a hand-held shaker jar. Following treatment application, granular treatments received 0.1 inch of water delivered with a watering can.

On 22 July the trial area was inoculated with 6.1 oz 1000 ft^{-2} of sterile, dried Kentucky bluegrass seed infested with *Rhizoctonia solani* to aid in uniform development of disease symptoms.

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

RESULTS AND DISCUSSION

Brown Patch Incidence

Disease was developed throughout the trial area by 1 August, with untreated plots averaging 17% brown patch as of this date (Table 1). Disease levels on untreated plots remained unacceptable (>10%) through 16 August.

Headway TL, a premix of azoxystrobin and propiconazole, was applied at 3 rates (1.5, 2.25, and 3.0 fl.oz. 1000-ft^{-2}) and three application intervals (14, 21, and 28-d). All combinations adequately (<10% plot area blighted) controlled disease on 1 August, and all provided total control of disease on 16 August (Table 1).

Heritage G, a granular formulation of azoxystrobin, and Heritage TL, a liquid formulation, provided near total control of disease at all rates and intervals as of 16 August (Table 1). Conversely, differences between formulations of other fungicides were observed. Banner MAXX, a sprayable formulation of propiconazole, maintained adequate control throughout the trial. Whereas, Prophesy, a granular formulation of propiconazole, applied at the same interval and rate of active ingredient, initially provided comparable control as the sprayable formulation (i.e., Banner MAXX) 4 DAT (days after treatment), but was less effective 19 DAT (16 August). Similarly, Pillar G, a granular premix of pyraclostrobin and triticonazole, provided comparable control to equivalent rates and intervals of sprayable Insignia Intrinsic + Trinity tank mixes initially (1 August), although was less effective than the sprayable tank mix on 16 August, reaching an unacceptable level.

The SDHI fungicides Velista, Xzemplar, and Kabuto were each applied at 21- and 28-d intervals. Velista provided adequate control of disease at all dates, although the 28-d interval had slightly more (albeit acceptable) disease as of 16 August. Xzemplar (21-d) provided good (<5%) control of disease, but failed to adequately control brown patch at the 28-d interval. Kabuto did not adequately control disease at either interval after 1 August.

Differences in the efficacy of granular formulated fungicides versus their sprayable equivalent were observed. Heritage G provided equivalent control as Heritage TL; whereas Prophesy and Pillar G did not seem to provide as effective control as there sprayable equivalent. This may be due to differences in fungicide coverage, carrier technology, phytomobility of the fungicide, and the inherent activity of the fungicide, among other considerations. Headway applied at 2.25 to 3.0 fl.oz. every 21- to 28-d provided very good brown patch control in this trial. New SDHI fungicides Velista and Xzemplar were also effective and provide new options for brown patch control in residential lawn turf.

Table 1. Brown patch severity influenced by various fungicides on a tall fescue lawn turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment Rate per 1000ft²	Int[z]	Brown Patch Severity			
		1 Jul	28 Jul	1 Aug	16 Aug
		--------------- % plot area blighted ---------------			
Headway TL ....1.5 fl.oz.	14-d	0.0	0.0[y]	6.8 a-f[x]	0.0 e
Headway TL ....1.5 fl.oz.	21-d	0.0	0.0	1.8 efg	0.0 e
Headway TL ....2.25 fl.oz.	21-d	0.0	0.0	4.2 b-g	0.0 e
Headway TL ....2.25 fl.oz.	28-d	0.0	0.0	5.8 a-g	0.0 e
Headway TL ....3.0 fl.oz.	28-d	0.0	0.0	4.6 b-g	0.0 e
Heritage G.......................3.0 lb.	21-d	0.0	0.0	1.4 fg	0.8 de
Heritage G.......................3.0 lb.	28-d	0.0	0.4	6.2 a-f	0.0 e
Heritage TL...............1.49 fl.oz.	21-d	0.0	0.0	3.7 c-g	0.0 e
Heritage TL...............1.49 fl.oz.	28-d	0.0	0.0	4.6 b-g	0.0 e
Prophesy ....2.5 lb.	21-d	0.0	0.0	7.1 a-f	25.5 a
Banner Maxx ....1.77 fl.oz.	21-d	0.0	0.6	7.5 a-f	4.8 bcd
Pillar G........................... 3.0 lb.	21-d	0.0	0.8	11.8 a-d	14.9 abc
Pillar G............................3.0 lb.	28-d	0.0	0.0	7.0 a-f	18.3 ab
Insignia Intrinsic ....0.7 fl.oz. + Trinity..................0.98 fl.oz.	21-d	0.0	0.0	2.6 d-g	0.0 e
Insignia Intrinsic ....0.7 fl.oz. + Trinity..................0.98 fl.oz.	28-d	0.0	0.0	2.5 d-g	0.0 e
Velista............................0.3 oz.	21-d	0.0	0.0	2.8 c-g	0.0 e
Velista............................0.5 oz.	21-d	0.0	0.0	8.4 a-e	0.0 e
Velista............................0.5 oz.	28-d	0.0	0.0	0.9 g	4.2 cd
Xzemplar ....0.21 fl.oz.	21-d	0.0	0.0	4.1 b-g	0.0 e
Xzemplar ....0.21 fl.oz.	28-d	0.0	0.8	11.5 a-d	11.9 abc
Kabuto ....0.4 fl.oz.	21-d	0.0	2.8	11.3 a-d	12.6 abc
Kabuto ....0.5 fl.oz.	28-d	0.0	1.1	23.2 a	26.4 a
Untreated		0.0	0.8	17.2 ab	10.7 abc
ANOVA: Treatment (P > F)		1.0000	0.1649	0.0206	0.0001
Days after treatment	14-d	1	0	4	5
	21-d	15	0	4	19
	28-d	15	14	18	5

[z]Treatments were initiated on 16 June, prior to disease development. Treatments were reapplied at specified intervals through 11 August.

[y]Brown Patch data were log transformed for ANOVA and mean separation tests, although means presented are de-transformed values.

[x]reatment 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 COPPER SPOT CONTROL USING VARIOUS SDHI FUNGICIDES APPLIED WITH AND WITHOUT SECURE ON A CREEPING BENTGRASS PUTTING GREEN TURF, 2016

K. Miele, J. Dunnack, Z. Esponda, S. Vose, and J. Inguagiato

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

INTRODUCTION

Copper spot disease of cool-season turfgrasses caused by the *Gloeocercospora sorghi* fungal pathogen. On golf course putting greens it is characterized by small, copper-colored spots. The fungus produces abundant spores which may be tracked by turf equipment leaving linear patterns on the putting surface as the disease spreads. It is particularly active during periods of hot daytime temperatures (85°F), warm nighttime temperatures (65°F), and high humidity. Excessive nitrogen and low pH can also enhance disease growth. Copper spot can be controlled by a wide range of fungicides, and because it typically develops later in the summer than other diseases, control is often achieved as part of an already-in-place fungicide rotation program. The objective of this study was to evaluate the efficacy of various SDHI fungicides in controlling copper spot on a creeping bentgrass putting green turf.

MATERIALS & METHODS

A field study was conducted on a 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inch. Nitrogen was applied at a total of 2.0 lb N $1000\text{-}ft^{-2}$ as water soluble sources from April through September. Dylox 80 was applied on 27 May for control of white grubs. Quicksilver was applied on 6 August and 20 August for control of silvery-thread moss. Scimitar was applied on 27 August for control of cutworms. To help alleviate dry surface conditions, the wetting agent Dispatch was applied on 18 June and Revolution was applied on 23 July. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of various SDHI fungicides, applied individually or tank-mixed with Secure. Initial applications were made prior to the onset of disease symptoms on 30 June. Subsequent applications were made on a 14-d interval through 25 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Copper spot incidence was assessed as a count of individual disease foci within each plot. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Copper spot incidence data were log transformed for ANOVA and mean separation tests, although means presented are de-transformed values.

RESULTS AND DISCUSSION

Copper Spot Incidence

Copper spot symptoms first developed on 28 July from a natural infestation, increasing slowly to 16 spots 18 ft^{-2} in untreated plots by 19 August (Table 1). Disease continued to increase through 2 September, when untreated plots reached a maximum of 53 spots 18 ft^{-2}.

Secure applied alone or as a tank-mix with an SDHI fungicide provided complete or near-complete control of disease on all observation dates. Lexicon Intrinsic, a premix of fluxapuroxad (an SDHI and the active ingredient in Xzemplar) plus pyraclostrobin, also provided complete control of disease regardless of the addition of Secure. SDHI fungicides applied alone generally failed to control copper spot (i.e., no different from control), except Kabuto. Kabuto-alone treated turf consistently maintained acceptable levels of copper spot (i.e., < 5 spots 18 ft^{-2}) and reduced disease compared to untreated control. However, the Kabuto + Secure tank mix reduced copper spot greater than Kabuto-alone as disease increased in late-August and September. This is the first year where Kabuto has been evaluated for copper spot control at this location.

SDHI fungicides tested in this trial generally did not provide control of copper spot unless another, non-SDHI fungicide was present either as a premix or tank-mix, with the exception of Kabuto. It remains unclear whether Kabuto has unique activity among SDHI fungicides to control copper spot, or whether disease was not sufficiently distributed in the field to adequately test Kabuto. These results should be confirmed with an additional year of observation. While it is likely that copper spot will be controlled by a typical fungicide rotation, SDHI's alone should not be relied upon for copper spot control when conditions are conducive for this disease.

Table 1. Copper spot incidence influenced by various SDHI fungicides and Secure on a creeping bentgrass putting green turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[z]	Copper Spot Incidence				
			28 Jul	11 Aug	19 Aug	26 Aug	2 Sep
			------------------- # copper spot foci 18ft^{-2} ------------------				
Kabuto	0.4 fl.oz.	14-d	0.7	0.7[y] bc[x]	0.6 c	4.7 c	4.6 b
Kabuto + Secure	0.4 fl.oz. + 0.5 fl.oz.	14-d	0.4	0.3 bc	0.0 c	0.0 d	0.0 c
Velista	0.3 oz.	14-d	1.0	11.7 a	46.1 a	97.5 a	77.1 a
Velista + Secure	0.3 oz. + 0.5 fl.oz.	14-d	0.0	0.3 bc	0.0 c	1.8 cd	0.4 c
Emerald	0.13 oz.	14-d	2.2	2.8 ab	5.4 b	19.3 b	24.0 a
Emerald + Secure	0.13 oz. + 0.5 fl.oz.	14-d	0.5	0.0 c	0.0 c	1.6 cd	0.6 c
Xzemplar	0.16 fl.oz.	14-d	0.9	3.9 ab	16.4 ab	47.4 ab	31.9 a
Xzemplar + Secure	0.16 fl.oz. + 0.5 fl.oz.	14-d	0.8	0.0 c	0.0 c	0.8 cd	0.0 c
Lexicon Intrinsic	0.34 fl.oz.	14-d	0.0	0.0 c	0.0 c	0.6 d	0.0 c
Lexicon Intrinsic + Secure	0.34 fl.oz. + 0.5 fl.oz.	14-d	0.0	0.0 c	0.0 c	0.0 d	0.0 c
Secure	0.5 fl.oz.	14-d	0.1	0.6 bc	0.0 c	0.3 d	0.0 c
Untreated			1.9	6.2 a	16.1 ab	35.3 ab	53.8 a
ANOVA: Treatment (P > F)			0.2675	0.0018	0.0001	0.0001	0.0001
Days after treatment			14	14	8	1	7

[z]Treatments were initiated on 30 June, prior to disease development. Treatments were reapplied on a 14-d basis through 25 August.

[y]Copper spot data were log transformed for ANOVA and mean separation tests, although means presented are de-transformed values.

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

PREVENTIVE DOLLAR SPOT CONTROL WITH PINPOINT AND SDHI FUNGICIDES APPLIED AT VARIOUS RATES AND INTERVALS ON A CREEPING BENTGRASS FAIRWAY TURF, 2016

K. Miele, J. Dunnack, Z. Esponda, S. Vose, and J. Inguagiato

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

INTRODUCTION

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

MATERIALS & METHODS

A field study was conducted on a 'Nintey-six Two' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage dollar spot development. A total of 0.45 lb N 1000-ft^{-2} was applied as water soluble sources from April through September. The study area was inoculated with *Sclerotinia homoeocarpa* infested, dried Kentucky bluegrass seed at 3.6 oz. 1000-ft^{-2} on 29 June. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of new fungicide formulations, currently available products applied individually, as tank mixes, and/or in rotational programs, and nutritional programs. Initial applications for most treatments were made on 19 May prior to disease developing in the trial area. Fourteen day intervals of Pinpoint, UC16-15 and UC16-16 were initially applied on 1 June. Twenty-one day intervals of Pinpoint, UC16-16, and UC16-8 (21-d) were applied initiallyon 10 June. Subsequent applications were made at specified intervals through 11 August. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9504E flat fan nozzle calibrated to deliver 1.0 gal 1000-ft^{-2} at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual dollar spot infection centers within each plot from 3 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. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Dollar spot data were log-transformed, and means were detransformed for presentation.

RESULTS AND DISCUSSION

Dollar Spot Incidence

Dollar spot developed from a natural infestation on 3 June and increased slowly throughout the month with 62 dollar spot infection centers (DISC) in untreated control plots forming by 1 July (Table 1a). All treatments provided good dollar spot control during this time except, UC16-8, Pinpoint, UC16-15, and UC16-16 since initial applications of these products did not occur until 1 June (14-d interval) or 10 June (21-d interval). Following inoculation and favorable environmental conditions for disease, dollar spot incidence increased dramatically during July (80 to 213 DISC in untreated) and August (250 to 326 DISC in untreated plots) (Tables 1a and 1b).

Kabuto + TebuStar tank mixes were evaluated at various rates and intervals; with and without Transfilm, a surfactant. Kabuto + TebuStar applied every 14-d generally provided acceptable dollar spot control (~30 DISC plot^{-1}) throughout July and August regardless of fungicide rate (Table 1b). However, when applied every 28-d these same tank mixes and rates failed to consistently provide acceptable dollar spot control during the height of the epidemic in July and August. The addition of Transfilm had little effect on dollar spot incidence.

All currently commercially available SDHI fungicides labeled for dollar spot control were applied at various rates and intervals to assess duration of control of these products. Xzemplar applied at 0.21 fl.oz. every 21-d or 0.26 fl.oz. every 28-d routinely provided good dollar spot control through July and August (Table 1b). Velista applied at 0.3 oz. every 14-d generally provided acceptable disease control. However applications at 0.3 to 0.5 oz. at 21 to 28-d intervals did not provide adequate dollar spot control, particularly during August. Emerald applied at 0.13 oz. or 0.18 oz. every 21- or 28-d, respectively consistently provided acceptable disease control. Kabuto applied alone did not provide acceptable disease control regardless of rate or application interval under the high disease pressure experienced in this trial during July and August.

Secure, UC16-8, UC16-7, Pinpoint (14-d interval), UC16-15, UC16-16, and the Plant Food Program (a rotating tank mix consisting of various nutrients and a low rate of Tebuconazole) all provided good to acceptable dollar spot control during July and August. Pinpoint is a new strobilurin (Q_oI) fungicide which is unique among other fungicides in this chemical class due to its significant activity against the causal agent of dollar spot. However, it has a slightly reduced spectrum activity against other turf diseases compared to most currently used strobilurin fungicides.

Turf Quality and Phytotoxicity

There was little to no phytotoxicity caused by any of the treatments for the duration of the study. As such, turf quality was primarily influenced by disease incidence. On 8 July, most treatments showed acceptable levels of turf quality, with the exception of Kabuto (0.5 oz.) + TebuStar (0.68 oz) (28-d), Kabuto (0.5 oz, 21-d), and Interface (2.0 oz). Due to the inclusion of various nutrients, the Plant Food Program yielded exceptionally good quality as of this date, and was consistently the highest performer in terms of quality on a field that was otherwise fairly nitrogen-deficient. Although quality continued to deteriorate on plots with severe disease breakthrough as of 28 July, plots treated with Kabuto + TebuStar, Xzemplar, Velista (0.5 oz), Emerald (0.18 oz), UC16-8, Secure, UC16-7, UC16-16 (14-d), UC16-15, and the Plant Food Program showed very good-excellent turf quality on this date.

CONCLUSION

Numerous fungicide options exist for dollar spot control in golf course fairways. Data presented in this study demonstrate that optimal disease control is dependent not only on product selection, but also application rate and interval. When selecting fungicides for use, superintendents should consider first your preferred spray interval and evaluate appropriate fungicide products and rates accordingly. Keep in mind that there are very few fungicides which will reliably provide 28 days of dollar spot control. Targeting an extended application interval such as this may result in periodic disease breakthrough, and limit the number of fungicide options available to rotate among. Fewer rotation options will contribute to resistance development.

Table 1a. Dollar spot incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment Rate per 1000ft²	Int[y]	Dollar Spot Incidence 3 Jun	9 Jun	17 Jun	24 Jun	1 Jul	8 July	15 July
		# of dollar spot infection centers 18 ft^{-2}						
Kabuto ....0.4 fl.oz. + TebuStar ....1.1 fl.oz.	14-d	0.0[x] e[w]	0.0 f	0.6 fgh	0.0 e	0.3 hi	1.2 gl	2.7 l-o
Kabuto ....0.4 fl.oz. + TebuStar ....1.1 fl.oz.	28-d	0.3 e	1.4 b-f	1.7 c-g	0.5 cde	0.2 hi	3.0 f-j	12.9 c-h
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz.	14-d	0.0 e	0.0 f	0.2 gh	0.2 e	0.0 i	0.0 l	7.0 g-n
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz.	28-d	0.0 e	0.3 ef	0.2 gh	0.0 e	0.0 i	5.7 d-g	12.0 d-i
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz. + Transfilm .... 2.2% v/v	14-d	0.0 e	0.0 f	0.3 fgh	0.3 de	0.8 f-i	0.2 kl	1.7 no
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz. + Transfilm .... 2.2% v/v	28-d	0.0 e	2.1 b-f	3.4 b-e	0.4 de	0.2 hi	2.3 g-l	8.7 f-l
Kabuto ....0.5 fl.oz. + TebuStar ....0.68 fl.oz.	14-d	0.0 e	0.0 f	0.3 fgh	0.0 e	0.0 i	0.0 l	2.9 j-o
Kabuto ....0.5 fl.oz. + TebuStar ....0.68 fl.oz.	28-d	3.8 bc	4.0 bcd	7.9 b	2.8 b	10.5 bc	19.0 bcd	52.8 ab
Fame+T...................0.9 fl.oz.	28-d	0.3 e	1.3 b-f	1.5 d-h	0.7 cde	3.7 c-f	12.8 b-e	35.9 bcd
Xzemplar ....0.21 fl.oz.	21-d	0.0 e	0.2 ef	0.9 e-h	0.2 e	0.0 i	0.2 kl	2.8 k-o
Xzemplar ....0.21 fl.oz.	28-d	0.3 e	0.4 ef	0.2 gh	0.2 e	0.0 i	2.7 f-k	10.8 e-i
Xzemplar ....0.26 fl.oz.	28-d	0.0 e	0.0 f	0.9 e-h	0.3 de	0.0 i	1.0 h-l	11.6 d-i
Velista........................0.3 oz.	14-d	0.0 e	0.6 def	0.7 e-h	0.2 e	0.0 i	0.2 kl	5.1 g-n
Velista........................0.3 oz.	21-d	0.0 e	0.2 ef	0.3 fgh	0.0 e	0.2 hi	0.0 l	3.6 i-o
Velista........................0.5 oz.	21-d	0.0 e	0.7 c-f	0.7 e-h	0.0 e	0.5 ghi	0.9 i-l	7.4 g-m
Velista........................0.5 oz.	28-d	0.0 e	0.0 f	1.1 e-h	0.2 e	0.0 i	0.6 jkl	5.2 g-n
Emerald....................0.13 oz.	21-d	0.0 e	0.3 ef	0.4 fgh	0.6 cde	2.2 d-h	2.4 g-k	13.1 c-h
Emerald....................0.13 oz.	28-d	0.0 e	0.0 f	1.4 d-h	0.0 e	1.2 f-i	4.9 e-i	15.3 c-g
Emerald....................0.18 oz.	28-d	0.0 e	1.1 b-f	0.0 e	0.0 e	0.7 f-i	1.1 g-l	10.3 e-j
Kabuto ....0.4 fl.oz.	14-d	0.6 e	0.6 def	0.0 e	0.0 e	3.1 c-g	1.9 g-l	13.9 c-h
Kabuto ....0.4 fl.oz.	21-d	0.0 e	0.9 b-f	0.3 de	0.3 de	5.4 b-e	10.4 c-f	61.2 ab
Kabuto ....0.5 fl.oz.	21-d	1.0 e	3.9 bcd	0.0 e	0.0 e	9.8 bc	37.5 ab	124.3 a
Interface..................2.0 fl.oz.	14-d	0.0 e	0.2 ef	0.0 e	0.0 e	5.7 b-e	15.4 b-e	40.3 bc
Interface..................2.0 fl.oz.	21-d	0.0 e	1.8 b-f	0.6 cde	0.6 cde	14.6 b	23.2 bc	66.4 ab
Interface..................3.0 fl.oz.	21-d	0.0 e	0.9 b-f	0.0 e	0.0 e	0.0 i	4.8 e-i	29.7 b-e
UC16-8 ....1.5 fl.oz.	21-d	11.5 a	20.7 a	1.7 bcd	1.7 bcd	1.4 e-i	1.2 g-l	4.3 h-n
Headway ....1.5 fl.oz.	21-d	0.0 e	2.8 b-e	0.0 e	0.0 e	1.9 d-h	1.0 h-l	10.1 e-k
Secure ....0.5 fl.oz.	14-d	0.0 e	0.6 def	0.3 de	0.3 de	0.0 i	0.0 l	1.9 mno
UC16-7 ....0.5 fl.oz.	14-d	0.0 e	0.0 f	0.0 e	0.0 e	0.0 i	1.2 g-l	5.9 g-n
Pinpoint.................0.31 fl.oz.	14-d	13.6 a	4.7 b	2.1 bc	2.1 bc	3.7 c-f	1.7 g-l	10.7 e-i
Pinpoint.................0.31 fl.oz.	21-d	2.4 cd	4.6 bc	0.3 de	0.3 de	6.5 bcd	5.5 d-h	26.3 b-f
UC16-16 ....1.5 fl.oz.	21-d	7.7 ab	21.2 a	0.0 e	0.0 e	1.9 d-h	1.4 g-l	5.8 g-n
UC16-16 ....1.5 fl.oz.	14-d	6.7 abc	0.6 def	0.0 e	0.0 e	0.2 hi	0.0 l	0.6 o
UC16-15 ....0.5 fl.oz.	14-d	5.5 abc	2.0 b-f	0.6 cde	0.6 cde	0.3 hi	1.9 g-l	1.8 mno
Plant Foods Program[z]	14-d	0.0 e	0.0 f	0.0 e	0.0 e	0.3 hi	0.3 jkl	1.8 no
Untreated		8.3 ab	28.0 a	28.3 a	30.6 a	61.7 a	80.1 a	138.6 a
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment	14-d	2	8	2	9	2	9	2
	21-d	15	21	7	14	2	9	16
	28-d	15	21	2	9	15	22	2

[z] The Plant Food program consists of 20-3-3 (6.0 fl.oz.), Impulse (3.0 fl.oz.), Phosphite 30 (2.0 fl.oz.), Green Blade (0.36 fl.oz.), and Torque (0.36 fl.oz.) tank-mixed and applied every 14-d.

y Most treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals. Pinpoint, UC16-15 and UC16-16 (14-d) received their initial application on 1 June. Pinpoint, UC16-16, and UC16-8 (21-d) received their initial application on 10 June.

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

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

Table 1b. Dollar spot incidence influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[y]	Dollar Spot Incidence 22 Jul	28 Jul	11 Aug	19 Aug	26 Aug	2 Sep
			# of dollar spot infection centers 18 ft^{-2}					
Kabuto	0.4 fl.oz.	14-d	0.0[x] n[w]	0.0 o	2.0 n	3.0 l	26.4 n-q	77.8 j-o
+ TebuStar	1.1 fl.oz.							
Kabuto	0.4 fl.oz.	28-d	1.6 k-n	7.2 e-j	72.8 i-l	69.6 fgh	148.7 d-g	357.5 bcd
+ TebuStar	1.1 fl.oz.							
Kabuto	0.4 fl.oz.	14-d	1.4 lmn	1.0 l-o	14.0 mn	7.3 kl	59.2 j-o	140.8 g-k
+ TebuStar	0.7 fl.oz.							
Kabuto	0.4 fl.oz.	28-d	2.2 j-m	10.6 d-i	107.8 f-i	91.2 d-g	151.0 d-g	204.6 e-h
+ TebuStar	0.7 fl.oz.							
Kabuto	0.4 fl.oz.	14-d	0.8 mn	2.2 j-o	3.0 n	6.4 kl	39.5 k-q	102.2 i-n
+ TebuStar	0.7 fl.oz.							
+ Transfilm	2.2% v/v							
Kabuto	0.4 fl.oz.	28-d	2.8 i-m	3.7 h-m	74.0 i-l	76.0 fg	140.8 e-h	174.0 e-i
+ TebuStar	0.7 fl.oz.							
+ Transfilm	2.2% v/v							
Kabuto	0.5 fl.oz.	14-d	0.0 n	3.7 h-m	6.5 n	5.9 kl	63.2 i-n	120.4 g-n
+ TebuStar	0.68 fl.oz.							
Kabuto	0.5 fl.oz.	28-d	16.0 efg	30.7 bcd	163.0 def	150.8 cd	192.3 c-f	280.4 cde
+ TebuStar	0.68 fl.oz.							
Fame+T	0.9 fl.oz.	28-d	7.3 f-j	19.3 d-g	130.5 e-h	107.4 def	147.0 d-g	183.5 e-i
Xzemplar	0.21 fl.oz.	21-d	9.1 e-i	3.0 i-n	38.3 j-n	14.1 jkl	19.5 opq	62.7 k-p
Xzemplar	0.21 fl.oz.	28-d	1.2 lmn	1.7 j-o	65.0 i-m	32.0 hij	43.8 k-q	49.9 m-p
Xzemplar	0.26 fl.oz.	28-d	0.8 mn	0.7 l-o	20.8 lmn	8.8 jkl	16.7 pq	20.4 p
Velista	0.3 oz.	14-d	0.6 mn	2.4 i-o	30.0 k-n	54.0 ghi	150.0 d-g	184.1 e-i
Velista	0.3 oz.	21-d	6.8 f-k	4.8 g-l	73.0 i-l	93.4 d-g	135.7 e-h	176.3 e-i
Velista	0.5 oz.	21-d	28.0 b-e	14.6 d-h	78.5 h-k	88.5 efg	126.1 f-i	177.4 e-i
Velista	0.5 oz.	28-d	1.2 lmn	2.9 i-n	76.0 h-l	89.4 efg	189.8 c-f	216.4 efg
Emerald	0.13 oz.	21-d	21.9 c-f	7.5 e-j	5.8 n	6.8 kl	26.7 n-q	49.1 nop
Emerald	0.13 oz.	28-d	3.8 h-m	7.5 e-j	90.5 g-j	80.0 efg	103.9 g-j	137.0 g-k
Emerald	0.18 oz.	28-d	0.9 mn	2.2 j-o	25.5 k-n	19.4 jkl	25.1 n-q	32.7 op
Kabuto	0.4 fl.oz.	14-d	8.9 e-i	25.8 c-f	78.0 h-k	71.4 fgh	132.8 e-h	213.5 efg
Kabuto	0.4 fl.oz.	21-d	118.2 a	93.2 abc	186.8 cd	151.5 cd	236.7 bcd	370.0 bcd
Kabuto	0.5 fl.oz.	21-d	161.5 a	132.1 a	283.0 a	228.4 b	352.4 ab	496.3 ab
Interface	2.0 fl.oz.	14-d	55.7 a-d	95.7 ab	193.0 cd	179.8 bc	252.3 bc	357.9 bcd
Interface	2.0 fl.oz.	21-d	100.7 a	156.3 a	219.0 bc	202.7 bc	287.0 bc	426.0 abc
Interface	3.0 fl.oz.	21-d	68.2 abc	96.2 ab	177.3 cde	137.7 cde	221.7 cde	359.1 bcd
UC16-8	1.5 fl.oz.	21-d	5.7 g-l	1.9 j-o	8.0 n	7.4 kl	21.9 n-q	48.7 nop
Headway	1.5 fl.oz.	21-d	20.6 def	22.1 def	96.3 ghi	67.4 fgh	75.3 h-m	105.3 h-n
Secure	0.5 fl.oz.	14-d	0.0 n	2.4 i-o	7.0 n	6.8 kl	36.7 l-q	89.4 i-o
UC16-7	0.5 fl.oz.	14-d	0.0 n	1.7 j-o	9.0 n	10.9 jkl	85.8 g-l	150.3 f-j
Pinpoint	0.31 fl.oz.	14-d	2.5 i-m	6.6 f-k	38.3 j-n	25.7 ijk	55.4 j-p	171.7 e-i
Pinpoint	0.31 fl.oz.	21-d	79.5 ab	27.2 b-e	140.0 d-g	112.3 def	193.9 c-f	262.0 def
UC16-16	1.5 fl.oz.	21-d	13.1 e-h	4.2 h-l	32.3 k-n	23.9 ijk	91.4 g-k	134.1 g-l
UC16-16	1.5 fl.oz.	14-d	0.0 n	0.4 mno	2.5 n	2.7 l	14.5 q	52.6 m-p
UC16-15	0.5 fl.oz.	14-d	0.0 n	0.2 no	8.8 n	10.8 jkl	55.0 j-p	126.5 g-m
Plant Foods Program[z]		14-d	1.8 j-n	1.3 k-o	8.5 n	7.1 kl	32.0 m-q	55.5 l-p
Untreated			167.2 a	213.0 a	250.8 ab	325.5 a	486.5 a	604.9 a
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	9	1	15	8	15	22
		21-d	2	8	22	8	15	22
		28-d	9	15	32	8	15	22

[z]The Plant Food program consists of 20-3-3 (6.0 fl.oz.), Impulse (3.0 fl.oz.), Phosphite 30 (2.0 fl.oz.), Green Blade (0.36 fl.oz.), and Torque (0.36 fl.oz.) tank-mixed and applied every 14-d.

[y]Most treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals. Pinpoint, UC16-15 and UC16-16 (14-d) received their initial application on 1 June. Pinpoint, UC16-16, and UC16-8 (21-d) received their initial application on 10 June.

xDollar spot data were automatically log-transformed. Means are de-transformed for presentation.

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

Table 2a. Turf quality influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment Rate per 1000ft²	Int[y]	Turf Quality				
		3 Jun	17 Jun	24 Jun	1 Jul	8 Jul
		---------------------- 1-9; 6 is min acceptable ----------------------				
Kabuto ....0.4 fl.oz. + TebuStar ....1.1 fl.oz.	14-d	6.5 bcd[x]	7.3 b-e	6.8 def	6.5 c-f	6.5 c-f
Kabuto ....0.4 fl.oz. + TebuStar ....1.1 fl.oz.	28-d	7.0 b	7.3 b-e	6.8 def	6.5 c-f	6.3 d-g
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz.	14-d	6.5 bcd	7.5 bcd	6.8 def	6.8 cde	6.5 c-f
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz.	28-d	6.5 bcd	6.8 c-g	7.0 c-f	6.8 cde	6.3 d-g
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz. + Transfilm .... 2.2% v/v	14-d	6.0 cde	7.3 b-e	6.5 ef	6.3 def	6.8 b-e
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz. + Transfilm .... 2.2% v/v	28-d	6.0 cde	6.5 d-g	7.0 c-f	6.5 c-f	6.5 c-f
Kabuto ....0.5 fl.oz. + TebuStar ....0.68 fl.oz.	14-d	6.3 bcd	7.3 b-e	6.5 ef	6.3 def	6.8 b-e
Kabuto ....0.5 fl.oz. + TebuStar ....0.68 fl.oz.	28-d	6.0 cde	6.3 efg	6.8 def	6.0 ef	5.3 h
Fame+T...................0.9 fl.oz.	28-d	6.8 bc	6.8 c-g	7.0 c-f	6.8 cde	5.8 fgh
Xzemplar ....0.21 fl.oz.	21-d	6.8 bc	6.5 d-g	7.3 b-e	6.8 cde	6.5 c-f
Xzemplar ....0.21 fl.oz.	28-d	6.5 bcd	7.0 b-f	7.0 c-f	7.0 bcd	6.8 b-e
Xzemplar ....0.26 fl.oz.	28-d	6.8 bc	7.0 b-f	7.0 c-f	6.8 cde	6.5 c-f
Velista........................0.3 oz.	14-d	6.8 bc	6.5 d-g	6.8 def	7.3 bc	7.0 bcd
Velista........................0.3 oz.	21-d	6.5 bcd	7.0 b-f	7.0 c-f	6.5 c-f	6.5 c-f
Velista........................0.5 oz.	21-d	6.5 bcd	7.0 b-f	7.3 b-e	6.8 cde	6.8 b-e
Velista........................0.5 oz.	28-d	6.8 bc	6.5 d-g	7.3 b-e	6.5 c-f	6.8 b-e
Emerald....................0.13 oz.	21-d	7.0 b	7.5 bcd	7.0 c-f	6.5 c-f	6.0 e-h
Emerald....................0.13 oz.	28-d	7.0 b	7.0 b-f	7.0 c-f	6.5 c-f	6.5 c-f
Emerald....................0.18 oz.	28-d	7.0 b	7.3 b-e	7.5 a-d	7.0 bcd	6.5 c-f
Kabuto ....0.4 fl.oz.	14-d	7.0 b	7.0 b-f	6.5 ef	6.3 def	6.3 d-g
Kabuto ....0.4 fl.oz.	21-d	6.5 bcd	6.8 c-g	6.8 def	6.3 def	6.0 e-h
Kabuto ....0.5 fl.oz.	21-d	6.5 bcd	6.3 efg	7.0 c-f	6.0 ef	5.3 h
Interface..................2.0 fl.oz.	14-d	7.0 b	8.0 ab	7.8 abc	6.3 def	5.8 fgh
Interface..................2.0 fl.oz.	21-d	6.8 bc	7.5 bcd	8.0 ab	5.8 f	5.5 gh
Interface..................3.0 fl.oz.	21-d	6.8 bc	7.8 bc	7.5 a-d	7.8 b	6.3 d-g
UC16-8 ....1.5 fl.oz.	21-d	5.0 f	6.3 efg	7.0 c-f	7.0 bcd	6.8 b-e
Headway ....1.5 fl.oz.	21-d	6.5 bcd	7.5 bcd	7.3 b-e	6.5 c-f	6.3 d-g
Secure ....0.5 fl.oz.	14-d	6.5 bcd	7.0 b-f	7.3 b-e	7.0 bcd	7.3 bc
UC16-7 ....0.5 fl.oz.	14-d	6.8 bc	7.3 b-e	7.3 b-e	7.0 bcd	7.0 bcd
Pinpoint.................0.31 fl.oz.	14-d	5.3 ef	5.8 g	6.3 f	6.5 c-f	6.3 d-g
Pinpoint.................0.31 fl.oz.	21-d	6.0 cde	6.3 efg	7.8 abc	6.0 ef	6.3 d-g
UC16-16 ....1.5 fl.oz.	21-d	5.8 def	6.0 fg	7.0 c-f	6.0 ef	6.3 d-g
UC16-16 ....1.5 fl.oz.	14-d	5.3 ef	7.5 bcd	7.5 a-d	7.3 bc	6.5 c-f
UC16-15 ....0.5 fl.oz.	14-d	6.0 cde	6.8 c-g	7.0 c-f	7.0 bcd	7.5 ab
Plant Foods Program[z]	14-d	8.0 a	9.0 a	8.3 a	8.8 a	8.3 a
Untreated		5.8 def	4.5 h	5.3 g	4.5 g	3.5 i
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment	14-d	2	2	9	2	9
	21-d	15	7	14	2	9
	28-d	15	2	9	15	22

[z]The Plant Food program consists of 20-3-3 (6.0 fl.oz.), Impulse (3.0 fl.oz.), Phosphite 30 (2.0 fl.oz.), Green Blade (0.36 fl.oz.), and Torque (0.36 fl.oz.) tank-mixed and applied every 14-d.

[y]Most treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals. Pinpoint, UC16-15 and UC16-16 (14-d) received their initial application on 1 June. Pinpoint, UC16-16, and UC16-8 (21-d) received their initial application on 10 June.

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

Table 2b. Turf quality influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment Rate per 1000ft^2	Int[y]	Turf Quality			
		15 Jul	22 Jul	28 Jul	19 Aug
		-------------- 1-9; 6 is min acceptable -----------------			
Kabuto ....0.4 fl.oz. + TebuStar ....1.1 fl.oz.	14-d	7.5 a-d[x]	7.5 abc	7.8 abc	7.5 abc
Kabuto ....0.4 fl.oz. + TebuStar ....1.1 fl.oz.	28-d	6.0 e-i	7.3 abc	7.3 a-e	5.8 e-h
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz.	14-d	6.8 b-g	7.3 abc	6.8 c-g	7.3 abc
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz.	28-d	5.5 g-k	6.5 cde	6.0 fgh	4.8 h-k
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz. + Transfilm .... 2.2% v/v	14-d	7.5 a-d	7.5 abc	7.3 a-e	7.5 abc
Kabuto ....0.4 fl.oz. + TebuStar ....0.7 fl.oz. + Transfilm .... 2.2% v/v	28-d	6.0 e-i	6.8 bcd	7.0 b-f	5.3 ghi
Kabuto ....0.5 fl.oz. + TebuStar ....0.68 fl.oz.	14-d	7.0 b-f	7.3 abc	7.3 a-e	7.0 bcd
Kabuto ....0.5 fl.oz. + TebuStar ....0.68 fl.oz.	28-d	4.3 klm	5.8 def	5.3 hi	3.8 kl
Fame+T...................0.9 fl.oz.	28-d	5.0 h-l	6.0 def	5.8 gh	4.3 i-l
Xzemplar ....0.21 fl.oz.	21-d	7.3 b-e	6.0 def	7.3 a-e	6.8 b-e
Xzemplar ....0.21 fl.oz.	28-d	6.5 c-g	7.3 abc	8.0 ab	6.5 c-f
Xzemplar ....0.26 fl.oz.	28-d	6.0 e-i	7.3 abc	7.3 a-e	7.5 abc
Velista........................0.3 oz.	14-d	7.5 a-d	7.8 ab	6.8 c-g	5.8 e-h
Velista........................0.3 oz.	21-d	7.0 b-f	6.0 def	6.8 c-g	5.0 g-j
Velista........................0.5 oz.	21-d	6.3 d-h	5.3 fg	6.8 c-g	5.0 g-j
Velista........................0.5 oz.	28-d	7.8 abc	7.5 abc	7.8 abc	5.0 g-j
Emerald....................0.13 oz.	21-d	6.5 c-g	5.5 efg	6.3 e-h	7.5 abc
Emerald....................0.13 oz.	28-d	5.8 f-j	6.5 cde	6.8 c-g	5.3 ghi
Emerald....................0.18 oz.	28-d	6.5 c-g	7.3 abc	7.0 b-f	7.0 bcd
Kabuto ....0.4 fl.oz.	14-d	6.5 c-g	6.5 cde	5.8 gh	5.5 fgh
Kabuto ....0.4 fl.oz.	21-d	4.5 j-m	3.8 h	4.3 ijk	3.3 l
Kabuto ....0.5 fl.oz.	21-d	3.3 mn	2.5 i	3.3 kl	3.3 l
Interface..................2.0 fl.oz.	14-d	4.8 i-l	4.0 h	4.3 ijk	3.5 l
Interface..................2.0 fl.oz.	21-d	3.8 lm	3.8 h	3.8 jk	3.3 l
Interface..................3.0 fl.oz.	21-d	6.0 e-i	4.5 gh	4.5 ij	3.8 kl
UC16-8 ....1.5 fl.oz.	21-d	7.0 b-f	6.5 cde	7.0 b-f	7.3 abc
Headway ....1.5 fl.oz.	21-d	6.0 e-i	5.5 efg	6.5 d-g	5.0 g-j
Secure ....0.5 fl.oz.	14-d	7.8 abc	7.8 ab	8.0 ab	7.8 ab
UC16-7 ....0.5 fl.oz.	14-d	7.5 a-d	7.5 abc	7.0 b-f	7.3 abc
Pinpoint.................0.31 fl.oz.	14-d	5.8 f-j	6.5 cde	6.5 d-g	6.8 b-e
Pinpoint.................0.31 fl.oz.	21-d	5.5 g-k	4.0 h	5.3 hi	4.0 jkl
UC16-16 ....1.5 fl.oz.	21-d	6.3 d-h	5.8 def	6.5 d-g	6.0 d-g
UC16-16 ....1.5 fl.oz.	14-d	8.0 ab	7.8 ab	7.5 ad	8.3 a
UC16-15 ....0.5 fl.oz.	14-d	7.5 a-d	7.8 ab	7.5 a-d	7.0 bcd
Plant Foods Program[z]	14-d	8.8 a	8.3 a	8.3 a	7.3 abc
Untreated		2.3 n	2.3 i	2.3 l	1.5 m
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001
Days after treatment	14-d	0	9	1	8
	21-d	5	2	8	8
	28-d	0	9	15	8

[z]The Plant Food program consists of 20-3-3 (6.0 fl.oz.), Impulse (3.0 fl.oz.), Phosphite 30 (2.0 fl.oz.), Green Blade (0.36 fl.oz.), and Torque (0.36 fl.oz.) tank-mixed and applied every 14-d.

[y]Most treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals. Pinpoint, UC16-15 and UC16-16 (14-d) received their initial application on 1 June. Pinpoint, UC16-16, and UC16-8 (21-d) received their initial application on 10 June.

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

Table 3. Phytotoxicity influenced by various fungicides on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment Rate per 1000ft²	Int[y]	Phytotoxicity 24 Jun	1 Jul	19 Aug
		-------- 0-5; 2=max acceptable -------		
Kabuto .... 0.4 fl.oz. + TebuStar .... 1.1 fl.oz.	14-d	0.3	0.0	0.0
Kabuto .... 0.4 fl.oz. + TebuStar .... 1.1 fl.oz.	28-d	0.3	0.0	0.0
Kabuto .... 0.4 fl.oz. + TebuStar .... 0.7 fl.oz.	14-d	0.0	0.0	0.0
Kabuto .... 0.4 fl.oz. + TebuStar .... 0.7 fl.oz.	28-d	0.3	0.0	0.0
Kabuto .... 0.4 fl.oz. + TebuStar .... 0.7 fl.oz. + Transfilm .... 2.2% v/v	14-d	0.5	0.0	0.0
Kabuto .... 0.4 fl.oz. + TebuStar .... 0.7 fl.oz. + Transfilm .... 2.2% v/v	28-d	0.0	0.0	0.0
Kabuto .... 0.5 fl.oz. + TebuStar .... 0.68 fl.oz.	14-d	0.0	0.0	0.0
Kabuto .... 0.5 fl.oz. + TebuStar .... 0.68 fl.oz.	28-d	0.3	0.0	0.0
Fame+T................. 0.9 fl.oz.	28-d	0.0	0.0	0.0
Xzemplar .... 0.21 fl.oz.	21-d	0.0	0.0	0.0
Xzemplar .... 0.21 fl.oz.	28-d	0.0	0.0	0.0
Xzemplar .... 0.26 fl.oz.	28-d	0.0	0.0	0.0
Velista.......................0.3 oz.	14-d	0.3	0.0	0.0
Velista.......................0.3 oz.	21-d	0.0	0.0	0.0
Velista.......................0.5 oz.	21-d	0.0	0.0	0.0
Velista.......................0.5 oz.	28-d	0.0	0.0	0.0
Emerald...................0.13 oz.	21-d	0.0	0.0	0.0
Emerald...................0.13 oz.	28-d	0.0	0.0	0.0
Emerald...................0.18 oz.	28-d	0.0	0.0	0.0
Kabuto .... 0.4 fl.oz.	14-d	0.0	0.0	0.0
Kabuto .... 0.4 fl.oz.	21-d	0.0	0.0	0.0
Kabuto .... 0.5 fl.oz.	21-d	0.0	0.0	0.0
Interface .... 2.0 fl.oz.	14-d	0.0	0.0	0.0
Interface .... 2.0 fl.oz.	21-d	0.0	0.0	0.0
Interface .... 3.0 fl.oz.	21-d	0.0	0.0	0.0
UC16-8 .... 1.5 fl.oz.	21-d	0.0	0.0	0.0
Headway .... 1.5 fl.oz.	21-d	0.0	0.0	0.0
Secure .... 0.5 fl.oz.	14-d	0.0	0.0	0.0
UC16-7 .... 0.5 fl.oz.	14-d	0.0	0.0	0.0
Pinpoint............... 0.31 fl.oz.	14-d	0.0	0.0	0.0
Pinpoint............... 0.31 fl.oz.	21-d	0.0	0.0	0.0
UC16-16 .... 1.5 fl.oz.	21-d	0.0	0.0	0.0
UC16-16 .... 1.5 fl.oz.	14-d	0.0	0.0	0.0
UC16-15 .... 0.5 fl.oz.	14-d	0.0	0.0	0.0
Plant Food Program[z]	14-d	0.0	0.0	0.0
Untreated		0.0	0.0	0.0
ANOVA: Treatment (P > F)		0.2139	1.00000	1.00000
Days after treatment	14-d	9	2	8
	21-d	14	2	8
	28-d	9	15	8

[z]The Plant Food program consists of 20-3-3 (6.0 fl.oz.), Impulse (3.0 fl.oz.), Phosphite 30 (2.0 fl.oz.), Green Blade (0.36 fl.oz.), and Torque (0.36 fl.oz.) tank-mixed and applied every 14-d.

[y]Most treatments were initiated on 19-May, prior to disease development, and were reapplied at specified intervals. Pinpoint, UC16-15 and UC16-16 (14-d) received their initial application on 1 June. Pinpoint, UC16-16, and UC16-8 (21-d) received their initial application on 10 June.

CURATIVE DOLLAR SPOT CONTROL WITH VARIOUS FUNGICIDES ON A CREEPING BENTGRASS FAIRWAY TURF, 2016

K. Miele, J. Dunnack, Z. Esponda, S. Vose, and J. Inguagiato

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

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 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 commercially avaliable fungicides against *S. homoeocarpa.*

MATERIALS & METHODS

A field study was conducted on a 'Ninety-Six Two' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed three days wk^{-1} at a bench setting of 0.5-inches. Minimal nitrogen was applied to the study area to encourage dollar spot development. A total of 0.45 lb N $1000\text{-}ft^{-2}$ was applied as water soluble sources prior to trial initiation. 0.5 lbs N $1000\text{-}ft^{-2}$ was applied on 12 July following initial treatment application to assist with turf recovery. The study area was inoculated with dried Kentucky bluegrass seed infected with *Sclerotinia homoeocarpa* on 29 June at a rate of 3.62 oz. $1000\text{-}ft^{-2}$. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of various fungicides applied curatively. Initial applications were made on 11 July after a severe epidemic had established in the trial area. Subsequent applications were made as detailed in Table 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 1.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Nitrogen was applied at a rate of 0.5 lbs $1000\text{-}ft^{-2}$ on 12 July to assist with turf recovery. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual disease foci within each plot from 11 July to 5 August. Mycelium intensity was assessed on a 0-5 scale, with 0 representing no visible mycelium and 5 representing a dense, cotton-like mass of mycelium on 15 July. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS AND DISCUSSION

Dollar Spot Incidence

A severe epidemic of dollar spot was evident throughout the trial area at the beginning of the study [average = 113 dollar spot infection centers (DSIC) $plot^{-1}$]. No treatments provided acceptable dollar spot control (i.e., ≤ 25) 7 days after initial treatment (DAIT) on 18 Jul, although all treatments reduced disease compared to untreated control (Table 1). Plots treated with Xzemplar, Interface, Velista or Secure applied alone generally showed the greatest reduction in disease on this date.

By 11 DAIT (22 Jul) nearly all treatments had provided acceptable dollar spot control with few differences among treated turf. However, at 16 DAIT (27 Jul), disease was greater in Secure-alone and Interface treated plots than all other treatments, albeit still less than untreated control. Both of these treatments provided good curative control in the days following initial application; although did not continue to suppress disease at the end of their intended application interval. Therefore, it is possible that a shorter re-application interval may be necessary for curative control with these fungicides.

As of 5 Aug, 9 days after the second application of 14-d treatments was made, all treated plots provided near complete disease control, whereas disease had continued to increase in untreated controls (229 DSIC $plot^{-1}$).

Aerial Mycelium

High humidity and warm overnight temperatures provided an opportunity to assess aerial mycelium production 4 DAIT (15 Jul). Faint to no visible aerial mycelium was observed in Xzemplar, Emerald, Secure, 26GT, and Velista + Secure; which may suggest that these treatments may act quickly to arrest fungal growth.

Table 1. Effect of various fungicides on applied curatively on dollar spot incidence and mycelium intensity on a creeping bentgrass fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[z]	Dollar Spot Incidence							Mycelium
			11 Jul	15 Jul	18 Jul	20 Jul	22 Jul	27 Jul	5 Aug	15 Jul
			# of dollar spot foci 18ft^{-2}							--0-5; 0=none---
Xzemplar	0.26 fl.oz.	14-d	124.0[w]	44.9[w]	33.6[v] bcd[u]	28.8 b	22.8 bc	13.4[w] d	2.4[w] de	0.2[v] ef
Emerald	0.18 oz.	14-d	123.0	59.1	44.1 b	33.0 b	24.0 bc	19.5 cd	2.3 de	0.4 def
Velista	0.5 oz.	14-d	113.9	51.3	35.8 bcd	38.5 b	28.5 bc	30.3 c	3.9 cde	1.5 bc
Secure	0.5 fl.oz.	14-d	89.0	32.8	22.7 d	22.5 b	17.0 c	61.3 b	3.2 de	0.0 f
26GT	4.0 fl.oz.	14-d	131.6	57.7	41.4 bc	33.0 b	24.8 bc	21.9 cd	2.4 de	0.6 de
Interface	4.0 fl.oz.	14-d	102.2	41.9	32.9 bcd	34.0 b	39.0 b	66.9 b	10.6 bc	2.2 b
Velista + Secure	0.5 oz. 0.5 fl.oz.	14-d	97.8	39.5	27.5 cd	24.8 b	17.8 c	15.2 d	1.1 e	0.0 f
Velista - Secure	0.5 oz. 0.5 fl.oz.	11 Jul[y] 26 Jul[y]	128.0	57.2	40.0 bc	40.5 b	35.0 bc	31.5 c	4.7 bcd	1.0 cd
Velista - Secure	0.5 oz. 0.5 fl.oz.	11 Jul[x] 18 Jul[x]	108.7	46.4	37.7 bcd	36.0 b	26.5 bc	18.3 cd	12.5 b	1.7 bc
Untreated			112.6	87.8	108.3 a	143.8 a	132.5 a	200.3 a	229.0 a	4.2 a
ANOVA: Treatment (P > F)			0.7145	0.0628	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		initial	0	4	7	9	11	16	25	4
		7-d	0	4	7	1	3	8	17	4
		14-d	0	4	7	9	11	1	9	4

[z]Treatments were initiated on 11 July, after disease had developed within the trial area. Subsequent applications were made 15-d later on 26 July, or as otherwise specified.

[y]Velista (0.5 oz.) was applied on 11 July. Secure (0.5 oz) was applied on 26 July.

[x]Velista (0.5 oz.) was applied on 11 July. Secure (0.5 oz) was applied on 18 July.

[w]Data were automatically log transformed. Means are de-transformed for presentation.

[v]Data were automatically square-root transformed. Means are de-transformed for presentation.

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

PREVENTIVE DOLLAR SPOT CONTROL WITH VARIOUS FUNGICIDES ON A CREEPING BENTGRASS PUTTING GREEN TURF, 2016

K. Miele, J. Dunnack, Z. Esponda, S. Vose, and J. Inguagiato

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

INTRODUCTION

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

MATERIALS & METHODS

A field study was conducted on a 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inches. Nitrogen was applied at a total of 2.0 lb N $1000\text{-}ft^{-2}$ as water soluble sources from April through September. Dylox 80 was applied on 27-May for control of white grubs. Quicksilver was applied on 6 August and 20 August for control of silvery-thread moss. Scimitar was applied on 27 August for control of cutworms. To help alleviate dry surface conditions, the wetting agent Dispatch was applied on 18 June and Revolution was applied on 23 July. Overhead irrigation was applied as needed to prevent drought stress. The trial area was aerated using 0.375 inch diameter hollow-tines at 1.5 by 2.0 inch spacing on 30 August. Cores were removed and filled with topdressing. The study area was inoculated with *Sclerotinia homoeocarpa* on 29 June at a rate of 1.1 g m^{-2}.

Treatments consisted of new fungicide formulations and currently available products applied individually, as tank mixes, and/or in rotational program. Initial applications for Bayer Programs 1-2 were made on 12 May prior to disease developing in the trial area and when soil temperatures reached 55°F over 5 days at a 2-inch depth. The following application of these treatments, as well as the initial application of Rotational Programs 1-2 took place on 10 June. Individually applied and/or tank-mixed treatments were initiated on 26 May with the exception of Pinpoint, which was first applied on 10 June. Subsequent applications were made on a 14-d or 21-d interval through 2 September. All treatments were applied using a hand held CO_2 powered spray boom outfitted with a single AI9508E flat fan nozzle calibrated to deliver 2.0 gal $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Dollar spot incidence was assessed as a count of individual disease foci within each plot. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best quality turf and 6 was the minimum acceptable level. Phytotoxicity was also assessed visually where 0 was equal to no discoloration and 2 represented the maximum acceptable level. NDVI measurements were taken with a FieldScout TCM 500 NDVI meter (Spectrum Technologies, Aurora, IL). Brown Patch incidence was assessed as a percentage of plot area blighted by disease. Aeration recovery was assessed on a 1 to 9 scale where 9 represented completely grown-in aeration holes and 6 represented the minimum acceptable level. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test. Dollar spot incidence data were square-root or log transformed for ANOVA and mean separation tests, although means presented are de-transformed values.

RESULTS AND DISCUSSION

Dollar Spot Incidence

Dollar spot pressure was high throughout the duration of the trial. As of the first observation date (3 June, Table 1a) untreated control plots averaged 50 disease foci per plot. This increased steadily through June, reaching over 100 foci by 1 July. The epidemic reached its peak in mid-August, with untreated plots averaging over 230 foci on 11 August. Though it remained high, disease pressure slowly declined through the remainder of the trial, averaging 180 disease foci for untreated control plots on 16 September.

Bayer Programs 1 and 2 were initiated on 12 May when soil temperatures reached 55°F; subsequent applications were withheld 30 days after initial treatment to assess the ability of fungicides applied for fairy ring control to influence dollar spot control. Bayer Programs 1-2 failed to reduce dollar spot compared to untreated control plots at the onset of symptoms on 3 Jun (22 days after treatment, DAT; Table 1a), averaging over 30 disease foci per plot. This is likely due to favorable environmental conditions for disease coinciding with an extended application interval. Disease continued to increase on these plots through 9 June (28 DAT), before receiving a follow-up application of Mirage on 10 June, after which disease slowly decreased before returning to acceptable levels (≤ 20 disease foci per plot) on 24 June. Rotations 1 and 2, are identical to the Bayer programs, except they did not receive the initial Tartan application on 12 May. Disease remained high in these plots (>70 foci per plot) through 17 June, before showing a reduction (~30 foci per plot) in disease on the 24 June observation date.

Bayer Programs 1 and 2, as well as Rotation 1, generally provided good (<10 foci per plot) control of disease through 8 July, although plots treated with Bayer Program 2 every 21-d had greater disease than Bayer Program 1 and Rotation 1applied every 14-d, most likely due to a longer (21-d vs. 14-d) application interval. Rotation 2 failed to control disease to acceptable levels for the remainder of the trial.

Although disease incidence in all four rotational programs reached unacceptable (>20 foci per plot) levels by mid-August (11 August, Table 1b), disease was generally lower in Bayer Program 1 and Rotational Program 1, indicating that a 14-d application interval is more effective at controlling dollar spot on putting greens than a 21-d interval, especially under high disease pressure.

Signature XTRA, a new fungicide containing fosetyl-Al (60%) and a new formulation of StressGard, was tank-mixed and applied with Lexicon Intrinsic, Briskway, Exteris Stressgard, and Secure. All four combinations provided excellent (<5 foci per plot) control of disease through 1 July, although Briskway + Signature XTRA was less effective (10 foci per plot) compared to Signature XTRA tank-mixes with Lexicon Intrinsic, Exteris StressGard, or Secure on 1 July, albeit still acceptable. From 8 July through the end of the trial, Lexicon Intrinsic + Signature XTRA, Exteris StressGard + Signature XTRA, and Secure + Signature XTRA provided acceptable levels of disease control, with Lexicon and Exteris treated plots providing near complete control of disease. Briskway + Signature XTRA failed to provide acceptable disease control from 8 July forward, peaking at over 180 disease foci per plot on 19 August.

Exteris Stressgard, a new fungicide containing fluopyram (SDHI) and trifloxystrobin (Q_OI),applied alone provided excellent (<5 foci per plot) control of disease on all dates..Secure applied alone provided acceptable dollar spot control on 11 of 15 observation dates, although it was less effective than when tank mixed with Signature XTRA.

Tourney (0.37 oz.) provided acceptable dollar spot throughout the trial except on 19 August, when disease reached almost 30 disease foci per plot. Lower rate applications of Tourney (0.28 oz.) failed to provide acceptable dollar spot control with disease foci per plot reaching 40 foci on 9 June and peaking at 96 foci on 19 August. When tank-mixed with Pinpoint, a new Q_OI fungicide, the lower rate of Tourney the combination provided acceptable disease control, except on 19 August. On plots where Pinpoint was applied alone, disease tended to fluctuate between acceptable and unacceptable levels. It is not clear whether delaying initial applications until 10 June may have contributed to poor control.

Daconil Action and Daconil Weather Stik failed to provide acceptable levels of control at any point during the trial, with both treatments reaching over 100 disease foci per plot as of 28 July, and over 300 foci per plot for Daconil Weather Stik (more than untreated control plots) on 19 August. Daconil Weather Stik treated plots remained at higher levels of disease than untreated plots from this date through the end of the trial, while Daconil Action showed no control of disease relative to untreated plots.

Brown Patch Incidence

Brown patch developed throughout the trial during late-July reaching 21% plot area blighted in untreated controls by early-August (Table 2). Most treatments provided complete control of the disease. However, brown patch developed in plots (2 to 7% plot area blighted) treated with Pinpoint alone regardless of rate, Daconil Weather Stik and Daconil Action. These treatments still reduced brown patch compared to untreated control. Secure applied alone (16% plot area blighted) failed to reduce brown patch compared to untreated, although the addition of Signature XTRA (4% plot area blighted) slightly improved brown patch control.

Turf Quality, NDVI, and Phytotoxicity

None of the treatments caused any phytotoxicity (Table 4) at any point during the trial. As such, turf quality (Table 3a + 3b) was primarily influenced by disease incidence. On 8 July, high levels of disease resulted in poor quality (< 6 out of 9) on plots treated with Rotational Program 2, Briskway + Signature XTRA, Pinpoint (0.28 fl.oz.), Secure, Daconil Weather Stik, and Daconil Action. Turf quality was exceptionally high (>8.5 out of 9) on plots treated with Lexicon Intrinsic + Signature XTRA and Exteris Stressgard + Signature XTRA due to improved color, uniformity and excellent disease control.

Aeration Recovery

The trial area received a routine aeration on 30 August. Plots were assessed for aeration recovery 10 and 17 days after aeration. Several treatments appeared to contribute to improved aeration recovery, resulting in an acceptable recovery level (i.e., ≥ 6) 10 days after aeration (9 Sep). An acceptable rate of recovery was observed in plots receiving Bayer Program 1, Rotational Program 1, Lexicon Intrinsic + Signature XTRA, Exteris StressGard, alone or tank mixed with Signature XTRA, and Tourney regardless of application rate. By 17 days after aeration nearly all treatments had reached an accpteable level of recovery except Rotational Program 2, Daconil Weather Stik, Daconil Action, and untreated control. It is likely that severe dollar spot damage to the turf canopy at this time reduced the recuperative ability of these treatments.

Table 1a. Effect of various fungicides on dollar spot incidence in a creeping bentgrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

			Dollar Spot Incidence							
Treatment	Rate per 1000ft^2	Int[v]	3 Jun	9 Jun	17 Jun	24 Jun	1 Jul	8 Jul	15 Jul	22 Jul
			---------- # dollar spot foci 18ft^{-2} ----------							
Bayer Program 1	pgm[z]	14-d	30.2[u] a-d[t]	62.3 cd	29.3 cd	6.2 de	2.0 fg	3.8 fg	4.6 fg	17.1 def
Bayer Program 2	pgm[y]	21-d	36.3 a-d	48.5 de	37.4 bcd	6.2 de	31.9 bc	6.6 ef	29.0 d	51.3 c
Rotational Program 1	pgm[x]	14-d	74.6 a	94.3 ab	74.6 a	28.1 abc	8.4 de	8.1 def	15.9 de	51.0 c
Rotational Program 2	pgm[w]	21-d	69.2 ab	86.3 abc	73.0 a	31.6 abc	60.8 ab	77.9 ab	97.2 b	105.7 b
Lexicon Intrinsic	0.34 fl.oz.	14-d	0.0 g	0.3 g	0.0 g	0.0 g	0.0 h	0.0 h	0.0 h	0.0 g
+ Signature XTRA	4.0 oz.									
Briskway	0.3 fl.oz.	14-d	4.0 e	15.8 fg	2.4 fg	0.4 g	10.9 de	33.4 bc	29.7 d	66.9 c
+ Signature XTRA	4.0 oz.									
Exteris Stressgard	4.0 fl.oz.	14-d	0.3 g	1.8 g	1.5 fg	0.2 g	0.2 gh	0.4 h	0.0 h	0.0 g
+ Signature XTRA	4.0 oz.									
Secure	0.5 fl.oz.	14-d	0.2 g	2.3 g	0.5 g	0.2 g	0.7 gh	1.1 gh	0.0 h	15.1 ef
+ Signature XTRA	4.0 oz.									
Tourney	0.37 oz.	14-d	2.4 ef	9.0 g	0.6 g	0.0 g	0.7 gh	3.0 fg	3.1 fgh	14.7 ef
Tourney	0.28 oz.	14-d	21.2 cd	40.5 def	25.5 cd	6.3 de	7.3 de	18.8 cd	29.3 d	67.4 c
Tourney	0.28 oz.	14-d	3.7 e	21.3 efg	8.8 ef	1.0 fg	0.7 gh	6.0 ef	1.4 gh	10.0 f
+ Pinpoint	0.28 fl.oz.									
Pinpoint	0.28 fl.oz.	14-d	34.3 a-d	52.0 d	44.3 bc	3.6 ef	12.7 cd	29.7 c	8.8 ef	29.7 d
Pinpoint	0.31 fl.oz.	14-d	19.3 d	46.0 de	26.0 cd	7.1 de	9.2 de	14.8 cde	7.8 efg	20.4 def
Exteris Stressgard	4.0 fl.oz.	14-d	0.0 g	1.8 g	0.0 g	0.0 g	0.6 gh	0.3 h	0.0 h	0.0 g
Secure	0.5 fl.oz.	14-d	0.6 fg	11.5 g	21.5 de	17.3 cd	3.7 ef	17.9 cd	5.8 fg	27.0 de
Daconil Weather Stik	2.0 fl.oz.	14-d	44.5 a-d	99.8 a	57.9 ab	59.0 ab	110.4 a	151.2 a	145.6 a	165.7 a
Daconil Action	2.0 fl.oz.	14-d	28.0 bcd	66.3 bcd	39.9 bcd	22.6 bc	66.0 ab	88.2 a	57.3 c	111.7 b
Untreated			50.3 abc	66.8 bcd	74.4 a	68.1 a	104.0 a	101.6 a	116.2 ab	120.8 b
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	8[s]	14[r]	7	1	7	1	8	1
		21-d	--	--	7	14	1	8	15	1

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d.

[u]Dollar spot data were log transformed for the following rating dates: 3 June, 24 June, 1 July, 8 July and 28 July. Dollar spot data were square-root transformed for the following rating dates: 17 June, 15 July, 22 July, 5 August, 11 August, 19 August, 26 August, 9 September, and 16 September.

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

[s]Bayer Programs 1-2 were last treated on 12 May, 22 days before this rating date. Rotational programs 1-2 did not yet receive an initial application as of this rating date.

[r]Bayer Programs 1-2 were last treated on 12 May, 28 days before this rating date. Rotational programs 1-2 did not yet receive an initial application as of this rating date.

Table of Contents

Table 1b. Effect of various fungicides on dollar spot incidence in a creeping bentgrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment Rate per 1000ft²	Int[v]	Dollar Spot Incidence 28 Jul	5 Aug	11 Aug	19 Aug	26 Aug	9 Sep	16 Sep
		# dollar spot foci 18ft⁻²						
Bayer Program 1 .... pgm[z]	14-d	0.3[u] g[t]	13.4 gh	47.0 de	58.8 e	35.2 fgh	13.2 fg	7.4 efg
Bayer Program 2 .... pgm[y]	21-d	15.5 de	63.0 de	106.7 c	98.1 d	67.9 d	35.8 de	12.6 def
Rotational Program 1 .... pgm[x]	14-d	9.4 ef	24.7 fg	57.2 d	53.5 ef	40.9 ef	21.6 ef	12.1 def
Rotational Program 2 .... pgm[w]	21-d	53.7 bc	130.2 bc	148.5 b	150.4 c	87.2 d	53.2 cd	21.8 d
Lexicon Intrinsic .... 0.34 fl.oz. + Signature XTRA .... 4.0 oz.	14-d	0.0 g	0.0 i	0.0 h	0.0 i	0.0 j	0.0 h	1.7 g
Briskway .... 0.3 fl.oz. + Signature XTRA .... 4.0 oz.	14-d	51.4 bc	97.8 cd	142.3 b	181.9 bc	128.7 c	78.1 c	45.3 c
Exteris Stressgard .... 4.0 fl.oz. + Signature XTRA .... 4.0 oz.	14-d	0.0 g	0.0 i	0.0 h	0.0 i	0.0 j	0.0 h	3.2 fg
Secure .... 0.5 fl.oz. + Signature XTRA .... 4.0 oz.	14-d	0.4 g	0.6 i	0.5 h	15.0 h	11.7 i	0.4 h	4.0 fg
Tourney.......................... 0.37 oz.	14-d	5.2 f	14.2 gh	19.6 fg	28.4 gh	18.3 hi	17.7 ef	8.2 d-g
Tourney.......................... 0.28 oz.	14-d	39.9 cd	51.0 ef	90.5 c	96.3 d	59.3 de	42.9 d	16.3 de
Tourney.......................... 0.28 oz. + Pinpoint .... 0.28 fl.oz.	14-d	1.0 g	5.8 hi	11.4 g	22.5 gh	14.4 i	1.3 h	5.4 efg
Pinpoint...................... 0.28 fl.oz.	14-d	5.3 f	25.4 fg	34.7 ef	50.9 ef	37.0 efg	5.3 gh	1.5 g
Pinpoint...................... 0.31 fl.oz.	14-d	4.7 f	22.2 g	33.6 ef	35.8 fg	19.0 hi	4.2 gh	4.9 efg
Exteris Stressgard .... 4.0 fl.oz.	14-d	0.2 g	0.2 i	0.2 h	0.4 i	0.2 j	0.2 h	5.5 efg
Secure .... 0.5 fl.oz.	14-d	13.0 ef	11.8 gh	9.0 g	30.7 g	21.1 ghi	2.8 h	4.2 fg
Daconil Weather Stik... 2.0 fl.oz.	14-d	203.8 a	194.8 a	220.2 a	304.7 a	286.5 a	281.5 a	239.0 a
Daconil Action............ 2.0 fl.oz.	14-d	87.3 abc	130.1 bc	175.2 b	216.8 b	215.8 b	200.8 b	166.4 b
Untreated		123.8 ab	173.6 abc	236.5 a	219.1 b	214.9 b	218.2 b	180.0 b
ANOVA: Treatment (P > F)		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment	14-d	7	1	7	1	8	7	14
	21-d	7	15	21	8	15	7	14

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d.

[u]Dollar spot data were log transformed for the following rating dates: 3 June, 24 June, 1 July, 8 July and 28 July. Dollar spot data were square-root transformed for the following rating dates: 17 June, 15 July, 22 July, 5 August, 11 August, 19 August, 26 August, 9 September, and 16 September.

[t]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. Effect of various fungicides program on brown patch incidence in a creeping bentgrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[v]	Brown Patch Severity 28 Jul	Brown Patch Severity 1 Aug
			------- % plot area blighted -------	
Bayer Program 1	pgm[z]	14-d	0.0 b[u]	0.0 d
Bayer Program 2	pgm[y]	21-d	0.0 b	0.0 d
Rotational Program 1	pgm[x]	14-d	0.0 b	0.0 d
Rotational Program 2	pgm[w]	21-d	0.0 b	0.0 d
Lexicon Intrinsic	0.34 fl.oz.	14-d	0.0 b	0.0 d
+ Signature XTRA	4.0 oz.			
Briskway	0.3 fl.oz.	14-d	0.0 b	0.0 d
+ Signature XTRA	4.0 oz.			
Exteris Stressgard	4.0 fl.oz.	14-d	0.0 b	0.0 d
+ Signature XTRA	4.0 oz.			
Secure	0.5 fl.oz.	14-d	0.0 b	3.7 c
+ Signature XTRA	4.0 oz.			
Tourney	0.37 oz.	14-d	0.0 b	0.0 d
Tourney	0.28 oz.	14-d	0.0 b	0.0 d
Tourney	0.28 oz.	14-d	1.5 b	0.0 d
+ Pinpoint	0.28 fl.oz.			
Pinpoint	0.28 fl.oz.	14-d	0.8 b	6.8 bc
Pinpoint	0.31 fl.oz.	14-d	1.8 b	5.6 bc
Exteris Stressgard	4.0 fl.oz.	14-d	0.0 b	0.0 d
Secure	0.5 fl.oz.	14-d	0.0 b	15.6 ab
Daconil Weather Stik	2.0 fl.oz.	14-d	0.8 b	2.0 cd
Daconil Action	2.0 fl.oz.	14-d	0.0 b	2.8 cd
Untreated			15.3 a	21.4 a
ANOVA: Treatment (P > F)			0.0001	0.0001
Days after treatment		14-d	7	11
		21-d	7	11

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d.

[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 3a. Effect of various rotational fungicide programs on turf quality in a creeping bent grass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[v]	Turf Quality 3 Jun	17 Jun	24 Jun	1 Jul	8 Jul	15 Jul	28 Jul
			1-9; 6=min acceptable						
Bayer Program 1	pgm[z]	14-d	4.8 ef[u]	5.5 bc	7.0 cd	7.5 cd	7.8 bcd	7.8 bc	8.3 ab
Bayer Program 2	pgm[y]	21-d	4.5 fg	5.5 bc	6.8 cde	5.8 f	7.0 def	5.5 ef	7.3 bc
Rotational Program 1	pgm[x]	14-d	4.8 ef	4.0 d	5.5 fgh	6.3 ef	6.5 fgh	6.5 de	7.3 bc
Rotational Program 2	pgm[w]	21-d	3.5 g	4.5 cd	5.0 h	4.8 g	4.3 k	3.3 g	4.3 de
Lexicon Intrinsic + Signature XTRA	0.34 fl.oz. + 4.0 oz.	14-d	7.5 a	8.5 a	9.0 a	8.8 a	9.0 a	8.8 ab	8.8 a
Briskway + Signature XTRA	0.3 fl.oz. + 4.0 oz.	14-d	6.3 bc	8.0 a	9.0 a	6.3 ef	5.3 ij	5.0 f	4.8 d
Exteris Stressgard + Signature XTRA	4.0 fl.oz. + 4.0 oz.	14-d	7.3 ab	7.8 a	8.5 ab	8.5 ab	8.5 ab	9.0 a	9.0 a
Secure + Signature XTRA	0.5 fl.oz. + 4.0 oz.	14-d	7.3 ab	8.3 a	8.8 a	8.3 abc	8.0 bc	8.8 ab	9.0 a
Tourney	0.37 oz.	14-d	5.8 cde	6.3 b	6.8 cde	6.8 de	6.8 efg	7.3 cd	7.0 c
Tourney	0.28 oz.	14-d	4.5 fg	5.3 bc	6.3 d-g	6.0 ef	6.0 ghi	5.5 ef	5.0 d
Tourney + Pinpoint	0.28 oz. + 0.28 fl.oz.	14-d	5.8 cde	6.3 b	7.5 bc	6.8 de	6.5 fgh	7.5 cd	8.3 ab
Pinpoint	0.28 fl.oz.	14-d	4.8 ef	5.0 cd	6.5 c-f	5.8 f	5.0 jk	7.0 cd	6.8 c
Pinpoint	0.31 fl.oz.	14-d	5.0 def	5.3 bc	6.3 d-g	6.0 ef	6.0 ghi	7.0 cd	6.8 c
Exteris Stressgard	4.0 fl.oz.	14-d	6.5 abc	7.8 a	8.5 ab	7.8 bc	7.5 cde	8.8 ab	8.5 a
Secure	0.5 fl.oz.	14-d	6.0 cd	5.5 bc	5.8 e-h	6.0 ef	5.8 hij	7.0 cd	7.0 c
Daconil Weather Stik	2.0 fl.oz.	14-d	4.8 ef	4.8 cd	4.8 hi	4.3 g	3.0 l	3.0 g	2.3 f
Daconil Action	2.0 fl.oz.	14-d	4.8 ef	5.5 bc	5.3 gh	4.8 g	4.3 k	4.5 f	3.3 ef
Untreated			4.3 fg	4.0 d	3.8 i	4.0 g	3.3 l	3.3 g	2.5 f
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	8[t]	7	1	7	1	8	7
		21-d	--	7	14	1	8	15	7

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d.

[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).

[t]Bayer Programs 1-2 were last treated on 12 May, 22 days before this rating date. Rotational programs 1-2 did not yet receive an initial application as of this rating date.

Table 3b. Effect of various fungicides on turf quality in a creeping bentgrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[v]	Turf Quality 11 Aug	19 Aug	26 Aug	9 Sep	16 Sep
			----------------------- 1-9; 6=min acceptable	-----------------------			
Bayer Program 1	pgm[z]	14-d	5.7 cd[u]	5.0 ef	5.5 de	6.5 b-e	7.5 bc
Bayer Program 2	pgm[y]	21-d	4.4 de	4.3 fg	4.8 ef	5.3 e-f	6.8 cd
Rotational Program 1	pgm[x]	14-d	5.9 c	5.0 ef	5.5 de	6.0 c-f	7.5 bc
Rotational Program 2	pgm[w]	21-d	3.7 ef	3.5 ghi	4.8 ef	5.5 def	5.8 ef
Lexicon Intrinsic	0.34 fl.oz.	14-d	8.7 a	8.8 a	8.3 ab	7.3 abc	8.3 ab
+ Signature XTRA	4.0 oz.						
Briskway	0.3 fl.oz.	14-d	3.7 ef	3.3 hi	4.0 f	4.8 f	5.0 f
+ Signature XTRA	4.0 oz.						
Exteris Stressgard	4.0 fl.oz.	14-d	9.0 a	9.0 a	8.8 a	8.5 a	8.3 ab
+ Signature XTRA	4.0 oz.						
Secure	0.5 fl.oz.	14-d	7.7 ab	7.3 b	7.3 bc	8.0 ab	8.0 ab
+ Signature XTRA	4.0 oz.						
Tourney	0.37 oz.	14-d	6.5 bc	5.8 cde	7.0 c	6.3 c-f	7.5 bc
Tourney	0.28 oz.	14-d	4.5 de	3.8 gh	4.8 ef	5.3 ef	6.3 de
Tourney	0.28 oz.	14-d	7.7 ab	6.5 bc	7.0 c	7.0 a-d	7.8 b
+ Pinpoint	0.28 fl.oz.						
Pinpoint	0.28 fl.oz.	14-d	6.5 bc	5.3 de	5.5 de	7.3 abc	8.8 a
Pinpoint	0.31 fl.oz.	14-d	6.2 c	5.8 cde	6.5 cd	7.0 a-d	7.8 b
Exteris Stressgard	4.0 fl.oz.	14-d	8.5 a	8.5 a	8.5 a	8.5 a	8.0 ab
Secure	0.5 fl.oz.	14-d	6.5 bc	6.0 cd	6.8 c	7.0 a-d	8.0 ab
Daconil Weather Stik	2.0 fl.oz.	14-d	2.2 g	1.8 k	1.8 g	2.0 g	2.8 g
Daconil Action	2.0 fl.oz.	14-d	2.7 fg	2.8 ij	2.5 g	2.5 g	3.5 g
Untreated			2.7 fg	2.0 jk	2.0 g	1.8 g	3.3 g
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001
Days after treatment		14-d	7	1	8	7	14
		21-d	21	8	15	7	14

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per $1000ft^2$.

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per $1000ft^2$.

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per $1000ft^2$.

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per $1000ft^2$.

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d.

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

Table 4. Effect of various fungicides on phytotoxicity in a creeping bentgrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[v]	Phytotoxicity			
			3 Jun	24 Jun	1 Jul	8 Jul
			---------------------- 0-5; 2=max acceptable --------------------			
Bayer Program 1	pgm[z]	14-d	0.0	0.0	0.0	0.0
Bayer Program 2	pgm[y]	21-d	0.0	0.0	0.0	0.0
Rotational Program 1	pgm[x]	14-d	0.0	0.0	0.0	0.0
Rotational Program 2	pgm[w]	21-d	0.0	0.0	0.0	0.0
Lexicon Intrinsic	0.34 fl.oz.	14-d	0.0	0.0	0.0	0.0
+ Signature XTRA	4.0 oz.					
Briskway	0.3 fl.oz.	14-d	0.0	0.0	0.0	0.0
+ Signature XTRA	4.0 oz.					
Exteris Stressgard	4.0 fl.oz.	14-d	0.0	0.0	0.0	0.0
+ Signature XTRA	4.0 oz.					
Secure	0.5 fl.oz.	14-d	0.0	0.0	0.0	0.0
+ Signature XTRA	4.0 oz.					
Tourney	0.37 oz.	14-d	0.0	0.0	0.0	0.0
Tourney	0.28 oz.	14-d	0.0	0.0	0.0	0.0
Tourney	0.28 oz.	14-d	0.0	0.0	0.0	0.0
+ Pinpoint	0.28 fl.oz.					
Pinpoint	0.28 fl.oz.	14-d	0.0	0.0	0.0	0.0
Pinpoint	0.31 fl.oz.	14-d	0.0	0.0	0.0	0.0
Exteris Stressgard	4.0 fl.oz.	14-d	0.0	0.0	0.0	0.0
Secure	0.5 fl.oz.	14-d	0.0	0.0	0.0	0.0
Daconil Weather Stik	2.0 fl.oz.	14-d	0.0	0.0	0.0	0.0
Daconil Action	2.0 fl.oz.	14-d	0.0	0.0	0.0	0.0
Untreated			0.0	0.0	0.0	0.0
ANOVA: Treatment ($P > F$)			1.0000	1.0000	1.0000	1.0000
Days after treatment		14-d	8[t]	1	7	1
		21-d	--	14	1	8

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d.

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

[t]Bayer Programs 1-2 were last treated on 12 May, 22 days before this rating date. Rotational programs 1-2 did not yet receive an initial application as of this rating date.

Table 5. Effect of various fungicides on normalized difference vegetative index in a creeping bentgrass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[v]	NDVI			
			17 Jun	1 Jul	8 Jul	12 Aug
			Vegetation Index			
Bayer Program 1	pgm[z]	14-d	0.744 def[u]	0.763 bc	0.770 a-d	0.745 de
Bayer Program 2	pgm[y]	21-d	0.750 c-f	0.764 abc	0.770 a-d	0.753 cd
Rotational Program 1	pgm[x]	14-d	0.757 cd	0.768 abc	0.776 abc	0.775 abc
Rotational Program 2	pgm[w]	21-d	0.752 cde	0.761 c	0.764 cde	0.759 bcd
Lexicon Intrinsic + Signature XTRA	0.34 fl.oz. + 4.0 oz.	14-d	0.776 a	0.776 a	0.779 a	0.762 a-d
Briskway + Signature XTRA	0.3 fl.oz. + 4.0 oz.	14-d	0.774 ab	0.764 abc	0.770 a-d	0.758 bcd
Exteris Stressgard + Signature XTRA	4.0 fl.oz. + 4.0 oz.	14-d	0.759 bcd	0.774 ab	0.777 ab	0.765 a-d
Secure + Signature XTRA	0.5 fl.oz. + 4.0 oz.	14-d	0.757 cde	0.773 abc	0.779 a	0.773 abc
Tourney	0.37 oz.	14-d	0.745 def	0.765 abc	0.762 de	0.768 a-d
Tourney	0.28 oz.	14-d	0.736 f	0.769 abc	0.769 a-d	0.754 cd
Tourney + Pinpoint	0.28 oz. + 0.28 fl.oz.	14-d	0.741 ef	0.764 abc	0.768 a-d	0.769 a-d
Pinpoint	0.28 fl.oz.	14-d	0.752 cde	0.760 c	0.766 b-e	0.769 a-d
Pinpoint	0.31 fl.oz.	14-d	0.746 def	0.766 abc	0.771 a-d	0.782 ab
Exteris Stressgard	4.0 fl.oz.	14-d	0.757 cd	0.764 abc	0.767 a-d	0.773 abc
Secure	0.5 fl.oz.	14-d	0.762 abc	0.764 abc	0.774 abc	0.786 a
Daconil Weather Stik	2.0 fl.oz.	14-d	0.762 abc	0.766 abc	0.761 de	0.761 a-d
Daconil Action	2.0 fl.oz.	14-d	0.764 abc	0.764 abc	0.767 a-d	0.758 bcd
Untreated			0.750 c-f	0.745 d	0.753 e	0.725 e
ANOVA: Treatment (P > F)			0.0001	0.0213	0.0101	0.0121
Days after treatment		14-d	7	7	1	8
		21-d	7	1	8	1

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft².

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d.

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

Table 6. Effect of various fungicides on Aeration Recovery in a creeping bent grass putting green at the Plant Science Research and Education Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[v]	Aeration Recovery 9 Sept	Aeration Recovery 16 Sept
			-1-9; 1=no recovery, 6=min acceptable-	
Bayer Program 1	pgm[z]	14-d	7.5 a[u]	7.8 ab
Bayer Program 2	pgm[y]	21-d	5.3 bcd	7.8 ab
Rotational Program 1	pgm[x]	14-d	6.5 ab	8.5 ab
Rotational Program 2	pgm[w]	21-d	3.5 def	5.8 cd
Lexicon Intrinsic	0.34 fl.oz.	14-d	7.3 a	8.0 ab
+ Signature XTRA	4.0 oz.			
Briskway	0.3 fl.oz.	14-d	5.8 abc	7.3 bc
+ Signature XTRA	4.0 oz.			
Exteris Stressgard	4.0 fl.oz.	14-d	7.3 a	9.0 a
+ Signature XTRA	4.0 oz.			
Secure	0.5 fl.oz.	14-d	5.3 bcd	7.8 ab
+ Signature XTRA	4.0 oz.			
Tourney	0.37 oz.	14-d	6.0 abc	8.3 ab
Tourney	0.28 oz.	14-d	5.8 abc	8.0 ab
Tourney	0.28 oz.	14-d	6.5 ab	8.5 ab
+ Pinpoint	0.28 fl.oz.			
Pinpoint	0.28 fl.oz.	14-d	5.0 b-e	7.5 ab
Pinpoint	0.31 fl.oz.	14-d	5.0 b-e	7.3 bc
Exteris Stressgard	4.0 fl.oz.	14-d	6.8 ab	8.3 ab
Secure	0.5 fl.oz.	14-d	5.0 b-e	7.8 ab
Daconil Weather Stik	2.0 fl.oz.	14-d	4.5 cde	5.5 de
Daconil Action	2.0 fl.oz.	14-d	3.3 ef	5.5 de
Untreated			1.8 f	4.0 e
ANOVA: Treatment ($P > F$)			0.0001	0.0001
Days after treatment		14-d	7	14
		21-d	7	14

[z]Treatments in Bayer Program 1 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[y]Treatments in Bayer Program 2 were applied as follows. 12 May: Tartan Stressgard (1.5 fl.oz.), 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[x]Treatments in Rotational Program 1 were applied as follows: 10 June: Mirage (1.5 fl.oz.), 23 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 7 July: Mirage (1.0 fl.oz), 21 July: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz) + Daconil Ultrex (3.2 oz.), 4 August: Interface (3.0 fl.oz), 18 Aug: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 2 September: Mirage (1.0 fl.oz) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[w]Treatments in Rotational Program 2 were applied as follows. 10 June: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 30 June: Fiata Stressgard (5.0 fl.oz.) + Exteris Stressgard (4.0 fl.oz), 21 July: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.), 11 August: Fiata Stressgard (5.0 fl.oz.), 2 September: Mirage (1.5 fl.oz) + Fiata Stressgard (5.0 fl.oz.) + 26GT (2.0 fl.oz). All rates are per 1000ft^2.

[v]Except for Pinpoint, which did not receive its first application until 10 June, treatments other than the rotational programs described above were initiated on 26 May, prior to disease development in the trial area. Treatments were reapplied every 14-d. The trial area was aerated using 0.375 inch hollow-tines at 1.5 by 2.0 inch spacing on 30 August

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

INFLUENCE OF FIATA ON PHYTOSAFETY OF PLANT GROWTH REGULATORS ON CREEPING BENTGRASS PUTTING GREEN TURF, 2016

K. Miele, J. Dunnack, Z. Esponda, S. Vose, and J. Inguagiato

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

ONJECTIVE

The objective of this study was to evaluate the phytosafety of various plant growth regulators applied with and without Fiata StressGard.

MATERIALS & METHODS

A field study was conducted on a 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) turf grown on a Paxton fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT. Turf was mowed five days wk^{-1} at a bench setting of 0.125-inch. Nitrogen was applied at a total of 2.0 lb N $1000\text{-}ft^{-2}$ as water soluble sources from April through September. Dylox 80 was applied on 27 May for control of white grubs. Quicksilver was applied on 6 August and 20 August for control of silvery-thread moss. Scimitar was applied on 27 August for control of cutworms. To help alleviate dry surface conditions, the wetting agent Dispatch was applied on 18 June and Revolution was applied on 23 July. For control of turf disease, Secure was applied on 4 June and 19 August, Prostar was applied on 18 June and 15 July, Curalan was applied on 18 June, 15 July, and 27 August, and Xzemplar was applied on 2 July. Overhead irrigation was applied as needed to prevent drought stress.

Treatments consisted of various plant growth regulators applied with and without Fiata StressGard. Initial applications were made on 20 May and subsequent applications were made every 14-d or every 200 or 300 growing degree days as specified in 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 $1000\text{-}ft^{-2}$ at 40 psi. Plots measured 3 x 6 ft and were arranged in a randomized complete block design with four replications.

Phytotoxicity was also assessed visually on a 0 to 5 scale, where 0 was equal to no discoloration and 2 represented the maximum acceptable level of injury. Turf quality was visually assessed on a 1 to 9 scale; where 9 represented the best possible quality turf and 6 was the minimum acceptable level. Normalized difference vegetative index (NDVI) was calculated as the mean of 10 subsamples taken randomly throughout the plot area (NDVI 500, Spectrum Technologies). Algae severity was visually assessed on a 0 to 5 scale, where 0 was equal to no surface algae and 2 represented the maximum acceptable level of algae colonization. All data were subjected to an analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test.

RESULTS AND DISCUSSION

Phytotoxicity and Turf Quality

Phytotoxic symptoms characteristic of PGR application were apparent shortly after the initiation of treatments (Table 1). Plots treated with Trimmit and Cutless were off color (blue-gray in appearance) on 31 May (11 DAIT), and worsened in appearance through mid-June through mid-July, occasionally becoming unacceptable (>2.0) during this time. Plots treated with Primo Maxx exhibited less severe phytotoxic symptoms, and never reached unacceptable levels.

The addition of Fiata StressGard to the above materials resulted in less phytotoxicity, particularly during the mid-June through mid-July timeframe mentioned above. Fiata tank-mixes never reached unacceptable levels of phytotoxicity for the duration of the trial, and on 24 June, the addition of Fiata reduced phytotoxicty by 40% for Trimmit treated plots and 60% for Cutless treated plots. Turf quality (Table 2) was also influenced by the addition of Fiata, and quality was improved from unacceptable (<6.0) to acceptable levels for Cutless + Fiata treated plots vs. Cutless alone on 17 and 24 June. Except for the last observation date (26 August) there was no difference in turf quality for Trimmit + Fiata vs. Trimmit alone. While there was generally no difference between Primo Maxx treated plots that were applied on a 14-d or 200 GDD basis, 200 GDD plots exhibited no phytotoxicity on 17 June whereas the 14-d plots exhibited some, albeit acceptable, phytotoxicity. There was no difference in turf quality for Primo Maxx + Fiata vs. Primo Maxx applied alone except on 17 June.

Except for a 6.5 rating on 10 June for Appear treated plots, turf quality was high (>7.8) and there was no phytotoxicty for the entirety of the trial for plots treated with either Fiata StressGard alone or Appear. Anuew-treated plots exhibited unacceptable levels of phytoxicity from 31 May through 24 June, however Anuew treatments were applied at 10x the label rate in this trial.

Algae Intensity

Algae deveoled in the trial area in late-June and early-July (Table 3). Algae was more intense on Trimmit + Fiata and Cutless + Fiata plots compared to either Trimmit or Cutless applied alone. No differences were observed between Primo treatments.

Table 1. Phytosafety of PGRs with and without Fiata StressGard on a creeping bentgrass putting green at the Plant Science Research Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft^2	Int[z]	Phytotoxicity								
			31 May	10 Jun	17 Jun	24 Jun	1 Jul	15 Jul	28 Jul	4 Aug	26 Aug
			---------- 0-5; 2=maximum acceptable ----------								
Primo Maxx	0.125 fl.oz.	14-d	0.0 c	0.0 d	1.1 cd	0.3 e	0.0 d	0.0 c	0.0	0.5	0.0
Primo Maxx	0.125 fl.oz.	14-d	0.0 c	0.0 d	0.0 f	0.3 e	0.0 d	0.0 c	0.0	0.0	0.0
+ Fiata Stressgard	5.0 fl.oz	14-d									
Trimmit 2SC	0.184 fl.oz.	14-d	0.3 bc	1.0 c	1.9 bc	3.0 ab	1.5 ab	1.2 a	0.5	0.8	0.0
Trimmit 2SC	0.184 fl.oz.	14-d	0.3 bc	0.5 cd	0.4 def	1.8 c	0.4 cd	0.2 bc	0.0	0.3	0.0
+ Fiata Stressgard	3.5 fl.oz.	14-d									
Cutless MEC	0.564 fl.oz.	14-d	0.5 b	1.8 b	2.7 ab	2.5 b	1.7 a	0.2 bc	0.3	0.8	0.0
Cutless MEC	0.564 fl.oz.	14-d	0.0 c	0.3 d	0.2 ef	1.0 d	0.2 d	0.0 c	0.0	0.3	0.0
+ Fiata Stressgard	3.5 fl.oz.	14-d									
Fiata Stressgard	3.5 fl.oz.	14-d	0.0 c	0.0 d	0.0 f	0.0 e	0.0 d	0.0 c	0.0	0.0	0.0
Appear	5.0 fl.oz.	14-d	0.0 c	0.0 d	0.0 f	0.0 e	0.0 d	0.0 c	0.0	0.0	0.0
Primo Maxx	0.125 fl.oz.	GDD200[y]	0.0 c	0.5 cd	0.0 f	0.0 e	0.0 d	0.0 c	0.3	0.5	0.0
Anuew	0.9 oz.	14-d	3.0 a	3.5 a	3.7 a	3.5 a	0.9 bc	1.1 a	0.3	0.3	0.0
Anuew	0.9 oz.	GDD300[x]	3.0 a	2.0 b	3.7 a	1.5 cd	0.2 d	0.6 ab	0.8	0.5	0.0
Untreated			0.0 c	0.0 d	0.8 de	0.0 e	0.0 d	0.0 c	0.0	0.0	0.0
ANOVA: Treatment (P > F)			0.0001	0.0001	0.0001	0.0001	0.0001	0.0003	0.1960	0.0704	1.0000
Days after treatment		14-d	11	8	1	8	1	1	0	7	0
		GDD200	11	9	2	9	2	8	8	7	8
		GDD300	11	21	10	17	2	2	2	8	2

[z]Treatments were initiated on 20 May and reapplied on a 14-d basis.

[y] Primo Maxx GDD200 was applied on 20 May, 1 June, 15 June, 28 Jun, 7 Jul, 20 Jul, 28 Jul, 8 Aug, 18 Aug, 31 Aug.

[x]Anuew GDD300 was applied on 20 May, 7 June, 28 Jun, 13 Jul, 26 Jul, 11 Aug, 24 Aug.

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

Table 2. Turf Quality of PGRs with and without Fiata StressGard on a creeping bentgrass putting green at the Plant Science Research Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[z]	Turf Quality								
			31 May	10 Jun	17 Jun	24 Jun	1 Jul	15 Jul	28 Jul	4 Aug	26 Aug
			-----	-----	-----	-----	1-9; 6 min acceptable	-----	-----	-----	-----
Primo Maxx	0.125 fl.oz.	14-d	6.5 cd	6.5	6.3 cde	7.3 a-d	6.5 bcd	6.8 bc	7.5 bc	8.3 ab	7.8 cde
Primo Maxx	0.125 fl.oz.	14-d	7.3 abc	7.3	7.8 ab	7.5 abc	6.8 bcd	7.8 ab	8.5 ab	8.5 a	8.3 bc
+ Fiata Stressgard	5.0 fl.oz	14-d									
Trimmit 2SC	0.184 fl.oz.	14-d	7.3 abc	6.5	5.8 de	6.0 def	5.8 d	6.5 c	7.3 c	7.3 bcd	8.0 bcd
Trimmit 2SC	0.184 fl.oz.	14-d	6.8 bcd	5.5	6.5 cde	6.3 cde	5.8 d	6.8 bc	7.3 c	7.5 a-d	9.0 a
+ Fiata Stressgard	3.5 fl.oz.	14-d									
Cutless MEC	0.564 fl.oz.	14-d	6.3 d	6.5	5.5 e	5.3 ef	5.5 d	6.3 c	7.3 c	7.0 cd	7.3 efg
Cutless MEC	0.564 fl.oz.	14-d	7.5 ab	6.3	7.3 bc	6.8 bcd	6.3 cd	8.0 a	8.0 abc	8.0 abc	8.5 ab
+ Fiata Stressgard	3.5 fl.oz.	14-d									
Fiata Stressgard	3.5 fl.oz.	14-d	7.8 a[w]	7.3	8.5 a	8.3 a	7.8 ab	7.8 ab	8.5 ab	8.3 ab	8.0 bcd
Appear	5.0 fl.oz.	14-d	7.8 a	6.5	8.5 a	8.0 ab	8.3 a	8.0 a	8.8 a	8.5 a	8.5 ab
Primo Maxx	0.125 fl.oz.	GDD_{200}[y]	7.3 abc	7.5	6.8 bcd	7.3 a-d	7.3 abc	7.8 ab	8.5 ab	8.3 ab	7.5 def
Anuew	0.9 oz.	14-d	5.0 e	5.5	3.5 f	4.8 f	6.0 cd	6.3 c	7.3 c	5.8 e	7.0 fg
Anuew	0.9 oz.	GDD_{300}[x]	5.0 e	5.5	4.3 f	6.0 def	6.5 bcd	6.8 bc	7.3 c	6.5 de	6.8 gh
Untreated			7.3 abc	5.8	6.3 cde	7.3 a-d	6.8 bcd	7.0 abc	7.8 abc	7.3 bcd	6.3 h
ANOVA: Treatment (P > F)			0.0001	0.3245	0.0001	0.0001	0.0115	0.0034	0.0085	0.0001	0.0001
Days after treatment		14-d	11	8	1	8	1	1	0	7	0
		GDD_{200}	11	9	2	9	2	8	8	7	8
		GDD_{300}	11	21	10	17	2	2	2	8	2

[z]Treatments were initiated on 20 May and reapplied on a 14-d basis.
[y] Primo Maxx GDD200 was applied on 20 May, 1 June, 15 June, 28 Jun, 7 Jul, 20 Jul, 28 Jul, 8 Aug, 18 Aug, 31 Aug.
[x]Anuew GDD300 was applied on 20 May, 7 June, 28 Jun, 13 Jul, 26 Jul, 11 Aug, 24 Aug.
[w]Treatment means followed by the same letter, within each column, are not significantly different based on Fisher's protected least significant difference test ($\alpha = 0.05$).

Table 3. NDVI, Etiolation, and Algae Intensity affected by PGRs with and without Fiata StressGard on a creeping bentgrass putting green at the Plant Science Research Facility in Storrs, CT during 2016.

Treatment	Rate per 1000ft²	Int[z]	NDVI					Algae Intensity	
			17 Jun	1 Jul	8 Jul	28 Jul	12 Aug	24 June	1 July
			-------------------Vegetation Index -----------------					0-5; 2=max acceptable	
Primo Maxx	0.125 fl.oz.	14-d	0.771	0.780	0.782	0.775	0.783	0.2 cd	1.0 cd
Primo Maxx	0.125 fl.oz.	14-d	0.775	0.773	0.770	0.745	0.769	0.4 bcd	1.5 cd
+ Fiata Stressgard	5.0 fl.oz	14-d							
Trimmit 2SC	0.184 fl.oz.	14-d	0.759	0.773	0.777	0.770	0.767	0.0 d	1.5 cd
Trimmit 2SC	0.184 fl.oz.	14-d	0.761	0.768	0.772	0.770	0.762	2.7 a	3.0 ab
+ Fiata Stressgard	3.5 fl.oz.	14-d							
Cutless MEC	0.564 fl.oz.	14-d	0.745	0.760	0.774	0.767	0.764	0.8 bcd	2.0 bc
Cutless MEC	0.564 fl.oz.	14-d	0.766	0.775	0.777	0.765	0.756	3.0 a	3.5 a
+ Fiata Stressgard	3.5 fl.oz.	14-d							
Fiata Stressgard	3.5 fl.oz.	14-d	0.772	0.783	0.780	0.763	0.767	0.0 d	1.0 cd
Appear	5.0 fl.oz.	14-d	0.767	0.774	0.781	0.765	0.772	0.0 d	1.3 cd
Primo Maxx	0.125 fl.oz.	GDD200[y]	0.768	0.779	0.785	0.777	0.759	0.4 bcd	1.3 cd
Anuew	0.9 oz.	14-d	0.757	0.762	0.776	0.777	0.758	1.3 b	2.0 bc
Anuew	0.9 oz.	GDD300[x]	0.761	0.763	0.776	0.776	0.773	1.1 bc	1.8 cd
Untreated			0.761	0.771	0.780	0.748	0.776	0.2 cd	0.8 d
ANOVA: Treatment (P > F)			0.4314	0.3296	0.5694	0.4876	0.6287	0.0001	0.0009
Days after treatment		14-d	1	1	8	0	1	7	1
		GDD200	2	2	1	8	4	0	2
		GDD300	10	2	10	2	1	0	2

[z]Treatments were initiated on 20 May and reapplied on a 14-d basis.

[y] Primo Maxx GDD200 was applied on 20 May, 1 June, 15 June, 28 Jun, 7 Jul, 20 Jul, 28 Jul, 8 Aug, 18 Aug, 31 Aug.

[x]Anuew GDD300 was applied on 20 May, 7 June, 28 Jun, 13 Jul, 26 Jul, 11 Aug, 24 Aug.

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

DETERMINING DISLODGEABLE FOLIAR RESIDUE LEVELS FOLLOWING THE APPLICATION OF TWO PESTICIDES USED TO MANAGE SPORTS TURF, 2016

G.L. Maxey[1], J.J. Henderson[1], J.C. Inguagiato[1]
[1]Department of Plant Science and Landscape Architecture
University of Connecticut

INTRODUCTION

The safety of pesticides usage on athletic fields is a complicated issue. Pesticide fate post application largely determines the potential for human exposure (Clark, 2007). This means playing on treated turf could be a risk of exposure if those compounds remain on the surface. Connecticut has banned all pesticides on school grounds from Kindergarten through 8th grade due to that concern that children are exposed to pesticide residues (State of Connecticut, 2009). By law, the labels for these products have re-entry periods or some designated amount of time before it is safe to re-enter the turfgrass area that received the application. Once this time has expired, the labels deem the turfgrass can return to normal fuction. Little research has been conducted regarding human exposure of pesticide residues on sports fields the days following an application. Quantification of residues post application may help lawmakers with science-based information concerning future legislation of minimizing pesticide exposure.

The objective of this project is to quantify foliar residues on playing surfaces following the application of two herbicides in two formulations sampled at post application time intervals of 0, 1, 3, 5, 7, 9 & 14 days after treatment.

MATERIALS AND METHODS

The research area was a three-year-old monostand of ‘Granite’, Kentucky bluegrass (*Poa pratensis*). No pesticides were applied on this stand of turfgrass within three months of conducting the study. The experiment utilized a split block design arranged in a 2 x 2 x 8 factorial with three replications (Figure 1). The first factor, product, included Trimec and Dimension. The second factor, formulation, included granular and liquid. The third factor was days after treatment (DAT), 0,1, 3, 5, 7, 9 and 14. The granular form of Trimec was Ferti-lome Weed Out Broadleaf killer. The granular form of Dimension was Lesco Dimension 0.10%; plus fertilizer (0-0-7). The liquid formulations were Trimec Classic and Dimension 2EW. The laboratory testing for Trimec products included all three active ingredients; MCPP, Dicamba and 2,4-Dichlorophenoxyacetic acid (2,4-D). Dimension was tested for the only active incredient; Dithiopyr (DIT). Each product was applied according to their respective labels. The only modification to the application rates was matching the active ingredient levels across formulations. In other words, this avoided liquid formulation of 2,4-D being applied at a higher rate of active ingredient than the granual formulation.

Figure 1. Wetting surface before Granular 2,4-D application with flow gauge.

Per label instructions, granular Trimec was applied after watering the surface (0.25”) so the granules would adhear to the leaf surface. Both granular and liquid Dimension was watered in after application (0.50”). The amount of water was calculated beforehand and measured with a flow gauge. (Figure 1.)

Initial sampling took place a week before any chemicals were applied to the turf. The initial testing represented our untreated control. Once the pesticides were applied, the stand was no longer mowed, irrigated, or traveled through on foot. Day 0 sampling took place from 2pm to 5pm. Samples were collected immediately once a single product was applied to all three replications. Strenuous efforts were taken on Day 0 to prevent chemicals from drying before sampling. The remainder of samples for the subsequent days after treatment were taken at 5am to ensure morning dew was present on the foliage. This timing was chosen based on previous research that showed a spike at 5am in liquid applied 2,4-D residues that gradually declined throughout the day and days after treatment (Gannon and Jeffries, 2014). The climate conditions during sampling are shown in table 1.

Figure 2. Cloth sample after being rolled. Dew moisture visible on cloth.

A modified California roller was used for sampling. The roller weighed 32 lbs and was foam wrapped to help conform to small undulations on the surface of the ground (Williams et al., 2008). This device was rolled on top of a percale cotton cloth covered with a plastic sheet to prevent contamination between samples. These were held down by a frame that clamped the edges of the sheets (Figure 2) (Williams et al., 2008).

Each sample that was taken was rolled twenty times; down and back counted as two separate passes. After being rolled, the sample was carefully removed from the harness and placed in an amber colored jar, then placed directly into a cooler. Samples were frozen immediately following collection to ensure no active ingredients were compromised. Extreme precaution was taken to prevent any cross contamination between samples.

An analysis of variance was completed to test for significant differences (p <0.05) among treatments using SAS statistical software 9.4 (SAS Institute. Cary, NC. 2004). The Mixed procedure and Fisher's least significant difference (LSD) test was conducted to separate the means when the appropriate F-test values were below the p-value of 0.05.

RESULTS AND DISCUSSION

The average dislodgeable pesticide residues extracted from each treatment are summarized in Table 2. Significant main effects were observed across all three factors; active ingredient, formulation, and days after treatment (DAT). Significant interactions were also observed across all combinations of the three factors. The results of the mean separation test are shown in Figures 3 and 4. Liquid 2,4-D residues for Day 0 and Day 1 were statistically different as were the remaining days after treatment. Table 2 shows that Trimec, in liquid form, had the most detectible residues in total, and the most residue detected days after treatment. The sharp decline on Day 3 (Table 2) residues may have been a results of a significant rain event between the sampling Days 1 & 3. Interestingly, despite these rain events, the liquid formulation of Trimec had a slight increase in foliar residue on day 9 & 14. This suggests a potential relationship between the residues getting absorbed into, then re-suspending into the solution on the leaf blades.

The granular form of Trimec, however, had significantly less residues detected for total amounts and days after treatment and no statistical differences among days after treatment. Dithiopyr in granular and liquid formulations had low residues initially and were both non-detects one day after treatment. The only statistically different sample of Dithiopyr was the liquid formulation directly after sampling (Day 0) shown in Figure 3. Four consecutive non-detectible samples were considered no longer necessary to continue analyzing residue levels in the lab.

Dithiopyr had a minimum detectable residue level of 1.95 ug/sample. Any residue present that fell below this threshold was non-detectible. 2,4-D had a minimum detectable residue level of 0.39 ug/sample. It should be noted this experiment examined the worst-case scenario of pesticide exposure by sampling during the morning with optimum dew formation.

Additional research is needed to determine how the solubility of 2,4-D and Dicamba can lead to residues dislodging into solution multiple days and weeks after treatment. According to these data, Day 0 & 1 showed all four active ingredients tested in granular formulations had significantly reduced detectable residues compared to liquid formulations. This suggests that granular forms of Trimec and Dimension would be preferred over liquid formulations to minimize field closure times following the use of pesticides; however, this suggestion does not consider the efficacy of the products tested, which is an important component to sports turf maintenance. These results can help improve recommendations for minimizing potential exposure risks and help lawmakers make science-base decisions concerning future legislation.

LITERATURE CITED

Clark, J.M., R. Putnam, and J. Doherty. 2007. Determining golf exposure and hazard to pesticides. Green Section Record. Mar.-Apr.: 21-24.

State of Connecitcut. 2009. An act concerning pesticide applications at child day care centers and schools. https://www.cga.ct.gov/2009/act/Pa/pdf/2009PA-00056-R00SB-01020-PA.PDF (accessed 1 March. 2017).

Gannon, T. W., and M. D. Jeffries. 2014. Dislodgaeable 2,4-D from Athletic Field Turfgrass. *European Journal of Horticultural Science* 79: 116-22.

Williams, Ryan L., Craig E. Bernard, Melinda Bigelow Dyk, John H. Ross, and Robert I. Krieger. 2008. Measurement of Transferable Chemical Residue from Nylon Carpet Using the California Roller and a New Mega-California Roller. *Journal of Environmental Science and Health, Part B* 43.8: 675-79.

Table 1. Climate Conditions during experimental days after treatment[a]

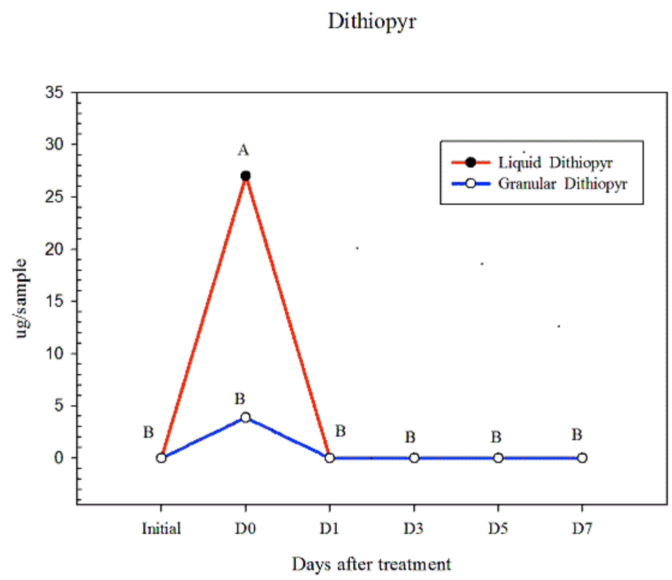
DAT[b]	Time	Precipitation (mm)[d]	RH (%)	Air Temp (˚C)	Dew Point (°C)	AT-DP (°C)
Initial	14:00	0	72	25.5	17.8	7.7
0[c]	14:00	0	82	20.0	15.0	5.0
1	5:00	0	85	18.9	18.3	0.6
3	5:00	12	80	19.4	21.7	1.3
5	5:00	0	80	20.5	20.0	0.5
7	5:00	10	67	21.1	18.3	2.8
9	5:00	0	66	14.4	13.3	1.1
14	5:00	16	70	20.6	19.4	1.2

[a] Climate conditions pulled from nearest weather station, Gurleyville Green (Gurleyville, Mansfield, CT)
[b]Abbreviations: DAT, days after treatment; RH, relative humidity.
[c]DAT of '0' is directly after application
[d]Precipitation is the total amount accumulated since the previous sampling day.

Table 2. Average dislodgeable residues days after treatment in granular and liquid forms.

		Days After Treatment							
formulation	a.i	Initial	0	1	3	5	7	9	14
		ug/sample							
L	2,4-D	ND	703.6	1251.9	18.5	4.3	2.1	8.1	7.3
G	2,4-D	ND	6.7	5.5	2.06	ND	ND	ND	0.5
L	MCPP	ND	210.1	176.1	3.9	1.2	0.5	1.1	1.8
G	MCPP	ND	6.0	ND	1.52	ND	ND	ND	ND
L	Dicamba	ND	689.5	1279.2	14.2	ND	ND	5.6	6.7
G	Dicamba	ND	5.4	5.5	ND	ND	ND	ND	ND
L	Dithiopyr	ND	26.4	ND	ND	ND	ND	-[e]	-
G	Dithiopyr	ND	3.9	ND	ND	ND	ND	-	-

[a]Abbreviations: DAT, Days after treatment; G/L, Granular/Liquid; a.i, active ingredient; ND, Non-detect
[b]Dithiopyr samples had a detection limit of 1.95 ug/sample.
[c]2,4-D and MCPP had a detection limit of 0.39 ug/sample.
[d]Dicamba had a detection limit of 3.9 ug/sample.
[e]Dashes '-' indicate no laboratory sampling took place because of four consecutive non-detects



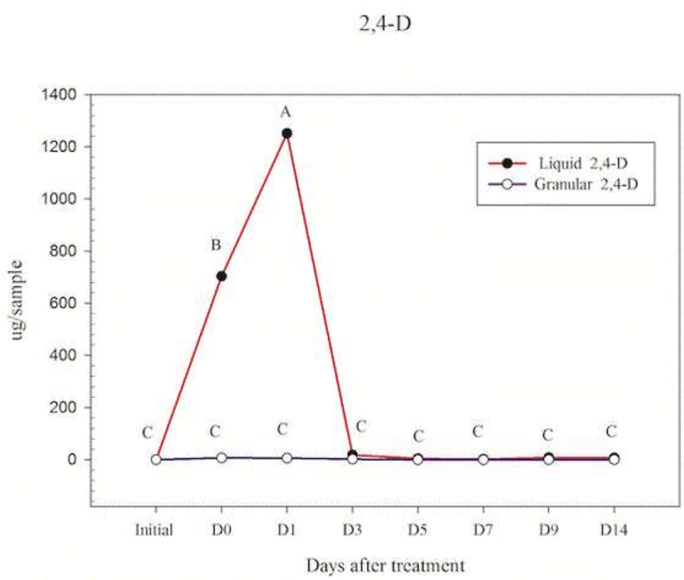


Figure 3 & 4. The effect of formulation and time on dislodgeable foliar residue levels of 2,4-D and Dithiopyr. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

ORGANIC TURF AND NO-PESTICIDE TURF DEMONSTRATION FOR HOME LAWNS AND ATHLETIC FIELDS 2016

G.L. Maxey[1], J.J. Henderson[1], T.F. Morris[1], K. Guillard[1], J.C. Inguagiato[1], S.L. Rackliffe[1], and V.H. Wallace[2]
[1]Department of Plant Science and Landscape Architecture
[2]Department of Extension
University of Connecticut

INTRODUCTION

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

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

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

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

MATERIALS AND METHODS

The research area was divided into two separate studies – athletic field and home lawn. The studies consisted of individual plots measuring 20ft x 30ft with eight treatments replicated three times. Both studies were arranged as a randomized complete block design with three replications. The athletic field section (190ft x 100ft) was seeded with a mix of 70% Kentucky bluegrass and 30% perennial ryegrass (% seed by weight). The home lawn section (190ft x 100ft) was seeded with a mix of 60% Kentucky bluegrass, 20% perennial ryegrass and 20% fine fescue (10% chewings and 10% creeping red) (% seed by weight). The treatments or “systems” evaluated are: 1) Organic High, 2) Organic Low, 3) Pesticide-free High, 4) Pesticide-free Low, 5) Calendar Based, 6) IPM, 7) ISM, 8) None (mow only control).

Each management system received applications of fertilizer, insect and weed control appropriate for each treatment. The athletic field received 4 lbs N 1000ft^{-2} to the listed treatments; Calendar, Organic High, Pesticide-free High, IPM, and ISM. Treatments Organic Low and Pesticide-free Low received 2 lbs N1000ft^{-2}. The home lawn’s Organic Low and Pesticide-free low received 1 lb N 1000ft^{-2}, while the Calendar, Organic High, Pesticide-free High, IPM, and ISM received 3 lbs N 1000ft^{-2}. These totals were for the entire 2016 growing season.

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

Figure 1. Modified greens aerator used to simulate traffic on athletic playing fields

A specially designed traffic machine (Figure 1) was used on the athletic field portion of the study to provide simulated athletic field wear to the field. The walk-behind aerator was converted from using aeration tines to steel plates with individual cleats underneath. This imposed wear simulates the intense traffic most athletic fields endure on a perennial basis. The athletic fields received traffic events two or three times per week with a total of 58.5 events from June to November. Each traffic event consisted of two perpendicular passes.

Data collection for the home lawn study included; color ratings, quality ratings, percent green cover, volumetric water content (VWC) (Spectrum Technologies, Inc. Plainfield, IL), normalized difference vegetative index (NDVI) (Spectrum Technologies, Inc. Plainfield, IL), and percent weed cover. In addition to the previous measurements, the athletic field was tested for surface hardness and rotational traction. Both fields were rated for their overall color and quality based on a scale from 1 to 9, where 1 represented the lowest quality, 6 was the minimum acceptable quality, and 9 was the optimum quality. This qualitative assessment was done once per month.

Digital image analysis (DIA) was used on both fields to quantify dark green color and percent green cover (Karcher and Richardson, 2005). These images were taken without interference of sunlight by using a light box that was wheeled to plots with a dolly. Three images were taken of each plot with the light box. The digital images were scanned by Sigma Scan software (Cranes Software International Ltd. Chicago, IL. 1991). NDVI data was collected by taking 15 readings per plot for data analysis. VMC data was collected by taking the average of 12 readings per plot for data analysis. The DIA, VWC, and NDVI were taken every month starting in June.

Weed counts for each plot was obtained by using a metal frame that had clear fishing line in perpendicular directions to make a crossing pattern. The frame had 240 intersections. The sum of intersections with weeds below each intersection was calculated as a percentage based on the 240 total intersections. The frame was counted in six separate locations within each plot to get an accurate quantitative number of weeds. Weed counts were conducted five times throughout the year.

Lastly, the Clegg Impact Soil Tester was used to measure the GMAX rating, which was a quantitative assessment of surface hardness (ASTM, 2008). The GMAX was measured 18 times per plot and the average was used for data analysis. Clegg measurements were taken three times during the year. Treatments were also assessed for rotational traction by measuring the resistance of twisting a weighted cleat on the surface. This was done six times per plot (Canaway and Bell, 1986).

Analysis of variance was used to test for significant differences (p <0.05) between treatments using SAS statistical software 9.4 (SAS Institute. Cary, NC. 2004). Where appropriate F-test showed significance, mean separations were conducted using Fisher's least significant difference (LSD) test with a 0.05 proabability level.

RESULTS AND DISCUSSION

The treatments in the home lawn study exhibiting the highest average color ratings were Calendar, ISM & IPM with ratings of 7.41, 7.28, and 6.88 respectively (Figure 3). Minimal differences were observed between Organic High, Organic Low, Pesticide Free High, and the mow only control. The average quality ratings showed a similar trend to the color rating across the management strategies. Calendar stood out statistically above the rest for quality at 7.57 overall (Figure 4). The athletic field study showed a different response across the management strategies regarding turfgrass quality ratings than the home lawn study. ISM remained a top performer, but Organic High (Figure 6) had higher turfgrass quality than the Calendar, Pesticide-Free Low, Pesticide-Free High and IPM treatments.

Home lawn results showed dramatic differences in percent weed cover (Figure 7). ISM, IPM and Calendar had nearly zero weeds. For these management strategies, it was often hard to spot more than one or two weeds per plot. None of the other treatments were statistically different. However, the athletic field study showed more statistical differences among treatments (Figure 8). Calendar, ISM, and IPM had the fewest weeds. The changes in percent weed cover was likey due to the changes in mowing height and from traffic.

Organic High had the lowest Gmax value and ISM had the highest; however, all treatments fell well within a range that would be considered acceptable for a well-maintained sports field (Figure 9). ISM retained greater percent green

Figure 2. Athletic field Organic High on December 1st.

cover under trafficked conditions than Pesticide-Free Low, IPM and the mow only control (Figure 10). This data presented was for 2016 only.

LITERATUER CITED

American Society for Testing and Materials (ASTM). 2008. Standard test method for measuring shock attenuation characteristics of natural playing surface systems using lightweight portable apparatus. F 1702-96 (reapproved 2002). In: Annual Book of ASTM Standards, vol. 15.07. ASTM International, West Conshohocken, PA. pg 347-351.

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

Karcher, D.E., and M.D. Richardson. 2005. Batch analysis of digital images to evaluate turfgrass characteristics. Crop Sci. 45:1536-1539.

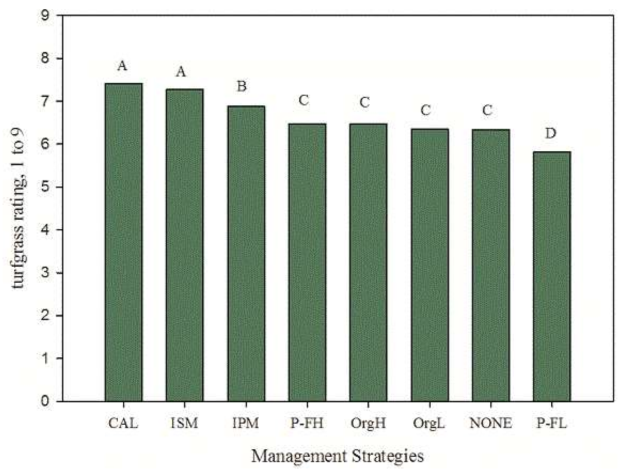


Figure 3. The effect of management strategies on home lawn qualitative turfgrass color. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

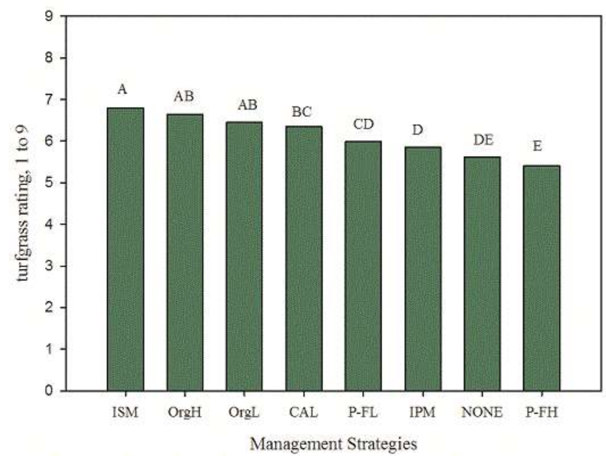


Figure 5. The effect of management strategies on athletic field qualitative turfgrass color. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

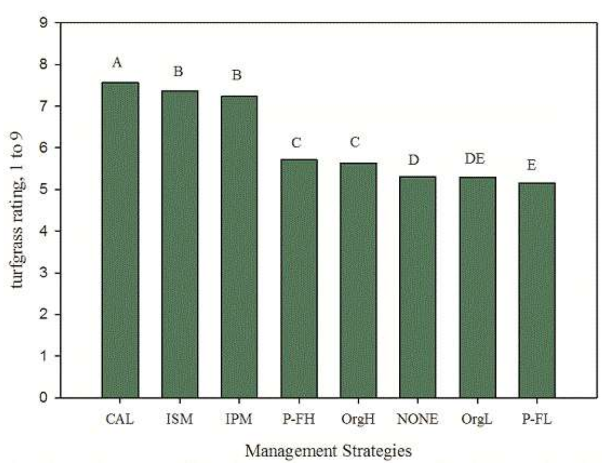


Figure 4. The effect of management strategies on home lawn turfgrass quality. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

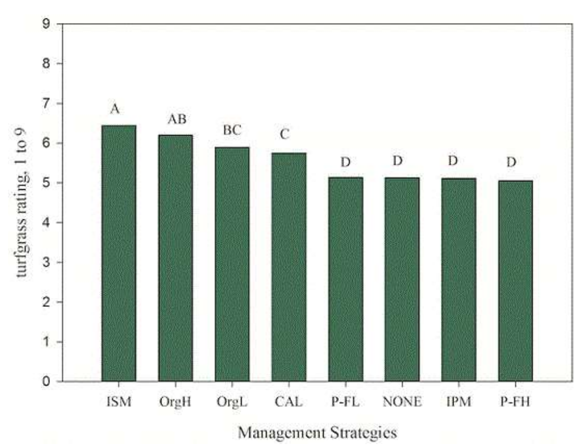


Figure 6. The effect of management strategies on athletic field turfgrass quality. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

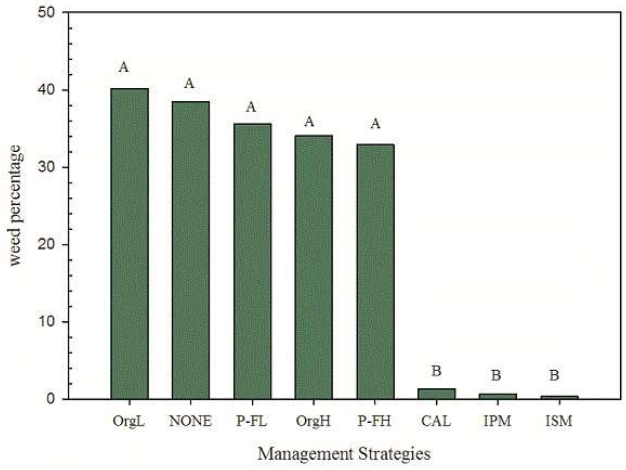


Figure 7. The effect of management strategies on home lawn percent weed cover. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

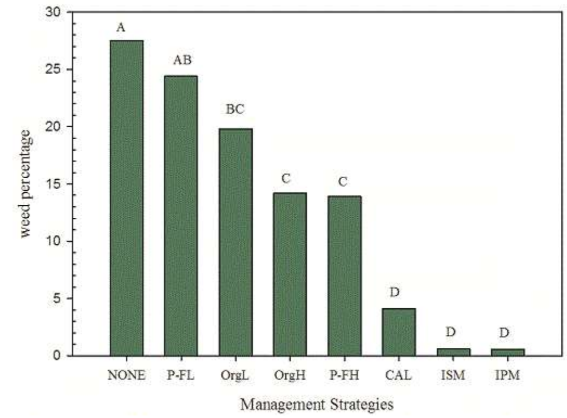


Figure 8. The effect of management strategies on athletic field percent weed cover. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

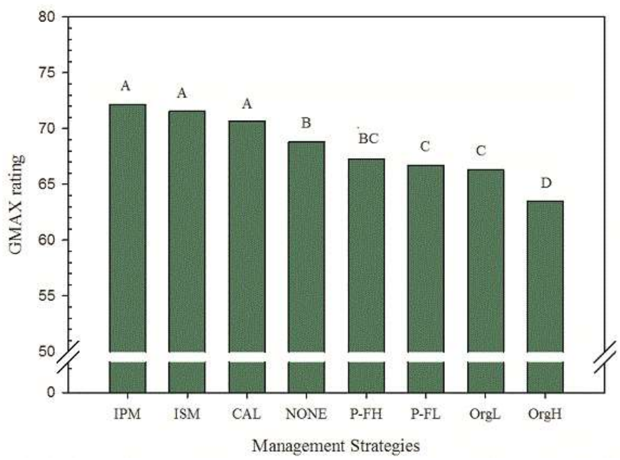


Figure 9. The effect of management strategies on athletic field surface hardness. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

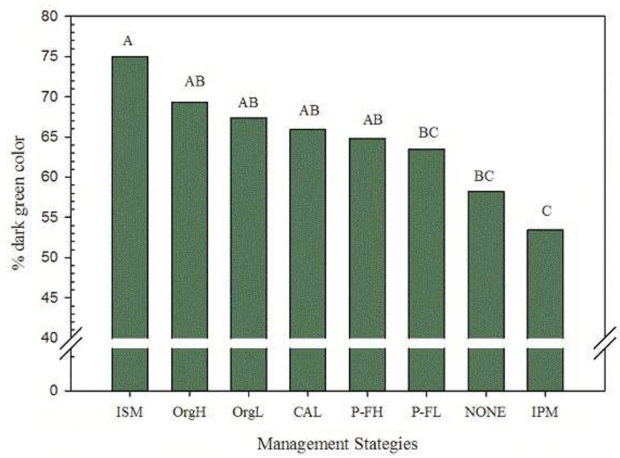


Figure 10. The effect of management strategies on athletic field percent green cover in November. Data points with the same letter are not statistically different according to Fisher's protected LSD (p<0.05).

Table of Contents

SOLVITA® SOIL TEST KITS TO CATEGORIZE TURFGRASS SITE RESPONSIVENESS TO NITROGEN FERTILIZATION – 2016 RESULTS

David Moore[1], Karl Guillard[1], and Will Brinton[2]
[1]Department of Plant Science and Landscape Architecture, University of Connecticut
[2]Woods End® Laboratories, Inc., Mt Vernon, ME

INTRODUCTION

Currently, there is no routine method of predicting nitrogen fertilization requirements for turfgrass areas. Nitrogen (N) is very transient in the soil, and routine soil tests for turf generally do not include a measure of N. N fertilizer is generally applied at a set rate regardless of soil characteristics. This is not ideal, as too little or too much fertilization can lead to problems related to turfgrass health and environmental pollution. The Solvita® Company (http://solvita.com/soil) offers two simple soil tests kits that could improve our ability to accurately predict N fertilization requirements for turfgrass. The Solvita Labile Amino Nitrogen (SLAN) Test measures the biologically active fraction of N in the soil (also called the 'nitrogen mineralization potential' of the soil); it measures the amount of ammonia gas that is released from the soil during a 24-hour incubation with 10 mls of 2 M NaOH. Presumably, the ammonia released is derived from the active, or labile, fraction of organic matter that contain easily-removable amine groups. The CO_2-Burst Test measures the biologically active fraction of carbon (C) in the soil; it measures the CO_2 released from the soil during a 24-hour incubation with 20 mls of water. Presumably, the CO_2 released is the byproduct of microbial degradation of active organic matter. It is well-understood that the labile C fractions in the soil that the CO_2-Burst Test measures are positively correlated with soil fertility and crop yield (Geng et al. 2014, Hurisso et al. 2016). These Solvita® tests take 1 day and could be done on site without the need to send soil samples to a laboratory for processing. The objective of this research is to determine if these new commercially-available test kits can categorize turf soils as to their responsiveness to N fertilization.

MATERIALS & METHODS

In September of 2007, an organic composted fertilizer (Suståne 5-2-4, all natural fine grade) was incorporated into the 15-cm depth of 1 × 1 m plots at two adjacent sites at 23 different rates ranging from 0 to 400 kg available N ha^{-1} $year^{-1}$. After compost incorporation, one site was seeded to tall fescue (*Festuca arundinacea* cvs. Shortstop II, Dynasty, Crossfire II), and the other was seeded to Kentucky bluegrass (*Poa pratensis* cv. America). The experiments were set out as randomized complete block designs with three replicates. In November of 2008-2010 and 2012-2016, plots were solid-tined aerified and compost was applied again to the same plots using the same rates, and brushed into the aerification holes. Additional treatments in each year include urea in split applications (May, June, Sept., Oct.) at 49, 98, 147, and 196 kg N ha^{-1} $year^{-1}$. The synthetic urea treatments were included so that response of the compost treatments could be matched to that of the synthetic N rate. Urea plots also received 98 kg of K_2O and P_2O_5 at the first urea application in the form of potassium sulfate and triple super phosphate.

On April 25th, 2016, before the first urea application, soil samples were collected from each plot to a depth of 10 cm below the thatch layer, oven-dried, then sieved to pass a 2-mm screen. These samples were analyzed with the Solvita® CO_2-Burst and SLAN test kits. Four grams of soil were used for the SLAN test and 40 grams of soil were used for the CO_2-Burst test. Results are reported as mg kg^{-1} NH_3-N for SLAN and mg kg^{-1} CO_2-C for CO_2-Burst.

At approximately every two weeks during the growing season, turf color quality was measured using Spectrum FieldScout CM 1000 Chlorophyll and TCM 500 NDVI Turf Color meters (Spectrum Technologies, Inc., Aurora, IL).

Grass clippings were harvested monthly from a 0.25-m^2 area in the center of each plot using a Toro push mower with a bagger. The clippings were dried in an oven between 60° and 70°C and weighed. The yearly sum of these monthly clipping weights was determined. Dried grass clippings were ground in a cyclone sample mill (Udy Corporation, Fort Collins, CO) and the ground tissue was analyzed using a LECO TruMac CN determinator (LECO Corporation, Saint Joseph, MI). Total N uptake was determined by multiplying the total N content of the tissue sample by the yearly sum of the harvested grass clippings.

Linear regression models were applied to determine the response of Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations as a function of organic fertilizer rates, and for mean NDVI readings, mean CM 1000 readings (Chlorophyll Index), sum of the clippings yields, clippings total N concentrations, and the sum of clippings total N uptake as a function of Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations. The REG procedure of SAS 9.4 (SAS Institute, Cary, NC) was used for the linear models. Logistic curves of binary responses for the probabilities of organic fertilizer responses equaling or exceeding the mean responses obtained from the 150 and 200 kg N ha^{-1} urea treatments (which would typically be the maximum recommended rates of N for lawns in our climate) in relation to Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations were determined with linear binary logistic models ($a + bx = \{\ln[\pi/(1-\pi)]\}$, where π is the probability of the organic fertilizer response being equal to or exceeding the mean response from the 150 and 200 kg N ha^{-1} urea treatments) using the LOGISTIC procedure of SAS 9.4.

RESULTS

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

Increasing organic fertilizer rates were generally well correlated with increasing Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations in a significant ($P < 0.001$) linear response (Figs. 1 and 2, panels A and B). The model fits were better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

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

Turfgrass color, as measured by NDVI and CM 1000 meters, was significantly ($P < 0.001$) and linearly associated with Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations for Kentucky bluegrass and tall fescue (Figs. 1 and 2, panels C, D, E, and F). The model fits were better for Kentucky bluegrass than for tall fescue.

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

Turfgrass clippings yield was significantly ($P < 0.001$) and linearly associated with Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations for Kentucky bluegrass and tall fescue (Figs. 1 and 2, panels G and H). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

Turfgrass Tissue Total Nitrogen Concentration and Total Nitrogen Uptake as a Function of Soil CO_2-C and NH_3-N Concentrations

Turfgrass tissue total N concentration and total N uptake were significantly ($P < 0.001$) and linearly associated with Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations for Kentucky bluegrass and tall fescue (Figs. 1 and 2, panels I, J, K, and L). The model fits were better for Kentucky bluegrass than for tall fescue, and better for SLAN NH_3-N than for CO_2-Burst CO_2-C.

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

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

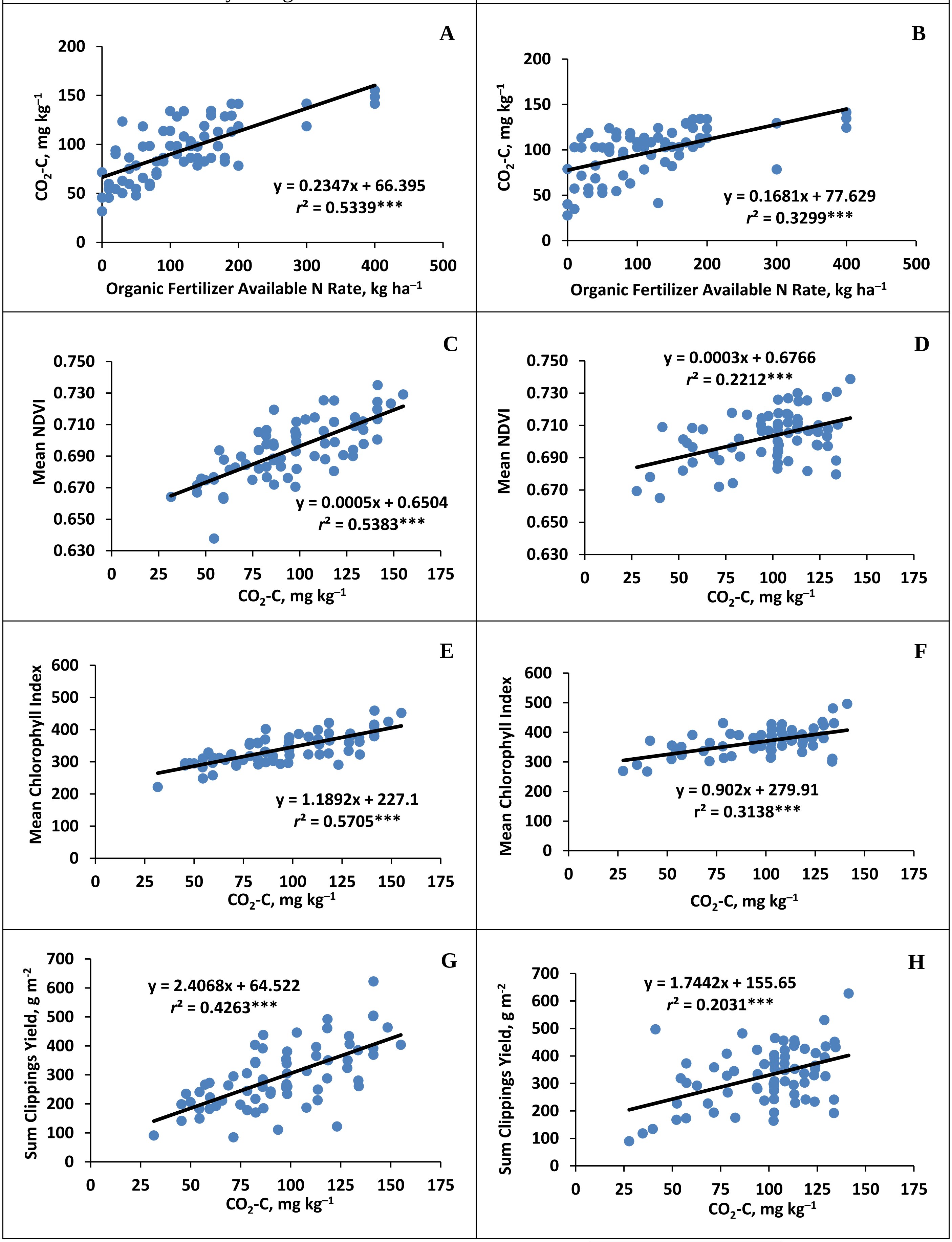
Estimates of the binary logistic regression coefficient parameters and their associated *P*-values are given in Table 1. As a guide for the reader, the Wald *P*-values are used to determine the significance of the slope for the logistic regression (considered significant when $P < 0.05$). The Hosmer-Lemeshow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

Significant ($P < 0.05$) logistic regression models were found for nearly all variables (NDVI, Chlorophyll Index, clippings yield, total N, and N uptake) for both Kentucky bluegrass and tall fescue (with the exception of tall fescue NDVI versus SLAN NH_3-N concentration) and when both species were combined as a function of soil CO_2-Burst CO_2-C and SLAN NH_3-N concentrations (Table 1). Probability curves indicated that when mean soil CO_2-Burst CO_2-C concentrations were ≤ 93 and ≤ 84 mg kg^{-1}, there was a low probability ($P \leq 0.33$) of response equal to or exceeding that of 150-200 kg N ha^{-1} from urea for Kentucky bluegrass and tall fescue, respectively, across the five measured variables (Fig. 3 panels A and B, and Table 2). When mean CO_2-C concentrations were between 93 to 120 mg kg^{-1} for Kentucky bluegrass and between 84 to 122 mg kg^{-1} for tall fescue, there was a moderate probability ($P > 0.33$ to 0.67) of equaling or exceeding the response obtained from the 150-200 kg N ha^{-1} urea treatments. Mean soil CO_2-C concentrations ≥ 148 mg kg^{-1} and ≥ 162 mg kg^{-1} were associated with a high probability ($P \geq 0.90$) of Kentucky bluegrass and tall fescue responses equaling or exceeding that of 150-200 kg N ha^{-1} from urea, respectively.

Probability curves indicated that when mean SLAN NH_3-N concentrations were ≤ 142 and ≤ 177 mg kg^{-1}, there was a low probability ($P \leq 0.33$) of response equal to or exceeding that of 150-200 kg N ha^{-1} from urea for Kentucky bluegrass and tall fescue, respectively (Fig.3 panels D and E, and Table 2). When mean NH_3-N concentrations were between 142 to 156 mg kg^{-1} for Kentucky bluegrass and between 177 to 213 mg kg^{-1} for tall fescue, there was a moderate probability ($P > 0.33$ to 0.67) of equaling or exceeding the response obtained from the 150-200 kg N ha^{-1} urea treatments. Mean soil SLAN NH_3-N concentrations ≥ 172 mg kg^{-1} and ≥ 250 mg kg^{-1} were associated with a high probability ($P \geq 0.90$) of Kentucky bluegrass and tall fescue responses equal to or exceeding that of 150-200 kg N ha^{-1} from urea, respectively.

When responses from both species were combined, there was a high probability ($P \geq 0.90$) of Kentucky bluegrass and tall fescue responses equaling or exceeding that of the 150-200 kg N ha^{-1} urea treatments when mean soil CO_2-Burst CO_2-C concentrations were ≥ 156 mg kg^{-1} and when mean SLAN NH_3-N concentrations were ≥ 220 mg kg^{-1} (Fig. 3 panels C and F, and Table 2).

Kentucky Bluegrass	Tall Fescue



Cont. on next page

Table of Contents

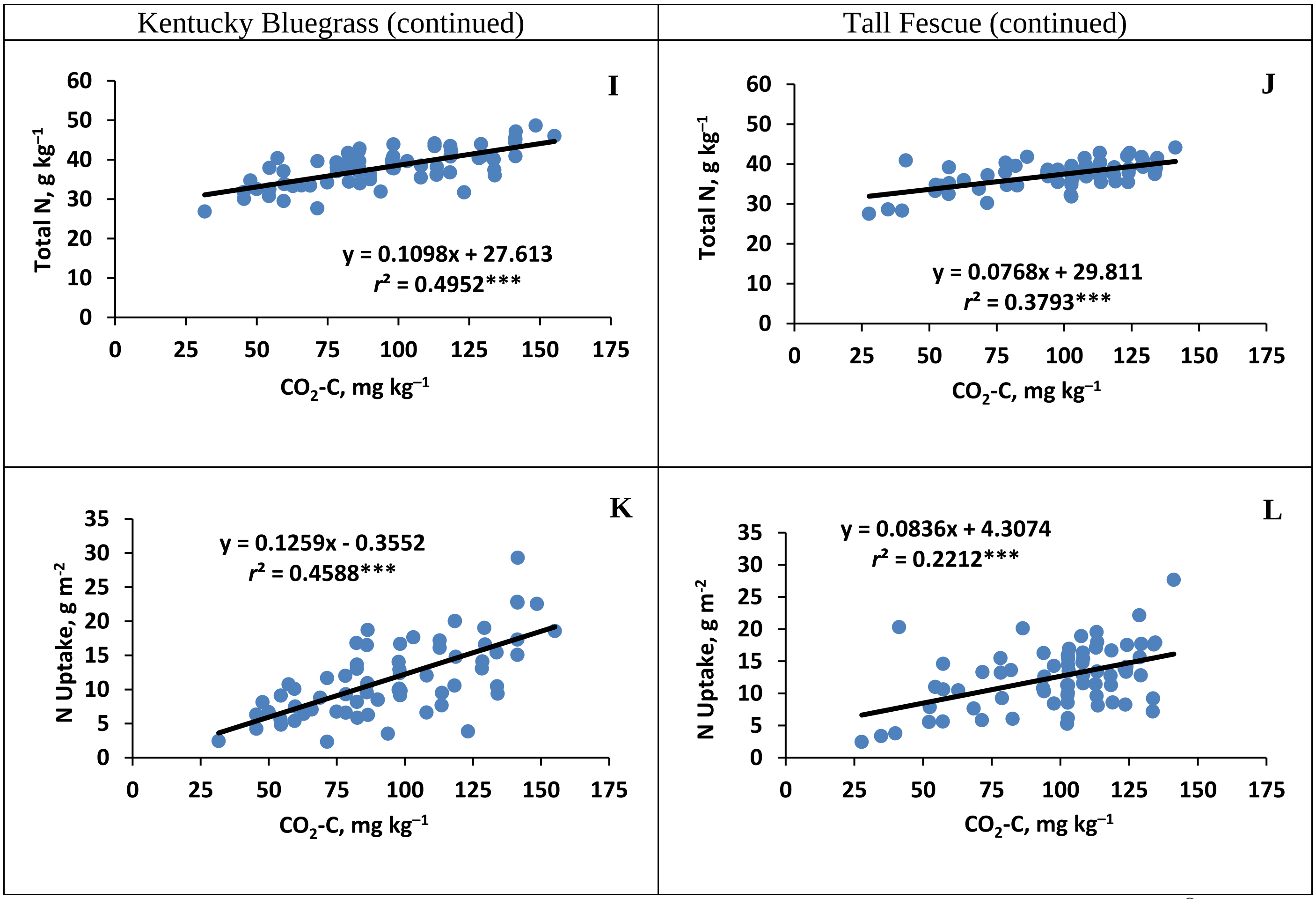


Figure 1. Effects of organic fertilizer rate on of CO_2-C concentrations as measured with the Solvita® CO_2-Burst Test Kit (panels A and B); and relationship between Solvita® CO_2-Burst Test CO_2-C concentrations and NDVI readings (panels C and D), chlorophyll meter readings (panels E and F), clippings yield (panels G and H), clippings total N concentration (panels I and J), and clippings total N uptake (panels K and L) from the organic fertilizer plots. The first column of panels corresponds to Kentucky bluegrass (*Poa pratensis*), and the second column of panels corresponds to tall fescue (*Festuca arundinacea*). Significance of the positive linear response: *** ($P < 0.001$).

Kentucky Bluegrass	Tall Fescue

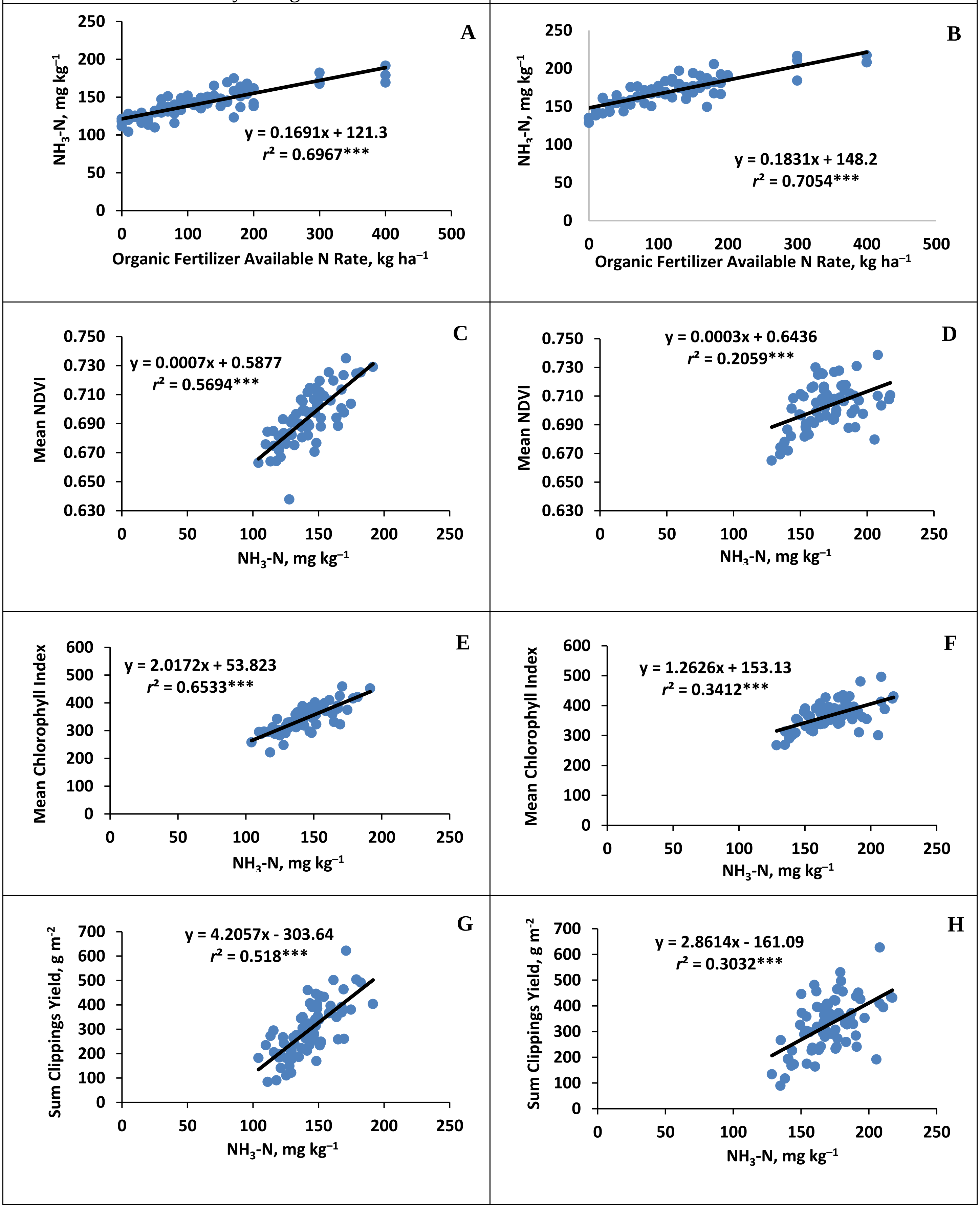


Table of Contents

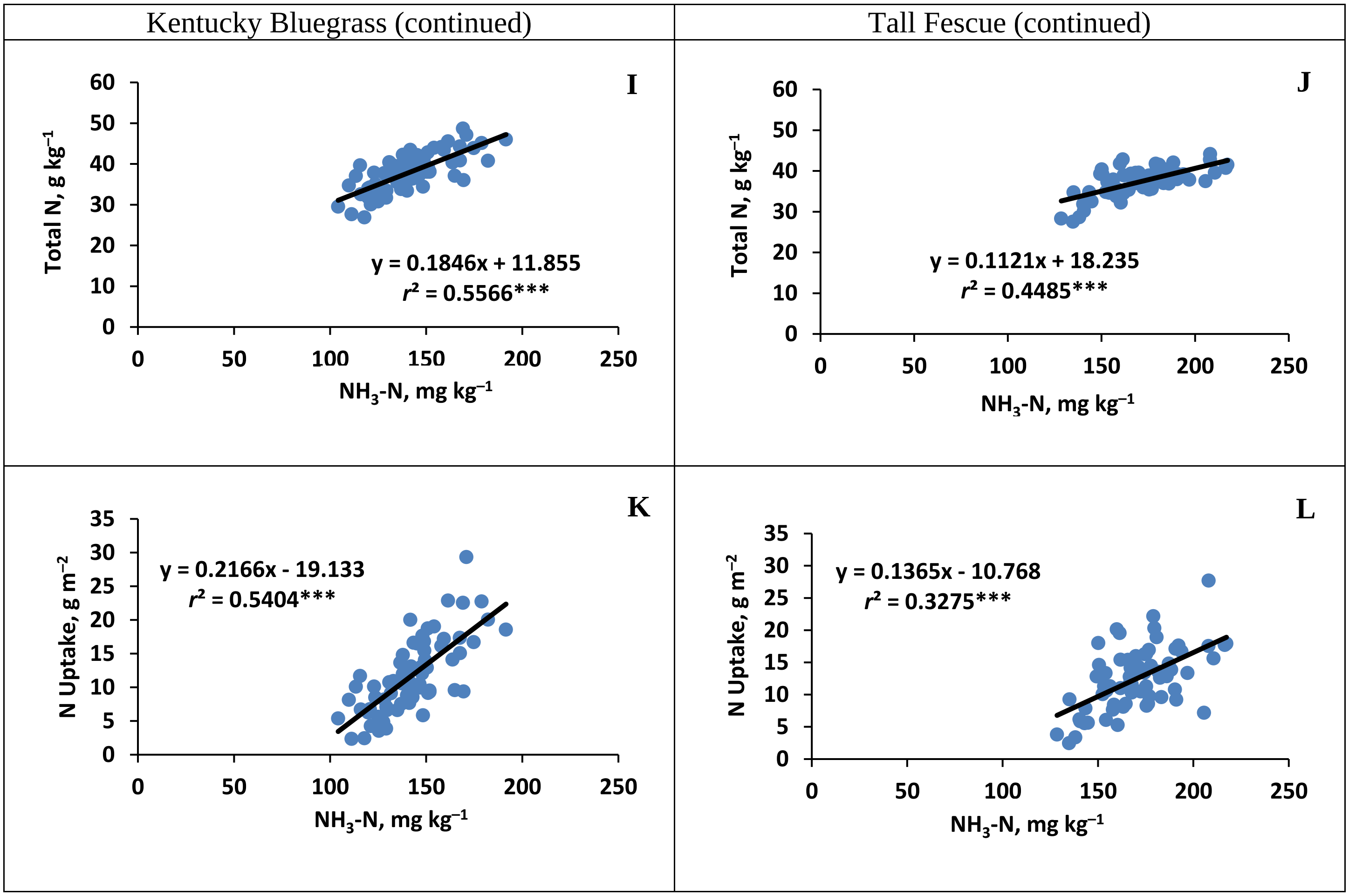


Figure 2. Effects of organic fertilizer rate on NH_3-N concentrations as measured with the SLAN Test Kit (panels A and B); and relationship between SLAN NH_3-N concentrations and NDVI readings (panels C and D), chlorophyll meter readings (panels E and F), clippings yield (panels G and H), clippings total N concentration (panels I and J), and clippings total N uptake (panels K and L) from the organic fertilizer plots. The first column of panels corresponds to Kentucky bluegrass (*Poa pratensis*), and the second column of panels corresponds to tall fescue (*Festuca arundinacea*). Significance of coefficient of for the positive linear response: *** ($P < 0.001$).

Table of Contents

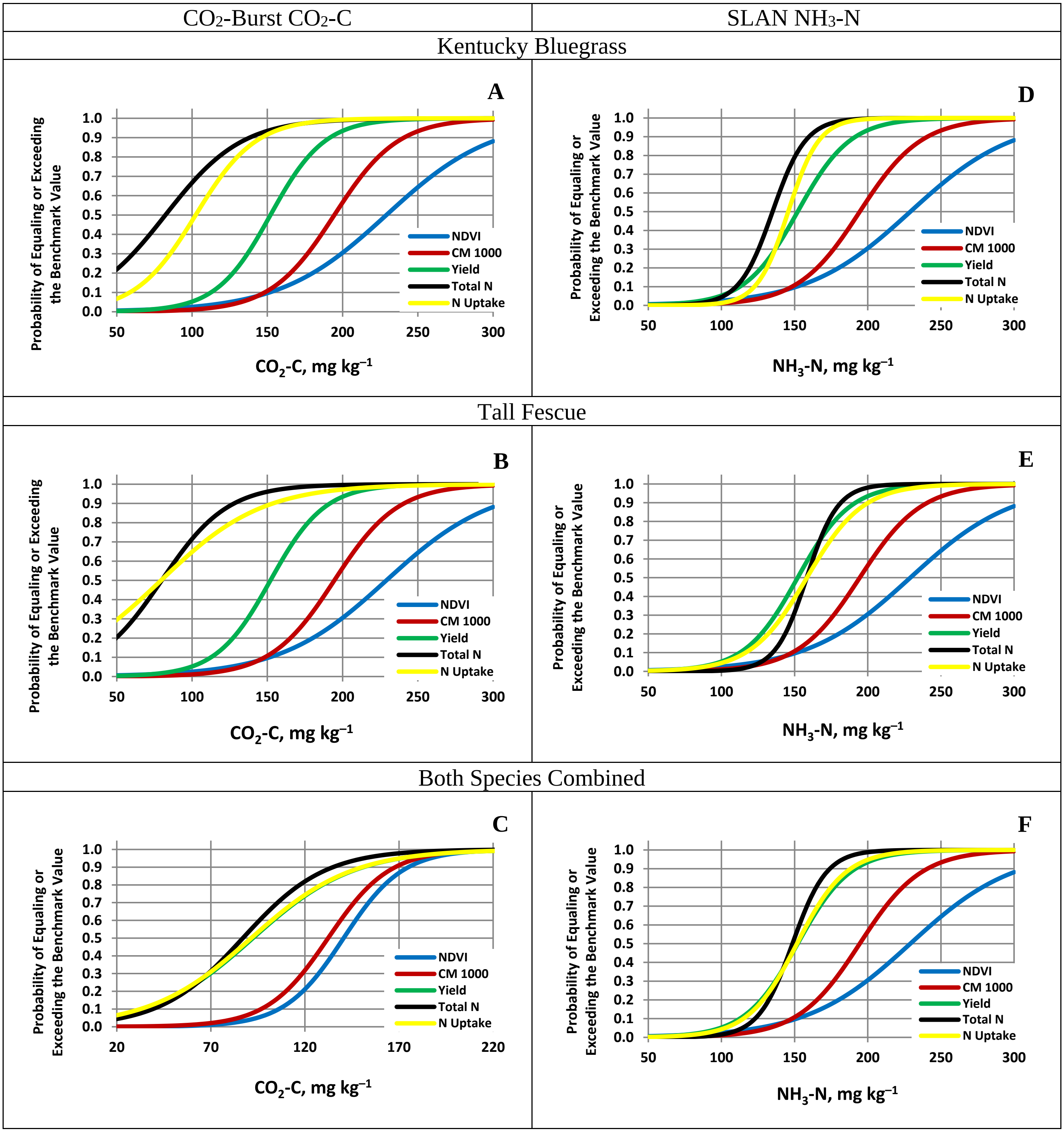


Figure 3. Probability curves of equaling or exceeding the NDVI, CM1000 (Chlorophyll Index), clippings yield, total N, and N uptake values of that obtained from the mean response of urea at the 150 and 200 kg N ha^{-1} rates in relation to Solvita® Soil CO_2-Burst CO_2-C concentrations (panels A, B, and C) and SLAN NH_3-N concentrations (panels D, E, and F) for the 2014 growing season. Mean urea response at the 150 and 200 kg N ha^{-1} rates for NDVI, CM1000, sum of the monthly clippings yield (g m^{-2}), total N (g N kg^{-1}), and N uptake (g m^{-2}) values were 0.711, 371, 285.4, 37.5, and 11.0 for Kentucky bluegrass, respectively; 0.723, 406, 299.6, 36.6, and 11.0 for tall fescue, respectively; and 0.717, 389, 292.5, 37.0, and 11.0 across both species combined, respectively.

Table 1. Logistic regression coefficients for binary response of NDVI, Chlorophyll Index (CM1000), clippings yield (Yield), Total N concentration, and N uptake (NUP) values being equal to or exceeding the mean response for the urea 150 and 200 kg ha^{-1} treatments for Kentucky bluegrass and tall fescue lawns in relation to Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N concentrations for the 2016 growing season.

	CO_2-Burst Test									
	Kentucky Bluegrass					Tall Fescue				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-8.024	0.0628	0.0002	0.4421	0.8208	-9.012	0.0633	0.0230	0.2263	0.9064
CM1000	-8.493	0.0702	<0.0001	0.5131	0.7056	-7.173	0.0521	0.0138	0.2142	0.2222
Yield	-5.381	0.0536	<0.0001	0.4270	0.6044	–1.810	0.0232	0.0185	0.1146	0.4967
Total N	-3.235	0.0393	0.0004	0.2890	0.1517	-3.649	0.0457	0.0002	0.3265	0.5542
NUP	-5.141	0.0502	<0.0001	0.3982	0.5118	-2.351	0.0296	0.0046	0.1721	0.6462

	SLAN Test									
	Kentucky Bluegrass					Tall Fescue				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	–14.779	0.0909	0.0003	0.4160	0.8042	-4.888	0.0165	0.3725	0.0224	0.1715
CM1000	–19.326	0.1235	0.0001	0.5510	0.8361	–13.002	0.0644	0.0017	0.2885	0.3625
Yield	–13.295	0.0919	<0.0001	0.4383	0.3924	-8.297	0.0519	0.0016	0.2350	0.4532
Total N	–11.886	0.0881	0.0001	0.4082	0.3264	–14.894	0.0941	0.0001	0.4503	0.0157
NUP	–13.821	0.0949	<0.0001	0.4518	0.3013	-8.300	0.0524	0.0016	0.2359	0.3066

	CO_2-Burst Test					SLAN Test				
	Kentucky Bluegrass and Tall Fescue Combined					Kentucky Bluegrass and Tall Fescue Combined				
Variable	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value	Intercept	Slope	Wald *p*-value	Max. rescaled r^2	Hosmer – Lemeshow *p*-value
NDVI	-8.982	0.0639	<0.0001	0.3168	0.8080	-6.484	0.0283	0.0100	0.0931	0.4696
CM1000	-8.164	0.0617	<0.0001	0.3452	0.3873	-9.240	0.0475	<0.0001	0.2434	0.8063
Yield	-3.462	0.0375	<0.0001	0.2602	0.4214	-8.456	0.0556	<0.0001	0.3374	0.1599
Total N	-3.993	0.0459	<0.0001	0.3402	0.5707	–12.761	0.0859	<0.0001	0.5118	0.6577
NUP	-3.410	0.0373	<0.0001	0.2590	0.5354	-9.083	0.0599	<0.0001	0.3671	0.1083

Table of Contents

Table 2. Concentrations of Solvita® CO_2-Burst CO_2-C and SLAN NH_3-N at selected probabilities of equaling or exceeding the response of 150-200 kg N ha^{-1} using urea for NDVI, Chlorophyll Index (CM1000), clippings yield (Yield), clippings Total N concentration, and N uptake (NUP) for 2016.

Kentucky Bluegrass

	CO_2-Burst CO_2-C Concentrations, mg kg^{-1}						SLAN NH_3-N Concentrations, mg kg^{-1}					
P	NDVI	CM1000	Yield	Total N	NUP	Mean	NDVI	CM1000	Yield	Total N	NUP	Mean
0.33	116	111	87	64	88	93	155	151	137	127	138	142
0.67	139	131	114	100	117	120	170	162	152	143	153	156
0.90	163	152	141	138	146	148	187	174	169	160	169	172

Tall Fescue

	CO_2-Burst CO_2-C Concentrations, mg kg^{-1}						SLAN NH_3-N Concentrations, mg kg^{-1}					
P	NDVI	CM1000	Yield	Total N	NUP	Mean	NDVI	CM1000	Yield	Total N	NUP	Mean
0.33	131	124	47	64	55	84	253	191	146	151	145	177
0.67	154	151	109	95	103	122	339	213	174	166	172	213
0.90	177	180	173	128	154	162	429	236	202	182	200	250

Kentucky Bluegrass and Tall Fescue Combined

	CO_2-Burst CO_2-C Concentrations, mg kg^{-1}						SLAN NH_3-N Concentrations, mg kg^{-1}					
P	NDVI	CM1000	Yield	Total N	NUP	Mean	NDVI	CM1000	Yield	Total N	NUP	Mean
0.33	129	121	73	72	72	93	204	180	139	140	140	161
0.67	152	144	111	102	110	124	254	209	165	157	163	190
0.90	175	168	151	135	150	156	307	241	192	174	188	220

SUMMARY AND CONCLUSIONS

The third-year results of this study suggest that the Solvita® CO_2-Burst and SLAN Test kits show promise in estimating cool-season turfgrass lawn response as a function of CO_2-C and NH_3-N concentrations in soil samples collected in the spring prior to fertilization. Better fits of the data were obtained with the SLAN test kit compared to the results of the CO_2-Burst test kit, but both did reasonably well.

One objective of the research is to establish response categories (Low, Moderate, or High) that will guide N fertilization of turfgrass lawns based on concentrations of CO_2-Burst CO_2-C and SLAN NH_3-N concentrations. Concentrations presented in Table 2 can be used as starting benchmark values for these categories for equaling or exceeding the response of 150-200 kg N ha^{-1} urea treatments. When concentrations have $P \leq 0.33$, then the category would be considered 'Low'; when concentrations have $P > 0.33$ to 0.67, then the category would be 'Moderate'; when concentrations have $P > 0.67$, then the category would be 'High'; when concentrations have $P > 0.90$, then the category would be 'Very High'.

Using Kentucky bluegrass NDVI response for turfgrass color as an example, it would be unlikely that much N fertilizer would be needed when soil CO_2-C concentrations are ≥ 139 mg kg^{-1}, or when SLAN NH_3-N concentrations are ≥ 170 mg kg^{-1} ($P \geq 0.67$, Table 2). When CO_2-C and NH_3-N concentrations exceed 163 and 187 mg kg^{-1}, respectively, there would be only a 10% chance or less that the Kentucky bluegrass NDVI would increase in a response equivalent to 150-200 kg N ha^{-1} to added N fertilization. In these cases, supplemental N should be withheld and applied only in special cases where turf response is less than optimum after growth is monitored before applying N. Application of supplemental N in areas when CO_2-Burst and SLAN test kits read high increases the likelihood of N losses from the system and more problems with insect and disease pests.

The 2016 CO_2-Burst SLAN responses are very similar to the trends obtained in previous research on these same plots when predicting turfgrass response to the soil permanganate-oxidizable carbon (POXC) and Illinois Soil N Test (ISNT)-N concentrations obtained from a spring soil sample across 5 years (2008-2012; Geng et al., 2014). SLAN NH_3-N concentrations obtained from archived soil samples from the Geng et al., 2014 study are highly correlated ($P < 0.01$) with the respective ISNT-N concentrations (data not shown). This suggests that the Solvita® SLAN test may have similar predictive power in guiding N fertilization as does the ISNT.

As more data are collected, different delineation ranges may come forth. However, we are encouraged with the results across three years, and think that the Solvita® could provide an objective guide for N fertilization of cool-season turfgrass lawns.

ACKNOWLEDGEMENTS

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

REFERENCES

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

Hurisso, T. T., S. W. Culman, W. R. Horwath, J. Wade, D. Cass, J. W. Beniston, T. M. Bowles, A. S. Grandy, A. J. Franzluebbers, M. E. Schipanski, S. T. Lucas, and C. M. Ugarte. 2016. Comparison of permanganate-oxidizable carbon and mineralizable carbon for assessment of organic matter stabilization and mineralization. Soil Sci. Soc. Am. J. 80:1352–1364. doi:10.2136/sssaj2016.04.0106

CLIPPINGS SAP NITRATE-N CONCENTRATIONS AND RELATIONSHIP TO NDVI AND DGCI – 2016

Xiaoling Wang[2], David Moore[1], and Karl Guillard[1]
[1]Department of Plant Science and Landscape Architecture, University of Connecticut
[2]Henan University of Science and Technology, P.R. China

INTRODUCTION

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

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

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

MATERIALS & METHODS

This study was conducted during May through November 2016 on two separate cool-season turfgrass stands – Kentucky bluegrass (*Poa pratensis*) (KBG) and tall fescue (*Festuca arundinacea*) (TF) – established on a fine sandy-loam soil. The experiments were set out as randomized complete block designs with three replicates for each species. Plot size was 1.5 × 1.5 m. Stands were fertilized every month from April to November with 11 N application rates (0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50 kg N ha^{-1}), applied as a mixture of slow- and fast-release urea. In the middle of each month before mowing, NDVI of each plot was measured with a Spectrum TCM 500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Aurora, IL) and DGCI was determined with Spectrum FieldScout GreenIndex+ mobile app (version 2.0) running on an Apple iPad.

Clipping samples were collected once a month from each plot by using a Toro Personal Pace Recycler mower with a bagger set at a mowing height of 57 mm. Fresh clipping samples were taken as a random grab sample from the mower bag. Tree leaves or other debris were removed from the samples. Clippings were then placed in a Spectrum hydraulic plant press to expel the sap. The sap was placed into the sample well of a Spectrum LAQUA Twin Nitrate Meter, and measurements were made for concentrations of NO_3-N. Sap measurements for all dates were taken between 1030 and 1600 hr with the N rates in order of low to high. The meter was recalibrated after each block was completed (11 samples).

Mean clippings sap NO_3-N concentrations were analyzed for treatment differences (N rates and dates) by using analysis of variance with Fisher's LSD for mean separation in the MIXED procedure of SAS 9.4 (SAS Institute, Cary, NC). The relationship between clippings sap NO_3-N concentrations and N rate was modeled with a simple linear regression using the REG procedure in SAS. Linear response-plateau (LRP) models were applied to the NDVI and DGCI data to determine a critical level for sap NO_3-N concentrations by using the NLIN procedure of SAS. The critical sap NO_3-N value marks the concentration where no further change in NDVI or DCGI response is observed with increasing concentration of clippings sap NO_3-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. If the LRP model was not applicable, then a simple linear regression model was used to analyze the data.

RESULTS & DISCUSSION

Monthly Clippings Sap Nitrate-N Concentrations

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

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

Across the entire growing season for KBG and TF, clippings sap NO_3-N concentrations showed considerable variation within each N rate. However, significant ($P < 0.01$) linear increases were observed in each month as N rates increased, except in June for TF (Fig. 3 and Table 1). Slopes of the regression model were lower in the stable phase (May-Aug.) when compared to the greater slope values in the accumulation stage (Sept.-Nov.) (Table 1).

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

In all months for both species, NDVI response significantly ($P < 0.0001$ to $P < 0.025$) fit the LRP model (Fig. 4 and Table 1), except for TF NDVI response in May, which showed a significant ($P < 0.01$) linear response only. Critical levels across species ranged from 147 to 227 mg L^{-1} during the stable phase (May-August), and from 190 to 560 mg L^{-1} during the accumulation phase (Sept.-Nov.). Compared on a month-by-month basis, the critical levels for KBG and TF in the stable or accumulation phases were relatively close to one another, and generally agreed.

With DGCI, the LRP model was significant ($P < 0.0001$ to $P < 0.0044$) in 5 of the 7 months for KBG, and significant ($P < 0.0001$ to $P < 0.0151$) in 4 of the 7 months for TF (Fig. 4 and Table 1). Critical levels across species ranged from 170 to 220 mg L^{-1} during the stable phase (May-August), and from 173 to 405 mg L^{-1} during the accumulation phase (Sept.-Nov.). A plateau could not be established for KBG in June and July (linear response only), and neither for TF in May, June, July, and November (linear only, except for June no significant response). There was much greater variation for DGCI than for NDVI. However, when a critical level could be established, the response between species was relatively in agreement.

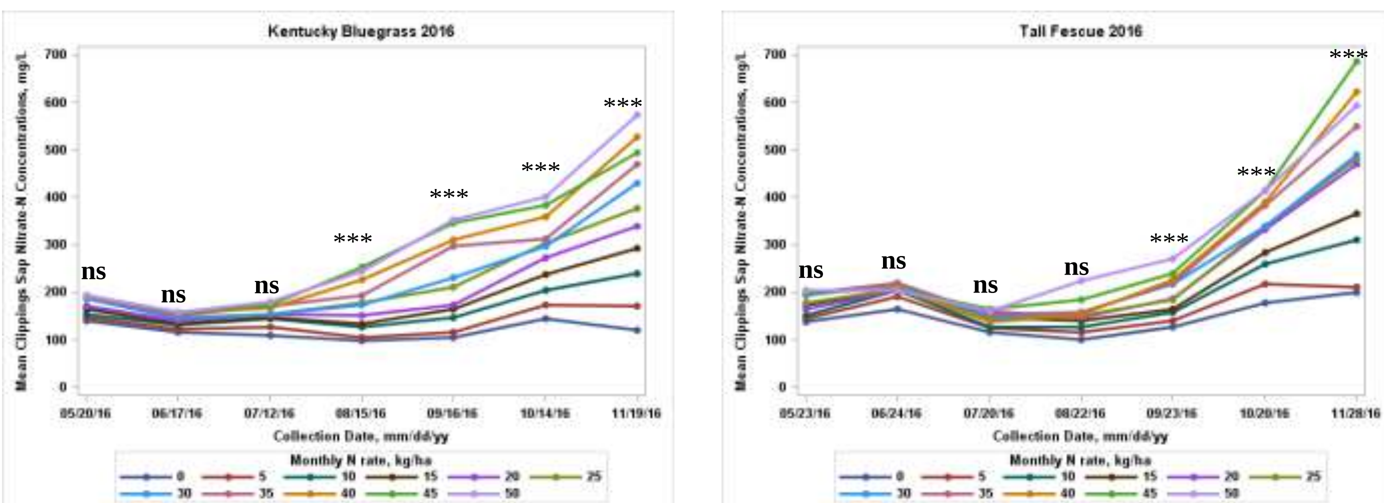


Figure 1. Responses of mean clippings sap NO_3-N concentrations for each N rate across the monthly sampling dates. Significance of the *F*-test for N rate means is shown above each date (ns, not significant; ***, P <0.001).

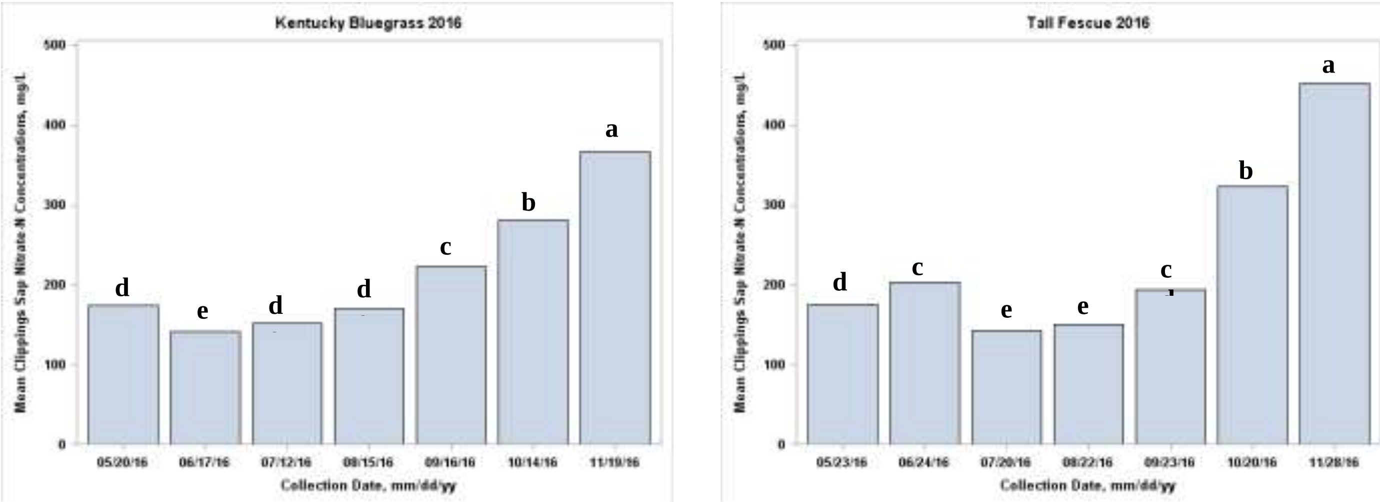


Figure 2. Responses of mean clippings sap NO_3-N concentrations for each monthly sampling date averaged across N rates. Means with the same letters are not different according to Fisher's Protected LSD (α=0.05).

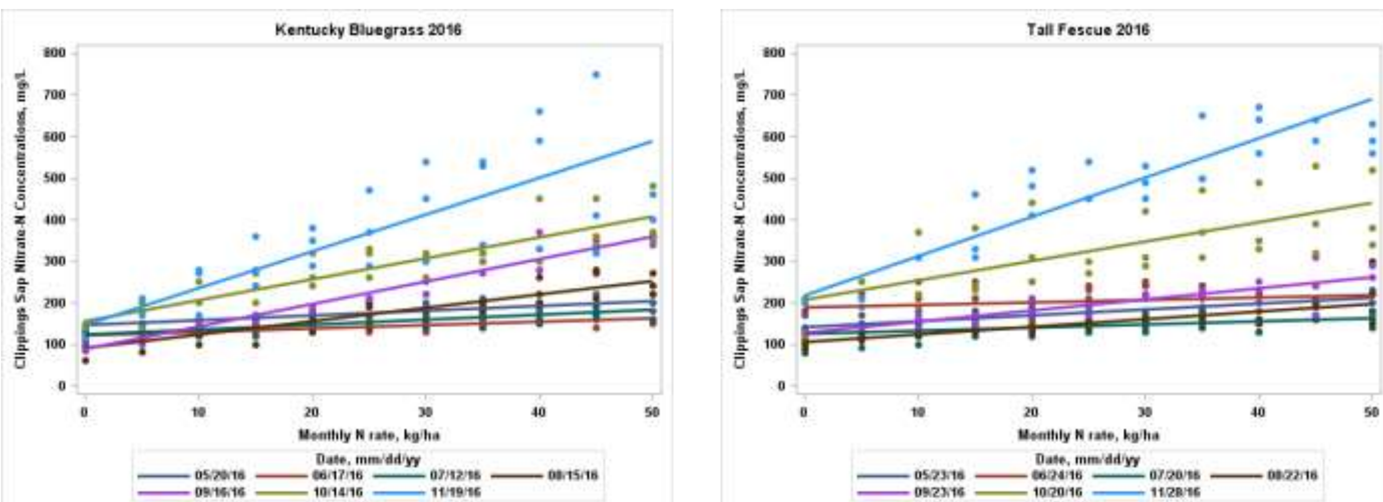


Figure 3. Linear response of clippings sap NO_3-N concentrations for each monthly sampling date across N rates. Model statistics and coefficients are presented in Table 1.

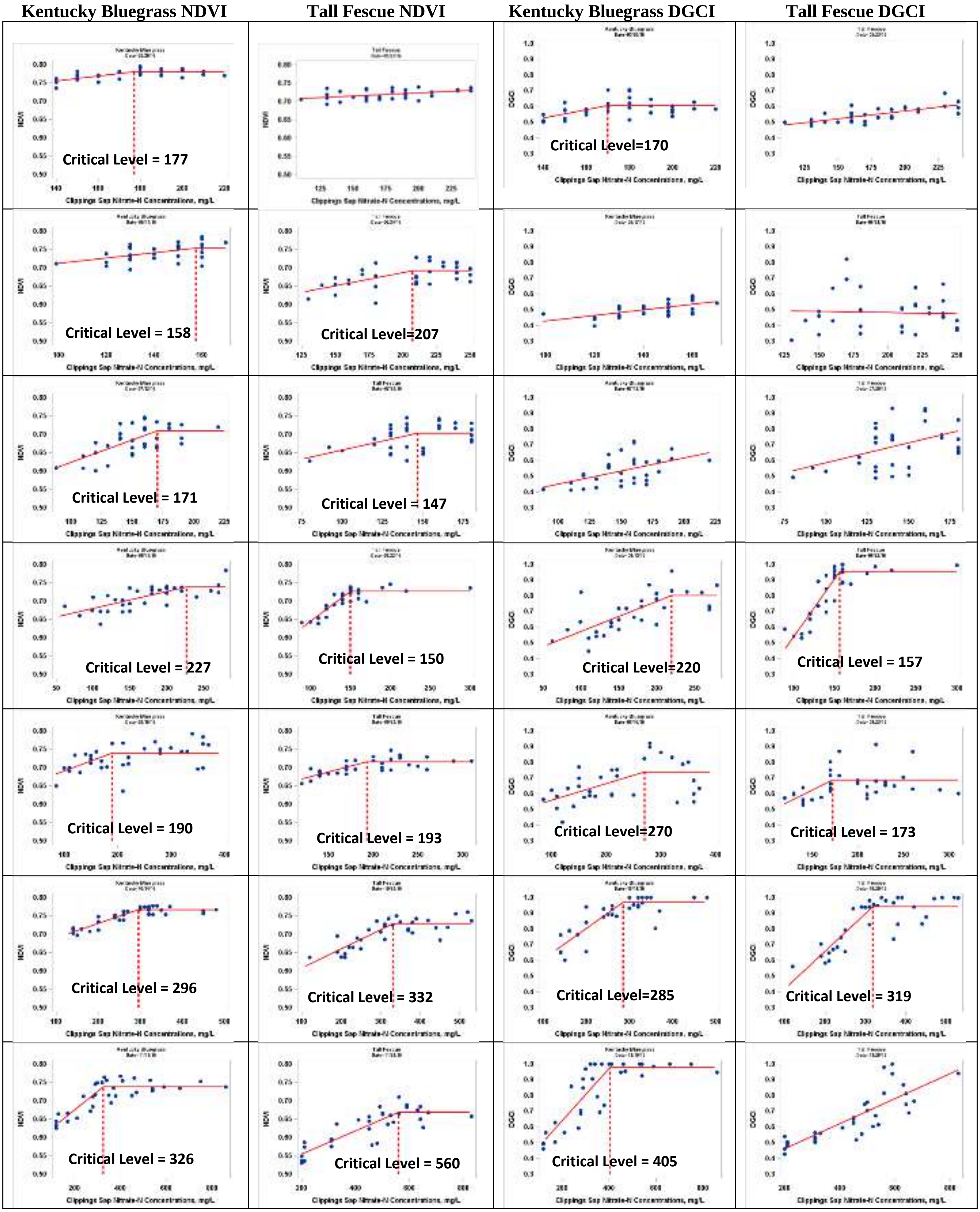


Figure 4. Response of monthly Kentucky bluegrass and tall fescue NDVI and DGCI readings as function of clippings sap nitrate-N concentrations.

Table 1. Model coefficients and statistics for Kentucky bluegrass (KBG) and tall fescue (TF) sap NO_3-N concentrations as a function of N rates, and NDVI and DGCI responses to sap NO_3-N concentrations, 2016.

	Month						
	May	June	July	Aug.	Sept.	Oct.	Nov.
KBG Sap NO_3-N vs. N rate, Fig. 3							
Intercept	145.455	120.652	122.515	90.167	87.652	154.697	145.606
Slope	1.152	0.821	1.194	3.221	5.409	5.036	8.842
R^2	0.651	0.660	0.481	0.830	0.933	0.804	0.618
P value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
TF Sap NO_3-N vs. N rate, Fig.3							
Intercept	140.455	187.879	124.273	104.439	126.818	206.061	216.364
Slope	1.412	0.594	0.753	1.833	2.673	4.667	9.455
R^2	0.392	0.066	0.228	0.592	0.793	0.520	0.836
P value	<0.0001	0.1497	0.0049	<0.0001	<0.0001	<0.0001	<0.0001
KBG NDVI vs. Clippings Sap NO_3-N, Fig.4							
Plateau	0.780	0.753	0.709	0.738	0.739	0.766	0.738
Intercept	0.660	0.639	0.501	0.633	0.636	0.651	0.573
Slope	0.00068	0.00072	0.00122	0.00046	0.00055	0.00039	0.00050
Critical Level	177	158	171	227	190	296	326
R^2	0.523	0.230	0.435	0.522	0.243	0.845	0.766
P value	<0.0001	0.02	0.0002	<0.0001	0.0155	<0.0001	<0.0001
TF NDVI vs. Clippings Sap NO_3-N, Fig.4							
Plateau	NA	0.692	0.703	0.726	0.715	0.728	0.668
Intercept	0.689	0.543	0.558	0.480	0.591	0.555	0.491
Slope	0.00017	0.00072	0.00098	0.00164	0.00064	0.00052	0.00032
Critical Level	NA	207	147	150	193	332	560
R^2	0.222	0.330	0.218	0.830	0.559	0.700	0.745
P value	0.0057	0.0025	0.025	<0.0001	<0.0001	<0.0001	<0.0001
KBG DCGI vs. Clippings Sap NO_3-N, Fig.4							
Plateau	0.606	NA	NA	0.801	0.738	0.968	0.978
Intercept	0.152	0.250	0.284	0.381	0.452	0.413	0.305
Slope	0.00267	0.00178	0.00166	0.00191	0.00106	0.00194	0.00166
Critical Level	170	NA	NA	220	270	286	405
R^2	0.314	0.379	0.265	0.545	0.303	0.746	0.759
P value	0.0035	0.0001	0.0022	<0.0001	0.0044	<0.0001	<0.0001
TF DCGI vs. Clippings Sap NO_3-N, Fig.4							
Plateau	NA	NA	NA	0.954	0.687	0.941	NA
Intercept	0.374	0.511	0.332	-0.199	0.187	0.179	0.302
Slope	0.00098	-0.00015	0.00253	0.00736	0.00290	0.00239	0.00079
Critical Level	NA	NA	NA	157	173	319	NA
R^2	0.540	0.002	0.211	0.809	0.244	0.759	0.683
P value	<0.0001	0.7978	0.0071	<0.0001	0.0151	<0.0001	<0.0001

SUMMARY

The results of this preliminary study suggests that clippings sap NO_3-N concentrations are relatively stable during the active leaf production periods of the growing season (May-Aug.). However, commencing at the onset of winter dormancy preparation, clippings sap NO_3-N concentrations significantly increase from September to November.

The data also suggest that NDVI is correlated to clippings sap NO_3-N concentrations, and could potentially serve as a guide to N fertilization. DGCI was also correlated to clippings sap NO_3-N concentrations, but showed more variability than NDVI.

BENTGRASS CULTIVAR PERFORMANCE OF ONE-YEAR OLD FAIRWAY TURF IN CONNECTICUT, 2016

J. Inguagiato, K. Miele, J. Dunnack, Z. Esponda, and S. Vose

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

INTRODUCTION

An increase in the number of creeping bentgrass cultivars has occurred in recent years. This increase is the result of significant efforts by turfgrass breeders to develop new cultivars with improved density and texture, but more importantly greater tolerance to heat, drought, and disease. Many of these newer creeping bentgrass cultivars generally exhibit superior performance over older industry standards such as 'Penncross'. In addition to creeping bentgrass, colonial bentgrass cultivars have also increased for use in fairways. Colonial bentgrass is not as widely recognized as a fairway turf, but its upright growth habit, dollar spot tolerance, and recuperative potential from drought stress make this a desirable turf for low input fairways.

The objective of this trial was to evaluate recently developed creeping bentgrass and colonial bentgrass cultivars to assess their performance as fairway turf in New England.

MATERIALS & METHODS

A field study was established as fairway turf on a Woodbridge fine sandy loam at the Plant Science Research and Education Facility in Storrs, CT in 2015. The field was mowed at 0.5 inch 3 times wk^{-1} with a triplex mower. A total of 1.0 lbs N 1000-ft^{-2} was applied from seeding through September 2015, and 2.9 lbs N 1000-ft^{-2} was applied as water soluble sources from March to November 2016. Minimal irrigation was applied from June through August to assess potential differences among cultivars. Annual bluegrass was suppressed with applications of Velocity at 6 oz A^{-1} on 6 and 25 July. Curative dollar spot and brown patch control was achieved with applications of Secure (0.5 fl oz) + Xzemplar (0.26 fl oz) on 20 August, Curalan (1.0 oz) on 27 August and Secure (0.5 fl oz) on 9 September. Cutworms were controlled with an application of Scimitar (0.169 fl oz) on 27 August.

New commercially available cultivars of creeping bentgrass and colonial bentgrass were seeded individually or as colonial bentgrass-Chewings fescue blends. All creeping bentgrass and colonial bentgrass single entry plots were seeded at 1.0 lbs 1000-ft^{-2}, except PennTrio which was seeded at 2.0 lbs 1000-ft^{-2}, to account for the 50% by weight of seed coating. Mixed stand seedings included colonial bentgrass at 0.2 lbs, with Chewings fescue at 4.0 lbs, or perennial ryegrass at 6.0 lbs 1000-ft^{-2}. All plots were seeded on 24 Aug. 2015.

To ensure uniform dollar spot development throughout the trial the study area was inoculated with *Sclerotinia homoeocarpa* infested, dried Kentucky bluegrass seed at 3.6 oz. 1000-ft^{-2} on 29 June.

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. Leaf texture was also assessed visually on a 1 to 9 scale where 9 represented the finest textured turf. Dark green color index derived from digital images of plots taken under controlled lighting conditions was used to differentiate color differences among cultivars and percent green turf cover. Compressed thatch thickness was determined from two 2 inch diameter cores per plot. Dollar spot and brown patch severity were visually assessed by as the percent plot area blighted by each disease. Wilt severity was evaluated on a scale of 0 to 5 where 0 is no wilt symptoms, and 5 represented blighted dead turf. All data were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

RESULTS & DISCUSSION

Establishment

All cultivars were relatively slow to establish due to limited fertility applied after seeding in 2015. However, plots filled in throughout the Spring of 2016 reaching near complete turf cover by 20 Jun. Cultivars differed in the rate of establishment with Proclamation, Greentime, Barracuda, Declaration, Luminary, and Pure Select among the entries with the greatest turf cover on 16 May 2016 (Table 1).

Turf quality

Turf quality was poor among all cultivars on 13 May due to incomplete turf cover during establishment (Table 1). Cultivars noted above which established more rapidly were among the only ones to have acceptable levels of turf quality (i.e., $\geq$ 6) at this time. Quality of all entries improved throughout the summer, although development of dollar spot or brown patch affected quality during July and August. An average of turf quality observations is reported to provide an overall perspective of cultivar visual performance throughout the season. Considerable differences among bentgrass cultivars were observed. 007, Proclamation, Barracuda, Luminary, and Declaration were among the highest turf quality grouping of creeping bentgrass cultivars throughout 2016 (Table 1). Similarly, colonial bentgrass cultivars Capri, Greentime, and the Capri + Radar Chewings fescue mix were also among the highest rated entries this year; with quality ratings comparable to the best creeping bentgrasses. As expected, Penncross plots ranked among the lowest turf quality, along with Tyee, Ninety-six Two, and Focus throughout the season.

Table of Contents

Thatch accumulation

After one year of growth, limited differences in thatch accumulation were observed among varieties evaluated. Colonial bentgrass cultivars (e.g., Greentime and Capri) generally had the least amount of thatch in the trial, but were not less than some moderate thatch accumulating creeping bentgrass cultivars such as 007, 13-M, or Tyee. Creeping bentgrass cultivars Memorial and MacKenzie were among those with the least thatch accumulation. Similarly, Penncross and Focus also had less thatch, although this may be due to disease, wilt, or other factors reducing overall growth as evidenced by poor turf quality ratings.

Dollar spot severity

Dollar spot developed uniformly throughout the trial area on 1 Aug and severity increased to a very high level with the most severe entry reaching 66% plot area blighted on 19 Aug (Table 2). All colonial bentgrass single entries and mixtures had less dollar spot compared to any of the creeping bentgrass cultivars, with ≤ 5% plot area blighted on 19 Aug. Few differences in dollar spot severity were observed within the colonial bentgrass group, although Capri + Radar Chewings fescue did have slightly more dollar spot compared to Capri alone, likely due to the susceptibility of Chewings fescue to this disease. Within creeping bentgrass varieties, dollar spot ranged from 11 to 66% plot area blighted (Table 2). Declaration, 13-M, Memorial, and Proclamation were among the cultivars with the least dollar spot (i.e., 11 to 20%). Whereas, Penncross, Cobra II, PennTrio, Pure Select, and Tyee had the greatest dollar spot in the trial (i.e., 53 to 65%).

Brown patch severity

Brown patch developed from a natural infestation during July. Disease severity was low (i.e., ≤ 6%) in all creeping bentgrass cultivars at the peak of disease on 1 Aug (Table 2). No statistical differences were observed among any creeping bentgrass cultivars, except Declaration which contained 5.7% plot area blighted at the height of the epidemic (1 Aug). Colonial bentgrass single entries developed moderate to high levels of brown patch (i.e., 28 to 63% plot area blighted). Brown patch was greatest in Capri plots, sustaining 63% plot area blighted compared to FT-12 and Greentime with 28 and 31% disease, respectively. Interestingly, the addition of Radar Chewings fescue to Capri colonial bentgrass reduced the severity of brown patch observed 50% compared to plots seeded to Capri only.

Drought tolerance

Prolonged drought conditions and limited irrigation resulted in wilt symptoms throughout the trial area on 16 Sep. Greatest wilt stress symptoms were observed in Penncross seeded plots compared to all other entries (Table 2). Slight wilt stress was apparent in Memorial, PennTrio, and Focus.

CONCLUSIONS

Results from this trial demonstrate that newly developed creeping bentgrass cultivars exhibit improved performance over older varieties such as Penncross. Moreover, that considerable differences in turf quality, disease resistance, and drought tolerance exist even among recently developed commercially available creeping bentgrass cultivars.

Distinct differences in turf quality and disease tolerance were observed among entries during this first year of what will be a multi-year trial. However, differences in thatch accumulation were limited after one year. It is anticipated that as cultivars continue to mature that differences in thatch accumulation may become more apparent. Potential differences in thatch accumulation should be an important consideration, in addition to quality and disease resistance, when selecting fairway turfgrasses. Challenges of managing thatch in fairways and the resulting impacts on turf drought, disease, and weed pressures make lesser thatch producing cultivars/species more desirable. This study will be continued to monitor thatch and organic matter accumulation for potential differences in subsequent years of this trial.

Colonial bentgrass cultivars evaluated in this trial had comparable or better turf quality, dollar spot tolerance, and less thatch accumulation compared to top performing creeping bentgrass varieties. This species is not as commonly used on fairways in the United States at this time. Beneficial attributes of this species such as improved dollar spot tolerance and upright growth habit, and good recuperative potential may make it good option golf courses looking for more sustainable fairway turfgrasses. This study will be continued to provide additional information on long term performance on creeping and colonial bentgrass cultivars for fairway turf in New England.

Table 1. Turf quality, turf cover, leaf texture, dark green color index, and thatch accumulation of creeping and colonial bentgrass cultivars and mixtures in a one-year old fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

		Turf quality						Turf cover	Leaf texture	Dark green color index	Thatch accumulation
Entry[z]	Species	13 May	13 Jun	9 Jul	1 Aug	27 Sep	Average	16 May	27 Sep		
		1-9; 6=min acceptable						percent	1-9; 9=fine	index	mm
007	creeping	6.0 abc	8.0 a	7.8 a	5.5 b-e	8.8 a	7.2 a	47.3 cde	7.8 cd	0.436 cd	23.8 a-f
MacKenzie	creeping	5.0 ef	7.0 bcd	6.3 de	3.8 ijk	6.8 fgh	5.8 ef	35.4 hi	7.0 efg	0.420 f	22.8 def
Memorial	creeping	5.0 ef	7.0 bcd	6.0 def	5.8 bcd	6.8 fgh	6.1 de	37.7 gh	6.8 fg	0.434 cde	22.8 c-f
Penncross	creeping	5.0 ef	6.0 ef	5.0 gh	3.3 k	4.8 j	4.8 hi	35.8 hi	5.3 i	0.426 ef	22.6 ef
PennTrio	creeping	5.3 def	6.3 def	6.0 def	4.3 g-j	6.8 fgh	5.7 efg	38.4 fgh	6.5 gh	0.445 ab	23.9 a-f
Cobra II	creeping	5.5 cde	7.5 abc	7.5 ab	4.8 e-h	7.5 c-f	6.6 bcd	44.9 def	7.5 cde	0.427 ef	25.8 a
13-M	creeping	5.5 cde	6.8 cde	6.0 def	5.3 c-f	7.3 d-g	6.2 de	35.2 hi	6.5 gh	0.432 cde	23.9 a-f
Tyee	creeping	4.8 fg	6.0 ef	5.5 efg	4.0 h-k	6.3 hi	5.3 fgh	34.6 hi	6.0 h	0.421 f	23.6 a-f
Declaration	creeping	5.8 bcd	6.8 cde	6.8 bcd	6.0 bc	8.5 ab	6.8 abc	53.9 abc	7.8 cd	0.439 bc	25.2 abc
Ninety-six Two	creeping	4.3 gh	5.8 fg	5.3 fgh	4.3 g-j	6.5 ghi	5.2 gh	28.9 i	6.0 h	0.430 de	23.4 a-f
Pure Select	creeping	5.8 bcd	6.3 def	7.3 abc	5.0 d-g	7.5 c-f	6.4 cd	52.5 bc	8.0 bc	0.430 de	24.5 a-e
Proclamation	creeping	6.3 ab	7.5 abc	7.8 a	6.0 bc	8.3 abc	7.2 a	59.7 a	7.8 cd	0.428 def	24.8 a-e
Luminary	creeping	6.0 abc	7.0 bcd	7.3 abc	5.8 bcd	7.8 b-e	6.8 abc	52.6 bc	7.0 efg	0.449 a	25.0 a-d
Barracuda	creeping	6.0 abc	7.0 bcd	7.5 ab	6.3 b	8.3 abc	7.0 ab	54.6 ab	7.5 cde	0.430 de	25.7 ab
Focus	creeping	4.0 h	5.0 g	4.5 h	3.5 jk	5.8 i	4.6 i	12.6 j	5.3 i	0.393 g	22.9 c-f
Greentime	colonial	6.0 abc	7.8 ab	6.5 cd	6.3 b	7.0 bc	6.7 abc	54.9 ab	8.0 bc	0.385 gh	22.0 f
FT-12	colonial	6.3 ab	7.3 abc	6.0 def	5.5 b-e	8.0 a	6.6 bcd	51.7 bcd	9.0 a	0.376 ij	24.7 a-e
Capri	colonial	6.5 a	8.0 a	7.3 abc	5.0 d-g	7.3 a	6.8 abc	47.0 cde	8.8 a	0.357 k	22.5 ef
Capri + Radar	colonial Chewings fescue	6.0 abc	6.8 cde	6.3 de	7.3 a	7.8 ab	6.8 abc	43.7 efg	8.5 ab	0.367 j	25.5 ab
Capri + Karma	colonial perennial ryegrass	6.0 abc	5.5 fg	5.3 fgh	4.5 f-i	6.5 ghi	5.6 fg	36.5 h	7.3 def	0.381 hi	23.4 b-f
ANOVA: Treatment (P > F)		***	***	***	***	***	***	***	***	***	*

[z]All entries were seeded on 24 Aug 2015.

Table of Contents

Table 2. Dollar spot and brown patch severity and wilt symptom development of creeping and colonial bentgrass cultivars and mixtures in a one-year old fairway turf at the Plant Science Research and Education Facility in Storrs, CT during 2016.

		Dollar spot severity		Brown patch severity		Wilt symptoms
Entry[z]	Species	1 Aug	19 Aug	9 Jul	1 Aug	16 Sep
		------------------ percent plot area blighted -----------------				0-5; 5=blighted
007	creeping	7.1 b-f	22.4 fg	0.0 b	5.4 def	0.0 d
MacKenzie	creeping	8.4 a-e	44.3 bcd	0.0 b	0.0 f	0.5 cd
Memorial	creeping	5.2 d-h	17.8 gh	0.0 b	0.0 f	1.3 b
Penncross	creeping	17.4 ab	65.8 a	0.5 b	0.0 f	3.3 a
PennTrio	creeping	21.5 a	52.5 abc	0.0 b	0.0 f	0.8 bc
Cobra II	creeping	18.2 ab	57.2 ab	0.0 b	0.5 ef	0.0 d
13-M	creeping	4.3 d-i	16.4 gh	0.0 b	0.0 f	0.5 cd
Tyee	creeping	21.2 a	52.8 abc	0.0 b	0.0 f	0.5 cd
Declaration	creeping	2.5 f-j	11.0 hi	0.0 b	5.7 de	0.0 d
Ninety-six Two	creeping	15.3 abc	35.8 c-f	0.0 b	0.0 f	0.3 cd
Pure Select	creeping	16.2 ab	56.8 ab	0.0 b	0.0 f	0.5 cd
Proclamation	creeping	5.5 c-g	19.6 gh	0.0 b	3.5 def	0.3 cd
Luminary	creeping	6.8 b-f	25.7 efg	0.0 b	0.0 f	0.3 cd
Barracuda	creeping	9.7 a-d	33.1 def	0.0 b	1.0 ef	0.0 d
Focus	creeping	15.6 ab	38.1 cde	0.5 b	0.0 f	0.8 bc
Greentime	colonial	3.0 e-i	3.3 jk	5.0 a	30.5 b	0.3 cd
FT-12	colonial	1.2 ij	2.2 jk	9.8 a	27.9 bc	0.3 cd
Capri	colonial	0.6 j	0.5 k	8.5 a	63.0 a	0.0 d
Capri + Radar	colonial Chewings fescue	1.4 hij	4.9 ij	0.3 b	12.6 cd	0.0 d
Capri + Karma	colonial perennial ryegrass	1.8 g-j	1.5 jk	0.0 b	5.1 def	0.0 d
ANOVA: Treatment (P > F)		***	***	***	***	***

[z]All entries were seeded on 24 Aug 2015.

Table of Contents

NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2014 NATIONAL FINELEAF FESCUE ANCILLARY TEST – 2016 RESULTS

Steven Rackliffe, John Inguagiato, Karl Guillard, Victoria Wallace, and Jason Henderson
Department of Plant Science and Landscape Architecture
University of Connecticut

INTRODUCTION

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

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

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

MATERIALS AND METHODS

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

As agreed upon by the cooperators of the ancillary traffic study, each plot was divided in half. One-half of each plot received simulated golf cart traffic and the other half of the plot was not subjected to traffic. The trafficked half of each plot received to two passes of simulated golf cart traffic three times per week for a total of 6 passes per week (figures 1 and 2). In 2016, traffic was intiated on plots beginning on 5/9/16 and continued throughout the season and concluded at the end of September 2016. Traffic will resume in the spring of 2017.

Management Practices

Since establishment, all plots and cultivars received the same management protocol throughout the study. Management practices for the 2014 grow-in and 2015 focused on establishment for the entire season. In 2016, plots received one pound of nitrogen per 1,000 ft^2. Water was applied as needed to relieve stress.

<u>Fertilizer and pesticide applications 2016</u>

4/22/16 - Pre-emergent 0.54 oz/1,000 ft^2 Prodiamine. 65 WDG
4/29/16 - 25-0-12 60% SCU at rate of 1#N/1,000 sq.'
5/13/16 Acelepryn, .367 fl. Oz./1,000 ft^2

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

<u>Irrigation</u> – Irrigation was applied only to prevent severe drought stress. Supplmental irrigation was applied on only three occasions for the 2016 growing season.

Spring Green-up Ratings

Spring green-up ratings were taken and recorded (Table 2 non-trafficked and Table 3 trafficked) on March 24, 2016. Green-up measures the transition from winter dormancy to active spring growth. Ratings were based on a scale of 1-9, with 1 equaling brown turf and 9 equaling dark green turf.

Quality Ratings

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2016 growing season. Overall turfgrass quality was determined using a visual rating system of 1-9. A score of 1 illustrates the poorest quality turf and 9 the highest quality. Monthly quality and mean quality ratings are provided in Table 2 for non-trafficked plots and Table 3 for trafficked plots.

Percent Living Cover

Ratings for percent living cover were taken on three separate dates; May 9th, July 14th and October 2nd. The last rating for percent living cover coincided with the last seasonal traffic treatment. Perecnt living cover ratings are provided in Table 2 for non-trafficked plots and Table 3 for trafficked plots.

Disease Ratings

Ratings for percent red thread and dollarspot disease were taken on May 13th and August 18th respectively. Perecnt disease is provided in Table 2 for non-trafficked plots and Table 3 for trafficked plots.

RESULTS & DISCUSSION

The University of Connecticut was chosen as a site for the 2014 Fineleaf Fescue Ancillary trial that will be investing the effect of simulated golf cart traffic on fineleaf fescue species and cultivars that are maintained at 0.5”. For the entire 2015 growing season, simulated golf cart traffic was withheld to allow for turf to mature. Beginning in April 2016 simulated golf cart traffic treatments began on one half of each plots. Results from both non-trafficked and trafficked treatments can be found in tables 2 qand 3.

In 2016 there were two disease outbreaks one for red thread and one for dollarspot. While there was no significant difference among species for red thread disease it appeared that the hard fescues exhibited the least amount of red thread damage. For dollarspot, while there were a few instances of significant differences between entries, a distinction among species could not be determined. It should be pointed out that for dollarspot ratings in the table 3, some plots were damaged so severly by traffic that a distinction could not be made bewtween disease and traffic injury. Those plots are denoted with a period in table.

Percent living cover ratings were taken on three separate occasions during the season, First, ratings were taken before traffic was intiated, the second rating was taken mid-season, and the third rating was when traffic concluded at the end of September. While percent cover ratings were taken for both trafficked and non-trafficked studies, the traffic effect is best noted in table 3. Of the fine leaf fescue species, the Chewings species appeared to perform best under traffic conditions. Nine of the top 12 species for percent cover at the conclusion of 2016 trafficking were chewings fescues. Rounding out the top-twelve were one slender creeping red fescue, one strong creeping red fescue and one hard fescue. In general, the hard fescues exhibited the least traffic tolerance. The bottom ten entries for percent living ground cover (trafficked) were all hard fescues.

Overall visual turfgrass quality ratings for both trafficked and non-trafficked plots illustrated that the chewings, slender, and creeping red fescues often exhibited higher quality ratings when compared to the hard and sheep fescues. One exception was hard fescsue DLFPS-FRC/3060 which scored in the top ten for both quality and percent density. Lower turf quality ratings for hard fescue and sheep fescue were likely impacted by the lower mowing heights and traffic treatments. Quality for both species (hard and sheep) would most likely be higher if plots where maintained at mowing heights greater than 0.5 inches and traffic in minimal.

The results of year one of this study are promising. There were cultivars and species that exhibited high quality turf even when subjected to traffic, reduced irrigation and reduced fertilizer. Many of the enties would be acceptable for playing surfaces such as golf course fairways. In 2016 Connecticut experienced one of the driest seasons on record. Plots received supplemental irrigation on only three separate occasions. Irrigation was applied when all plots began to show water stress. Perhaps the biggest key for success of these species in fairway turf would be to significantly reduce irrigation. This would require the manager to be diligent in scouting and monitoring the turf for drought symptoms as well as monitoring soil moisture levels.

In 2016 many of the entries performed exceptional well on 1 pound of supplemnatl fertilization for the season.

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

Figure 1 – 2014 NTEP Fineleaf fescue ancillary low cut/traffic Trials, University of Connecticut (photo- July 2016)

Figure 2 – Golf cart traffic simulator

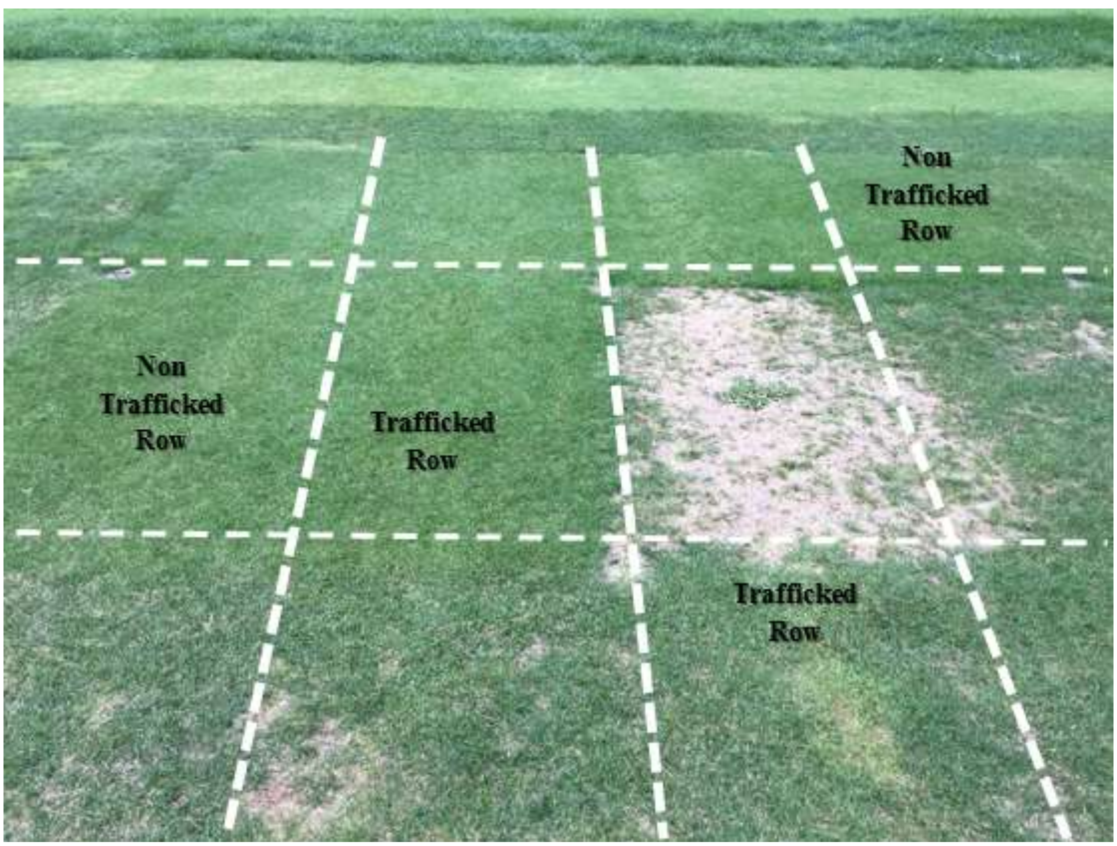


Figure 3- FineFescue turf plots subjected to traffic and non-traffic treatments
Photo taken September 2016

Table 2. 2016 results for non-trafficked fine fescue turfgrass plots. Ratings are for: spring green-up (ratings 1-9, where 9 equals darker green –up), monthly turfgrass quality (rating 1-9, where 9 equals the highest turf quality), percent living ground cover on three separate dates, disease ratings for percent dollarspot and red thread.Table is listed with highest mean quality cultivars listed first.

	Spring green up	Red thread (% of plot)	Dollar spot (% of plot)	Percent Living cover				Quality								
Entry	3/24	5/13	8/19	5/9	7/14	10/2	Mean	4/19	5/26	6/21	7/14	8/16	9/16	10/17	11/16	MeanQ
Radar	7.7	1.7	5.0	100.0	98.0	98.3	98.8	7.0	7.0	7.3	8.0	7.3	6.3	8.7	8.0	7.5
C14-OS3	6.7	0.7	3.3	100.0	95.7	100.0	98.6	7.0	6.3	6.7	7.3	7.7	8.0	8.7	7.7	7.4
DLFPS-FRC/3057	6.3	0.2	6.0	100.0	96.7	100.0	98.9	7.0	7.0	7.3	7.0	6.7	7.3	8.3	8.0	7.3
DLF-FRC 3338	7.3	0.2	6.3	98.3	96.0	98.3	97.6	7.3	6.7	7.7	7.3	6.7	6.3	8.0	8.0	7.3
PPG-FRC 113	7.0	0.8	7.7	100.0	96.0	95.0	97.0	7.3	8.0	7.0	6.7	7.0	6.7	7.7	7.3	7.2
PPG-FRC-114	7.3	1.0	6.7	100.0	98.7	95.0	97.9	7.0	6.3	7.0	7.3	7.0	6.3	7.3	7.3	7.0
RAD-FC32	8.0	1.0	4.7	98.3	95.7	96.7	96.9	6.0	7.3	7.0	6.3	6.0	6.7	7.3	7.7	6.8
BAR VV-VP3-CT	6.7	0.2	3.3	96.7	95.7	100.0	97.4	6.3	6.3	6.7	7.0	6.3	7.3	7.0	7.3	6.8
BAR 6FR 126	5.7	0.7	8.3	98.3	90.0	95.0	94.4	6.7	7.3	6.7	6.0	5.0	6.3	8.3	7.3	6.7
DLFPS-FRC/3060	7.3	0.8	5.0	96.7	97.0	96.7	96.8	6.3	6.7	6.3	7.3	7.0	6.0	6.3	7.3	6.7
RAD-FC44	9.0	2.0	7.3	96.7	91.0	98.3	95.3	6.7	7.0	6.0	6.0	6.0	6.3	7.7	7.7	6.7
PPG-FRT-101	5.0	0.8	5.0	95.0	92.7	95.0	94.2	6.0	7.3	6.3	6.0	5.7	6.7	7.0	7.0	6.5
BAR FRT 5002	4.0	0.7	5.7	100.0	93.3	76.7	90.0	6.3	7.7	7.0	6.7	5.0	5.3	6.3	6.0	6.3
7C34	7.0	1.5	11.3	100.0	91.3	88.3	93.2	6.7	7.7	6.7	6.0	5.7	5.3	5.7	5.3	6.1
DLF-FRR-6162	6.3	2.3	11.0	98.3	89.3	88.3	92.0	6.0	6.3	5.3	6.0	5.3	5.7	5.7	6.0	5.8
Cascade	6.7	1.3	4.3	91.7	88.3	96.7	92.2	5.0	5.0	4.7	5.7	5.3	6.0	7.0	6.7	5.7
RAD-FR47	8.3	3.2	18.3	92.7	83.7	75.0	83.8	6.3	6.3	5.3	5.7	5.0	5.3	6.0	5.0	5.6
Marvel	5.7	2.3	12.0	96.0	85.7	86.7	89.4	6.0	6.0	5.0	5.3	5.3	5.0	5.7	6.0	5.5
DLFPS-FRR/3068	5.3	1.7	22.0	96.0	86.7	73.3	85.3	5.7	7.3	5.3	5.7	5.0	4.7	5.7	5.0	5.5
PST-4BEN	7.3	1.7	12.0	90.0	85.3	86.7	87.3	6.0	5.7	5.0	5.7	5.0	5.0	6.0	6.0	5.5
PPG-FRC-111	6.3	0.8	17.3	91.7	84.3	76.7	84.2	5.7	6.0	5.3	5.3	5.3	5.3	5.7	5.3	5.5
Beudin	4.0	0.3	9.3	94.3	95.0	70.0	86.4	5.7	7.7	7.0	6.0	4.3	4.3	4.0	4.7	5.5
Navigator II	6.0	4.3	21.0	90.0	81.0	83.3	84.8	5.3	5.3	4.7	5.3	5.0	4.7	6.0	6.0	5.3
RAD-FR33R	8.0	1.2	20.7	95.0	88.7	71.7	85.1	6.3	6.7	5.0	5.0	5.0	5.0	4.7	4.7	5.3
PST-4DR4	7.0	3.7	10.3	92.7	90.3	85.0	89.3	4.7	6.0	5.0	5.7	5.0	5.0	5.7	5.3	5.3
DLFPS-FL/3066	6.3	0.0	3.7	91.7	80.0	75.0	82.2	4.3	5.3	5.3	5.3	4.7	5.3	6.3	5.3	5.3

DLFPS-FRR/3069	6.0	2.2	11.0	95.0	84.0	80.0	86.3	5.7	5.0	5.0	5.0	4.7	5.0	5.7	5.3	5.2
Seabreeze GT	5.0	2.3	9.0	89.3	91.3	80.0	86.9	5.0	5.0	5.7	6.0	4.7	4.3	5.3	5.0	5.1
PST-4ED4	6.3	4.3	10.3	94.3	83.7	76.7	84.9	5.3	5.0	5.0	5.0	5.3	5.0	5.0	5.0	5.1
DLFPS-FL/3060	6.3	0.0	6.0	93.3	78.3	81.7	84.4	4.3	5.7	5.0	5.3	5.0	5.0	4.7	5.3	5.0
7H7	6.0	0.0	3.5	88.3	75.0	75.0	79.4	3.7	5.3	5.0	4.7	5.0	5.7	6.0	5.0	5.0
Kent	6.0	2.0	17.3	93.3	85.0	78.3	85.6	5.7	5.0	5.0	5.0	5.0	4.7	4.3	5.3	5.0
MNHD-14	6.3	0.0	4.5	90.0	80.7	68.3	79.7	4.3	5.7	4.7	5.0	5.0	5.0	5.3	4.7	5.0
TH456	5.7	0.0	6.3	86.7	72.7	71.7	77.0	4.0	5.7	3.7	5.0	5.0	5.0	5.7	5.3	4.9
Boreal	5.7	0.3	6.7	88.3	78.3	85.0	83.9	5.3	4.7	4.3	5.0	4.3	5.3	5.0	5.0	4.9
Quatro	6.0	0.0	4.3	89.3	83.3	88.3	87.0	5.0	5.7	4.3	5.0	4.7	5.0	4.3	4.7	4.8
PST-4RUE	6.7	0.7	17.7	88.3	85.7	68.3	80.8	4.7	4.3	5.0	5.3	5.3	5.0	4.7	4.3	4.8
Beacon	6.0	0.0	4.3	93.7	83.3	71.7	82.9	3.7	6.3	4.7	4.7	4.3	4.7	4.7	5.0	4.8
Sword	6.0	0.0	5.0	87.7	74.0	68.3	76.7	4.0	4.7	3.7	4.3	4.0	5.0	5.3	4.7	4.5
PPG-FL-106	6.3	0.0	6.7	83.3	71.7	61.7	72.2	4.3	4.7	3.3	4.0	4.0	4.0	5.0	4.0	4.2
PST-4BND	6.0	0.0	3.5	84.3	69.3	50.0	67.9	3.7	4.7	3.7	3.7	3.3	3.3	4.0	3.3	3.7
Minimus	6.0	0.0	5.0	78.3	60.0	51.7	63.3	3.7	4.0	2.3	3.3	3.7	4.0	4.0	4.0	3.6
LSD$_{0.05}$	1.31	3.06	7.96	8.45	10.85	20.81	10.68	1.34	1.82	1.42	1.07	1.15	1.23	1.49	1.13	0.89
CV%	12.6	169.2	53.5	5.6	7.7	15.6	7.5	14.9	18.6	16.1	11.7	13.4	13.9	15.3	12.0	9.7

Table of Contents

Table 3. 2016 results for trafficked fine fescue turfgrass plots. Ratings are for: spring green-up (ratings 1-9, where 9 equals darker green –up), monthly turfgrass quality (rating 1-9, where 9 equals the highest turf quality), percent living ground cover on three separate dates, disease rating for percent dollarspot and red thread.Table is listed with highest mean quality cultivars listed first.

	Spring green up	Red thread (% of plot)	Dollar spot (% of plot)	Percent Living cover				Quality								
Entry	3/24	5/13	8/19	5/9	7/14	10/2	Mean	4/19	5/26	6/21	7/14	8/16	9/16	10/17	11/16	Mean
C14-OS3	6.7	0.7	5.3	100.0	88.7	100.0	96.2	7.0	7.0	7.3	7.0	6.3	7.0	7.7	7.3	7.1
PPG-FRC 113	7.0	0.8	4.7	100.0	91.3	98.3	96.6	7.3	7.0	7.0	6.7	6.3	7.0	7.3	6.7	6.9
PPG-FRC-114	7.3	1.0	5.0	100.0	91.3	96.7	96.0	7.0	6.3	7.3	6.7	6.0	6.7	7.7	7.0	6.8
BAR VV-VP3-CT	6.7	0.2	4.7	96.7	90.7	96.7	94.7	6.3	6.3	6.7	7.0	6.0	7.0	7.7	6.7	6.7
Radar	7.7	1.7	5.7	100.0	90.7	98.3	96.3	7.0	6.0	6.7	6.7	6.0	6.7	7.7	6.7	6.7
DLFPS-FRC/3057	6.3	0.2	9.0	100.0	89.3	95.0	94.8	7.0	7.0	6.3	6.7	5.7	6.7	7.0	7.0	6.7
DLF-FRC 3338	7.3	0.2	8.3	98.3	86.3	95.0	93.2	7.3	7.0	7.0	6.7	5.3	6.3	7.0	6.3	6.6
DLFPS-FRC/3060	7.3	0.8	4.0	96.7	90.0	98.3	95.0	6.3	6.3	6.7	6.7	6.0	6.7	7.0	6.3	6.5
RAD-FC32	8.0	1.0	6.7	98.3	85.3	95.0	92.9	6.0	6.7	6.3	6.7	5.7	6.7	7.3	6.7	6.5
PPG-FRT-101	5.0	0.8	5.0	95.0	86.7	88.3	90.0	6.0	6.3	6.3	6.3	5.3	6.3	6.3	6.3	6.2
7C34	7.0	1.5	9.7	100.0	86.0	76.7	87.6	6.7	6.7	7.0	6.0	5.3	5.3	5.7	5.3	6.0
RAD-FC44	9.0	2.0	5.5	96.7	81.7	83.3	87.2	6.7	6.3	6.0	5.3	5.0	6.0	5.7	6.0	5.9
Marvel	5.7	2.3	10.3	96.0	80.3	73.3	83.2	6.0	6.7	6.0	5.3	4.7	5.3	5.7	5.0	5.6
DLF-FRR-6162	6.3	2.3	5.7	98.3	82.3	80.0	86.9	6.0	6.3	6.3	5.0	5.0	5.0	5.7	5.3	5.6
DLFPS-FRR/3068	5.3	1.7	13.3	96.0	81.3	60.0	79.1	5.7	6.0	6.3	5.7	4.3	4.7	5.0	5.0	5.3
RAD-FR33R	8.0	1.2	14.0	95.0	87.0	68.3	83.4	6.3	6.0	6.0	5.0	5.0	5.0	4.3	4.7	5.3
RAD-FR47	8.3	3.2	11.3	92.7	80.3	75.0	82.7	6.3	5.3	5.0	6.3	4.3	4.7	5.3	5.0	5.3
BAR FRT 5002	4.0	0.7	.[†]	100.0	86.7	36.7	74.4	6.3	7.0	6.0	5.7	4.0	3.7	4.3	4.3	5.2
Cascade	6.7	1.3	6.7	91.7	80.3	88.3	86.8	5.0	5.0	5.0	5.0	4.7	6.0	5.3	5.3	5.2
PPG-FRC-111	6.3	0.8	16.3	91.7	73.7	63.3	76.2	5.7	5.7	5.3	5.0	5.0	5.0	4.7	4.7	5.1
PST-4BEN	7.3	1.7	12.0	90.0	75.0	78.3	81.1	6.0	5.0	4.7	5.0	4.7	5.3	5.3	5.0	5.1
DLFPS-FRR/3069	6.0	2.2	11.0	95.0	76.0	78.3	83.1	5.7	5.7	5.0	5.0	5.0	4.7	5.0	4.7	5.1
Beudin	4.0	0.3	12.5	94.3	86.0	38.3	72.9	5.7	5.7	6.3	6.3	4.3	3.7	4.0	4.3	5.0
BAR 6FR 126	5.7	0.7	7.5	98.3	81.0	55.0	78.1	6.7	5.3	5.3	4.7	4.0	4.7	5.0	4.3	5.0
Navigator II	6.0	4.3	14.0	90.0	80.3	75.0	81.8	5.3	5.0	5.0	4.7	4.3	4.3	5.3	5.0	4.9
PST-4DR4	7.0	3.7	11.0	92.7	71.3	65.0	76.3	4.7	5.3	5.0	5.0	4.7	5.3	4.3	4.7	4.9
Kent	6.0	2.0	18.0	93.3	76.7	65.0	78.3	5.7	4.3	4.3	4.3	4.3	5.3	5.3	4.7	4.8
Boreal	5.7	0.3	6.0	88.3	74.0	55.0	72.4	5.3	4.7	4.0	4.3	4.0	5.0	4.7	4.7	4.6
PST-4ED4	6.3	4.3	10.0	94.3	69.3	55.0	72.9	5.3	5.3	4.7	4.0	4.0	4.3	4.3	4.7	4.6

Table of Contents

Seabreeze GT	5.0	2.3	8.5	89.3	84.3	46.7	73.4	5.0	4.7	5.0	4.7	4.0	4.0	4.3	4.7	4.5
PST-4RUE	6.7	0.7	10.7	88.3	76.7	56.7	73.9	4.7	4.3	5.0	4.3	4.0	4.7	4.3	4.3	4.5
Quatro	6.0	0.0	7.0	89.3	65.0	71.7	75.3	5.0	4.7	3.7	4.3	4.3	4.0	4.3	4.7	4.4
DLFPS-FL/3060	6.3	0.0	2.0	93.3	55.3	26.7	58.4	4.3	5.0	3.7	3.3	3.7	3.0	3.3	3.3	3.7
MNHD-14	6.3	0.0	3.0	90.0	58.3	29.3	59.2	4.3	5.0	3.3	4.0	3.0	3.0	3.3	3.3	3.7
PPG-FL-106	6.3	0.0	.[†]	83.3	50.0	26.0	53.1	4.3	4.3	3.0	3.7	3.3	2.7	3.7	3.3	3.5
7H7	6.0	0.0	4.0	88.3	52.7	36.0	59.0	3.7	5.7	2.7	3.3	3.3	2.7	3.3	3.3	3.5
DLFPS-FL/3066	6.3	0.0	.[†]	91.7	60.0	25.0	58.9	4.3	4.7	3.3	3.7	3.0	2.3	3.0	3.3	3.5
Sword	6.0	0.0	2.0	87.7	50.0	40.0	59.2	4.0	4.7	2.3	2.7	3.0	3.7	3.3	3.7	3.4
Beacon	6.0	0.0	.[†]	93.7	51.0	31.0	58.6	3.7	4.7	2.7	3.3	2.7	2.7	2.7	2.7	3.1
TH456	5.7	0.0	8.0	86.7	47.3	23.7	52.6	4.0	4.3	2.7	3.0	2.7	2.0	2.7	2.7	3.0
PST-4BND	6.0	0.0	3.0	84.3	37.7	26.7	49.6	3.7	4.3	2.3	2.3	2.7	2.3	2.7	3.0	2.9
Minimus	6.0	0.0	.[†]	78.3	31.7	18.3	42.8	3.7	3.7	1.7	2.3	2.3	2.7	2.7	2.7	2.7
$LSD_{0.05}$	1.31	3.06	11.48	8.45	17.21	23.16	13.04	1.34	1.27	1.34	1.24	1.29	1.36	1.44	1.21	0.92
CV%	12.6	169.2	65.4	5.6	14.3	22.3	10.4	14.9	14.0	16.3	15.3	17.9	17.6	17.6	15.3	11.3

[†] No distinction could be made between disease and traffic injury

Acknowledgements:
This project is funded by the National Turfgrass Evaluation Program
Traffic Simulator made possible through the New England Turfgrass Research Foundation

Table of Contents

NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2012 NATIONAL TALL FESCUE TEST – 2016 RESULTS

Steven Rackliffe, Karl Guillard, Jason Henderson, John Inguagiato, and Victoria Wallace
Department of Plant Science and Landscape Architecture
University of Connecticut

INTRODUCTION

Turf-type tall fescue has gained in popularity over the last decade. Characteristics that make turf-type tall fescue desirable are: it maintains a dense, dark green color, lower fertility requirements than conventional Kentucky bluegrass/ryegrass home lawns, and it has good traffic tolerance and shade tolerance. Turf-type tall fescue also exhibits excellent drought avoidance characteristics. When trying to reduce inputs such as fertilizer and water, turf-type tall fescue can be a good alternative.

The National Turfgrass Evaluation Program (NTEP) is sponsored by the Beltsville Agriculture Research Center and the National Turfgrass Federation Inc. NTEP works with breeders and testing sites throughout the United States in evaluating turfgrass species and cultivars. Results from turfgrass evaluations can aid professionals in their selection of turfgrass species/cultivars that best meet their needs. Results also aid breeders in selecting new cultivars that they may put into production, as well as helping in marketing their varieties. In 2012 NTEP selected fifteen standard testing sites and eleven ancillary test locations for their 2012 Turf-type Tall Fescue Test. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected as a standard site for the 2012 Turf-type Tall Fescue Test.

MATERIALS AND METHODS

One hundred and sixteen cultivars of Turf-type Tall fescue were seeded on September 11, 2012 in Storrs Connecticut. A complete randomized block design with 3 replicates of each cultivar was utilized for this study. Plot size is 5’ X 5’. Sponsors and entries are listed in Table 1.

Management Practices

Since establishment, all plots and cultivars received the same management protocol throughout the study. Management practices for 2015 were as follows:

Mowing - Plots were maintained at a mowing height of 2.75 inches and mowed two times per week. Clippings were returned.

Irrigation – Although Connectcut experienced one of the driest summers in recent years, supplemental water through rrigation was not needed or applied 2016.

Fertilizer and pesticide applications

4/22/16 - Pre-emergent 0.54 oz/1,000 ft^2 Prodiamine. 65 WDG,
4/29/16 - 1# N /1,000 ft^2, 25-0-12 (60% SCU).
5/13/16 – Acelepryn, .367 fl. Oz./1,000 ft^2
5/20/16 - TZone® applied 1.4fl. oz /1,000 ft^2
9/15/16 – 1# N /1,000 ft^2, 25-0-12 (60% SCU).

Quality Ratings

Turfgrass quality ratings were taken on a monthly basis for overall turf quality (color / leaf texture / density) during the 2016 growing season. Overall turfgrass quality was determined using a visual rating system of 1-9. A score of 1 illustrates the poorest quality turf and 9 the highest quality. Monthly quality and mean quality ratings are provided in table 2.

Leaf Texture Ratings

Visual leaf texture ratings were taken in the late spring (May 27, 2016) while the grass was actively growing and not under stress conditions. Texture ratings were made using a visual scale with 1 equaling coarse turf and 9 equaling fine (Table 2).

Genetic Color Ratings

Genetic color ratings (Table 2) were taken in the late spring (May 27, 2016) while the grass was actively growing and not under stress conditions. Ratings were based on visual color with 1 being light green and 9 being dark green. Areas of plots that contained browning tissue (chlorosis or necrotic) from outside factors such as disease were not considered for genetic color (Table 2).

RESULTS & DISCUSSION

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

A few general observations noted were: mean quality values for overall quality continue to illustrate that there is little diversity between cultivars. Pick-W43 had the highest mean quality ratings for the 2016 growing season. However, there were no significant differences in quality between Pick-W43 and the next 71 cultvars listed in table 2 and seen in figure 1. Kentucky 31 exhibited the poorest quality. In 2016 all plots exhibited excellent drought avoidance characteristics. Although Connecticut experienced one of the driest years in recent history, plots did not require irrigation. All cultivars maintained color and avoided dormancy.

Table of Contents

Table 1- Sponsors and Entries

SPONSOR	ENTRY	SPONSOR	ENTRY
Semillas Fito S.A.	Terrano	DLF International Seed	IS-TF-272
Standard Entry	Ky-31	Pennington Seed	ATF 1736
Landmark Turf and Native Seed	Regenerate	Brett-Young Seeds	ATF 1754
Semillas Fito S.A	Fesnova	Burlingham Seeds	Hemi
Z Seeds	ZW 44	Burlingham Seeds	Firebird 2
Turf Merchants Inc.	W45	Standard Entry	Bullseye
Turf Merchants Inc.	U43	Pure-Seed Testing, Inc	PST-5EV2
Turf Merchants Inc.	LSD	Pure-Seed Testing, Inc	PST-5GRB
Turf Merchants Inc.	Aquaduct	Pure-Seed Testing, Inc	PST-5SALT
Standard Entry	Catalyst	Pure-Seed Testing, Inc	PST-5SDT
Ledeboer Seed LLC	Marauder	Pure-Seed Testing, Inc	PST-5DZP
Ledeboer Seed LLC	Warhawk	Pure-Seed Testing, Inc	PST-5RO5
Ledeboer Seed LLC	Annihilator	Pure-Seed Testing, Inc	PST-5BPO
Ledeboer Seed LLC	Comp.Res. SST	Pure-Seed Testing, Inc	PST-5BRK
Ledeboer Seed LLC	204 Res.Blk4	John Deere Landscapes	DB1
Jacklin Seed by Simplot	JS 819	John Deere Landscapes	RZ2
Jacklin Seed by Simplot	JS 818	Columbia Seeds LLC	TD1
Jacklin Seed by Simplot	JS 809	Columbia Seeds LLC	DZ1
Jacklin Seed by Simplot	JS 916	Landmark Turf and Native Seed	T31
Jacklin Seed by Simplot	JS 825	Pickseed West Inc.	PSG-GSD
The Scotts Company	MET 1	Pickseed West Inc.	PSG-8BP2
The Scotts Company	F711	Pickseed West Inc.	PSG-TT4
DLF International Seed	IS-TF 291	Standard Entry	Faith
DLF International Seed	IS-TF 276 M2	The Scotts Company	K12-13
DLF International Seed	IS-TF 305 SEL	The Scotts Company	K12-05
DLF International Seed	IS-TF 269 SEL	Peak Plant Genetics	PPG-TF-156

Table 1 (continued) - Sponsors and Entries

SPONSOR	ENTRY	SPONSOR	ENTRY
DLF International Seed	IS-TF 282 M2	Columbia Seeds LLC	PPG-TF-157
DLF International Seed	IS-TF 284 M2	Columbia Seeds LLC	PPG-TF-169
Great Basin Seed	OR-21	Columbia Seeds LLC	PPG-TF-170
Great Basin Seed	TY 10	Lewis Seed Company	PPG-TF-137
Great Basin Seed	EXP TF-09	Ampac Seed Company	PPG-TF-135
Seed Research Oregon	SRX-TPC	Lewis seed Company	PPG-TF-115
Pickseed West Inc.	PSG-WEI	Lewis seed Company	PPG-TF-105
Pickseed West Inc.	Pick-W43	Peak Plant Genetics	PPG-TF-172
Pickseed West Inc.	Grade 3	Grassland Oregon	PPG-TF-151
Pickseed West Inc.	PSG-PO1	Peak Plant Genetics	PPG-TF-152
Landmark Turf and Native Seed	U45	Peak Plant Genetics	PPG-TF-148
Pennington Seed	B23	Columbia Seeds	PPG-TF-150
Pennington Seed	ATF 1612	Semillas Fito S.A.	Bizem
Peennington Seed	ATF 1704	Proseeds Marketing	CCR2
Burlingham Seed	Burl TF-2	Proseeds Marketing	Met-3
Burlingham Seed	Burl TF-136	The Scotts Company	W41
Lebanon Turf Products	LTP-FSD	Peak Plant Genetics	PPG-TF-145
Lebanon Turf Products	LTP-TWUU	.Ampac Seed Company	PPG-TF-138
Lebanon Turf Products	LTP-F5DPDR	Landmark Turf and Native Seed	PPG-TF-139
DLF International Seed	IS-TF-289	Landmark Turf and Native Seed	PPG-TF-142
DLF International Seed	MET 6 SEL	Columbia Seeds LLC	RAD-TF-89
Columbia Seeds LLC	IS-TF-330	Radix Reasearch	RAD-TF-92
Columbia Seeds LLC	TF-287	Grasslands Oregon	GO-DFR
Columbia Seeds LLC	IS-TF-307 SEL	The Scotts Company	K12-MCD
Columbia Seeds LLC	IS-TF 308 SEL	Pure-Seed Testing Inc.	PST-5EX2
Brett-Young Seeds	IS-TF-311	Pure-Seed Testing Inc.	PST-5MVD
Brett-Young Seeds	IS-TF-285	Oak Park Farms	RAD-TF-83
Brett-Young Seeds	IS-TLF 310 SEL	Grassland Oregon	RAD-TF 88
Barenbrug USA	BAR Fa 120878	Pure-Seed testing Inc.	PST-R5NW
Barenbrug USA	BAR Fa 121089	Burlingham Seeds	Burl TF 69
Barenbrug USA	BAR Fa 121091	Standard Entry	Falcon IV
Barenbrug USA	BAR Fa 121095	Standard Entry	Falcon V

Figure 1 – 2012Turf-Type Tall Fescue NTEP Trial, University of Connecticut (photo- July 2016)

Table 2. Tall Fescue NTEP results 2016 for genetic color (ratings 1-9, where 9 equals darker green), leaf texture (rating 1-9, where 9 equals the finest texture leaf blade), turfgrass quality (rating 1-9, where 9 equals the highest turf quality). Table is listed with highest mean quality cultivars listed first.

	Genetic color	Texture	Brown patch (% of plot)	Quality								
Entry	05/31/16	05/31/16	05/27/15	04/19/16	05/26/16	06/27/16	07/14/16	08/16/16	09/16/16	10/17/16	11/16/16	mean
Pick-W43	6.3	6.3	3.3	7.0	6.7	6.7	6.7	6.3	7.3	7.7	7.3	7.0
ZW44	6.3	5.3	15.0	7.7	6.7	7.0	6.7	5.7	7.0	7.0	7.0	6.8
U45	7.0	6.0	1.7	5.7	7.0	7.0	7.0	6.7	6.7	7.3	7.3	6.8
PPG-TF-152	7.0	6.0	8.0	6.7	7.0	6.7	7.0	6.3	6.7	7.3	7.0	6.8
IS-TF 310 SEL	7.3	6.7	5.0	6.3	7.0	7.0	7.0	6.3	5.7	7.7	7.0	6.8
PPG-TF-157	7.3	6.3	16.7	6.3	7.0	7.0	7.0	5.3	6.0	7.7	7.3	6.7
PPG-TF-105	7.3	5.7	0.7	6.3	6.7	7.3	7.3	6.0	7.0	6.0	7.0	6.7
W41	6.7	6.0	12.3	6.7	7.0	6.7	6.0	6.0	6.3	8.0	7.0	6.7
F711	6.0	6.0	5.0	6.0	6.3	6.7	6.7	6.0	6.7	7.7	7.3	6.7
PPG-TF-135	5.3	6.0	1.7	6.7	7.0	7.3	6.3	5.7	6.3	7.0	7.0	6.7
RZ2	6.0	5.7	3.3	6.0	6.7	7.0	6.3	6.7	6.7	7.0	6.7	6.6
Regenerate	7.0	6.0	6.3	6.3	7.0	6.3	6.0	5.7	6.3	7.7	7.3	6.6
U43	6.0	5.7	0.0	6.3	7.0	6.0	6.3	6.0	6.7	7.3	6.7	6.5
LTP-TWUU	7.0	5.0	1.7	7.0	6.7	6.0	6.3	6.0	6.3	7.3	6.7	6.5
PPG-TF-156	6.0	6.0	0.7	6.0	7.0	6.3	6.7	6.3	6.3	7.0	6.7	6.5
IS-TF 311	6.0	6.3	8.3	6.3	6.7	6.3	6.0	5.3	7.7	7.3	6.3	6.5
PPG-TF-150	6.3	5.7	10.0	6.3	6.7	6.3	6.0	5.7	7.0	6.7	7.3	6.5
Bullseye	6.3	5.7	13.3	7.0	7.3	6.3	5.7	5.7	6.3	7.0	6.3	6.5
PPG-TF-115	7.0	5.0	9.0	6.3	6.7	6.3	7.0	6.0	5.7	7.0	6.7	6.5
CCR2	6.0	6.7	1.7	6.3	6.7	5.7	6.0	6.3	6.7	7.0	7.0	6.5
Burl TF-2	6.3	5.3	1.7	6.7	6.3	6.0	6.0	6.0	6.3	7.0	7.0	6.4
Hemi	6.0	5.7	3.3	6.7	6.7	6.0	6.0	5.7	7.0	7.3	6.0	6.4
T31	6.3	5.3	1.7	6.3	6.3	6.0	6.3	5.7	6.3	7.7	6.7	6.4
PPG-TF-172	7.0	5.7	3.3	6.0	7.0	6.3	6.0	6.0	6.3	6.7	7.0	6.4
PPG-TF-138	6.0	5.3	6.7	7.0	6.3	6.0	6.3	5.3	6.7	7.0	6.7	6.4
IS-TF 291	7.0	6.0	5.0	6.7	6.7	5.7	6.7	5.7	6.0	7.0	6.7	6.4
PSG-PO1	5.7	6.3	8.3	6.3	6.0	6.0	6.3	5.7	6.7	7.3	6.7	6.4
PPG-TF-170	6.7	5.3	1.7	6.7	6.0	5.7	6.0	6.0	6.3	7.3	7.0	6.4
K12-MCD	7.0	6.0	8.3	6.3	6.0	6.0	7.0	5.3	5.7	7.7	7.0	6.4

Table of Contents

LSD	6.3	5.3	1.7	5.7	7.0	6.3	6.7	6.3	6.3	6.3	6.0	6.3
MET 1	5.3	6.0	13.3	6.3	6.0	5.7	6.3	5.3	6.7	7.3	7.0	6.3
IS-TF 305 SEL	7.3	5.7	16.7	6.0	6.7	6.3	7.0	5.7	5.7	7.0	6.3	6.3
PST-5BRK	6.0	5.7	2.3	6.0	6.3	6.0	6.0	6.3	6.3	7.0	6.7	6.3
Bizem	6.3	5.7	10.0	6.3	6.3	6.0	6.3	6.3	5.7	6.7	7.0	6.3
IS-TF 308 SEL	6.7	6.0	1.3	5.7	6.3	6.3	6.3	6.0	6.3	7.0	6.3	6.3
Faith	5.7	5.3	11.7	6.3	6.7	6.0	5.7	5.3	7.0	6.7	6.7	6.3
PPG-TF-151	7.0	5.3	5.7	6.0	6.3	6.0	6.0	5.7	6.3	7.3	6.7	6.3
W45	7.3	6.0	6.7	6.3	6.3	6.0	6.7	5.7	5.7	7.0	6.3	6.3
Catalyst	5.7	5.7	0.7	6.0	6.3	6.0	6.7	6.0	6.7	6.0	6.3	6.3
SRX-TPC	7.0	6.3	2.3	6.0	5.3	5.7	6.3	6.0	6.7	7.3	6.7	6.3
LTP-FSD	6.3	4.7	3.3	6.0	6.0	6.3	6.0	6.0	6.0	7.0	6.7	6.3
MET 6 SEL	5.7	5.3	1.3	6.0	6.3	6.0	5.7	6.3	6.0	7.0	6.7	6.3
IS-TF 330	7.0	6.0	5.0	5.7	7.0	6.0	5.7	6.0	6.3	7.0	6.3	6.3
LTP-F5DPDR	6.3	5.0	13.3	6.3	6.0	6.0	6.0	5.0	6.3	7.0	7.0	6.2
IS-TF 284 M2	8.0	6.0	6.7	5.3	6.0	6.0	7.3	5.7	6.3	6.3	6.3	6.2
Grade 3	6.3	5.7	4.0	6.7	5.7	5.7	5.7	5.7	6.0	7.3	6.7	6.2
B23	6.0	5.3	0.0	6.0	6.3	6.0	5.7	6.0	6.7	6.3	6.3	6.2
PST-5SALT	5.7	5.3	5.7	6.3	6.0	5.7	6.0	6.0	6.3	7.0	6.0	6.2
Falcon IV	6.0	4.3	25.0	6.7	6.3	6.0	6.0	5.0	6.7	6.3	6.3	6.2
Fesnova	6.0	5.3	10.0	6.7	6.3	6.0	6.3	5.3	5.7	6.7	6.0	6.1
TF-287	6.7	5.7	16.7	6.0	6.7	6.0	5.3	5.3	6.0	7.3	6.3	6.1
PST-5MVD	6.0	4.7	5.0	6.3	6.0	5.7	6.3	5.7	6.0	6.7	6.3	6.1
Burl TF-69	7.0	6.3	23.3	6.7	6.7	6.0	5.7	4.7	5.7	7.0	6.7	6.1
Falcon V	5.3	6.0	3.3	6.3	6.0	5.7	5.7	6.0	6.3	6.3	6.7	6.1
PSG-WE1	5.7	6.0	6.7	5.7	5.7	5.7	6.0	5.7	6.3	7.0	6.7	6.1
IS-TF 307 SEL	7.3	6.0	16.7	5.3	6.7	6.3	6.3	5.3	5.7	6.3	6.7	6.1
PPG-TF-137	6.3	6.0	5.7	5.3	6.0	6.0	5.3	5.7	6.7	7.0	6.7	6.1
PPG-TF-148	5.0	5.7	10.0	6.7	6.3	6.0	6.0	5.7	6.0	6.3	5.7	6.1
MET-3	5.7	6.3	5.0	5.7	5.7	5.3	6.0	5.7	6.3	7.0	7.0	6.1
RAD-TF-88	6.7	6.3	28.3	7.0	6.7	6.3	5.0	5.0	5.3	6.7	6.7	6.1
IS-TF 282 M2	7.0	5.7	20.0	6.0	6.3	6.3	6.3	5.3	5.3	6.3	6.3	6.0
IS-TF 285	6.7	5.7	13.3	6.0	7.0	6.0	6.3	5.3	6.0	6.0	5.7	6.0

Firebird 4	6.3	5.7	11.7	6.0	6.3	6.0	6.0	5.7	6.0	6.0	6.3	6.0
PST-5EV2	5.7	5.0	12.3	5.7	6.0	5.3	6.0	5.0	6.7	7.0	6.7	6.0
PSG-GSD	6.0	4.3	5.7	6.7	5.7	6.0	6.0	6.0	6.0	6.3	5.7	6.0
PPG-TF-145	7.3	4.7	15.0	5.3	6.7	6.0	7.3	5.7	5.3	6.0	6.0	6.0
IS-TF 269 SEL	7.0	5.3	15.0	5.3	6.3	6.3	5.7	5.7	6.3	6.0	6.3	6.0
ATF 1704	5.0	5.3	9.0	5.7	6.0	5.3	5.7	5.3	6.3	7.3	6.3	6.0
PST-5BPO	6.3	5.0	5.0	5.7	6.0	5.3	6.0	5.3	6.7	6.7	6.3	6.0
PSG-TT4	5.7	5.0	11.3	7.0	6.0	5.3	6.0	5.3	5.3	6.3	6.7	6.0
PPG-TF-169	5.3	4.7	25.0	6.7	6.3	5.7	5.3	5.0	5.7	7.0	6.3	6.0
IS-TF 289	7.7	5.0	2.3	5.0	6.7	6.7	5.7	5.3	5.7	6.3	6.3	6.0
PST-5EX2	5.0	4.7	3.3	6.7	5.3	5.0	6.0	5.7	5.7	7.0	6.3	6.0
Burl TF-136	6.0	6.0	13.3	5.7	5.7	5.3	5.7	4.7	6.0	7.0	7.3	5.9
PPG-TF-142	7.3	5.7	21.7	6.0	6.7	6.3	5.7	5.0	5.0	6.3	6.3	5.9
IS-TF 276 M2	7.3	4.7	38.3	5.3	7.3	6.0	5.3	4.7	5.7	6.3	6.3	5.9
PST-5DZP	6.7	5.3	31.7	5.7	6.7	6.0	6.0	5.0	5.7	6.0	6.0	5.9
DB1	7.7	5.7	43.3	5.7	7.3	6.0	5.0	4.3	5.7	6.7	6.3	5.9
JS818	8.0	5.3	31.7	5.3	7.0	6.0	5.7	5.0	5.7	6.0	6.0	5.8
ATF 1754	5.0	5.3	1.7	5.7	6.0	5.3	5.0	6.3	6.3	6.3	5.7	5.8
TD1	7.3	6.3	40.0	6.3	6.3	5.7	5.3	5.0	5.3	6.0	6.7	5.8
DZ1	6.7	6.0	8.3	5.7	6.0	5.7	6.0	5.3	5.7	5.3	6.7	5.8
PSG-8BP2	6.3	4.7	6.7	5.7	6.0	5.7	6.0	5.0	6.0	6.3	5.7	5.8
RAD-TF-83	6.7	5.7	13.3	5.7	6.3	6.3	5.0	5.3	5.0	6.7	6.0	5.8
ATF 1736	5.3	5.0	11.7	6.0	5.3	5.3	4.7	5.3	6.0	7.0	6.3	5.8
JS819	6.7	5.7	28.3	5.3	6.7	5.7	5.7	5.3	5.0	5.7	6.3	5.7
ATF 1612	6.0	5.3	18.3	5.7	5.7	5.3	6.0	4.7	5.3	6.7	6.3	5.7
PST-5R05	6.3	5.0	20.0	5.3	5.7	5.3	6.0	5.3	6.0	5.7	6.3	5.7
Terrano	6.7	4.7	5.0	5.7	5.3	5.3	6.0	5.3	5.3	6.0	6.3	5.7
PPG-TF-139	6.0	5.7	23.3	5.7	6.7	5.7	5.7	4.7	5.3	5.7	6.0	5.7
RAD-TF-89	7.0	5.0	15.0	5.7	6.0	5.3	5.3	5.0	5.7	5.7	6.7	5.7
IS-TF 272	8.0	6.7	18.3	4.7	6.0	6.3	5.3	5.0	5.3	6.3	6.0	5.6
Annihilator	5.7	5.7	26.7	6.3	5.7	5.3	4.7	4.3	4.7	7.0	6.7	5.6
JS916	6.0	5.7	10.7	5.7	6.0	5.3	5.3	5.0	5.3	6.3	5.7	5.6
K12-05	7.7	6.0	41.7	5.0	6.0	6.7	5.0	4.0	5.0	6.0	7.0	5.6

PST-57DT	5.0	4.7	21.7	5.7	5.3	5.3	5.0	5.3	5.0	6.3	6.3	5.5
TY 10	7.3	4.7	18.3	6.3	5.7	5.0	5.0	5.0	5.3	5.7	6.0	5.5
RAD-TF-92	6.3	6.0	30.0	5.7	5.0	5.7	4.3	5.3	5.7	5.7	6.3	5.5
OR-21	7.7	4.7	23.3	5.7	6.0	5.3	5.7	4.7	5.0	5.7	5.3	5.4
204 Res. Blk4	5.0	6.3	28.3	5.7	5.3	4.7	4.7	4.7	4.7	7.0	6.3	5.4
Exp TF-09	7.7	4.7	41.7	6.0	5.3	5.3	5.3	4.0	5.7	5.7	5.3	5.3
BAR Fa 121089	6.0	4.7	25.0	5.7	5.3	5.3	5.3	4.7	5.0	5.3	6.0	5.3
BAR Fa 121091	7.3	4.7	41.7	5.3	5.7	5.3	5.0	4.3	5.3	5.7	5.7	5.3
JS809	7.3	5.7	33.3	5.3	6.0	5.0	4.3	4.0	5.0	6.3	6.0	5.3
PST-5GRB	5.0	6.3	10.0	6.0	5.3	5.0	5.0	4.7	5.0	5.3	5.7	5.3
GO-DFR	6.7	5.3	30.0	4.7	5.7	5.3	5.3	4.3	5.3	5.7	5.7	5.3
BAR Fa 121095	7.3	5.7	41.7	5.3	5.3	6.0	5.0	4.7	5.0	5.3	5.3	5.3
PST-R5NW	6.0	3.7	18.3	5.0	5.7	5.7	5.0	4.7	5.0	5.3	5.3	5.2
Comp. Res. SST	5.7	6.0	40.0	4.7	5.7	4.7	4.7	4.3	5.0	6.3	6.0	5.2
K12-13	7.7	6.0	45.0	4.7	5.3	5.0	4.7	4.3	5.0	5.3	6.3	5.1
Aquaduct	5.3	4.3	26.7	5.0	4.7	5.0	4.7	5.0	5.0	5.3	5.7	5.0
JS825	7.0	4.7	36.7	4.7	6.0	5.0	5.0	4.3	4.3	5.7	5.3	5.0
Marauder	5.3	5.7	36.7	4.7	5.0	4.3	4.7	4.7	4.7	5.0	6.3	4.9
Warhawk	6.3	6.0	35.0	5.3	5.7	4.3	4.0	4.3	4.7	5.3	5.0	4.8
BAR Fa 120878	4.3	3.0	23.3	5.0	4.3	4.7	4.7	4.7	4.3	5.3	4.7	4.7
Ky-31	2.0	2.0	15.0	3.0	3.0	3.0	4.0	4.0	4.0	3.3	4.0	3.5
$LSD_{0.05}$	1.06	1.21	16.46	1.32	1.20	1.19	1.40	1.08	1.33	1.37	1.07	0.80
CV%	10.3	13.7	71.0	13.8	12.1	12.7	15.0	12.5	14.1	13.0	10.4	8.3

Acknowledgements: This project is funded by the National Turfgrass Evaluation Program

NATIONAL TURFGRASS EVALUATION PROGRAM (NTEP)
2015 STANDARD AND ANCILLARY LOW INPUT COOL SEASON TEST – 2016 RESULTS

Steven Rackliffe, Karl Guillard, Victoria Wallace
Department of Plant Science and Landscape Architecture
University of Connecticut

INTRODUCTION

There has been increased interest to develop new plant management strategies, or to investigate new plant systems that require less input such as water, fertilizer, and pesticides. Overall quality and functionality are still desired. This trial is unique in that the maintenance of this trial, after the establishment period, will be minimal. There will be no water, fertilizer or pesticides applied after the establishment period. (Exception is the Ancillary Trial, which received one preemergent application in the first year of the study). Also unique about this trial is that it not only includes single cultivars, it includes, blends, mixtures and mixtures with grass and non-grass species.

In 2015 the National Turfgrass Evaluation Program (NTEP) selected thirteen standard testing locations and thirteen ancillary test locations for their 2015 Low Input Cool-Season Trials. The University of Connecticut, Plant Science Teaching and Research Facility in Storrs CT, was selected for both a Standard and Ancillary site. The duration of this study is five years and will conclude in the fall of 2021.
The National Turfgrass Evaluation Program (NTEP) is sponsored by the Beltsville Agriculture Research Center and the National Turfgrass Federation Inc. NTEP works with breeders and testing sites throughout the United States in evaluating turfgrass species and cultivars. This low input study differs from conventional NTEP trials in two ways. One is that many of the entries are not single cultivars or varieties being evaluated, they contain mixtures. The second difference is that many of the entries contain non-turfgrass species. Results from this trail may aid homeowners and professionals in their selection of low input species and mixtures that best meet their needs, and those that provide a suitable ground cover that will require less water, fertility and mowing.

MATERIALS AND METHODS

Two low-input trials were seeded on September 14, 2015 in Storrs Connecticut. One trial was a "standard" test while the second trial was an "ancillary" test. Each test consisted of thirty-two entries (Table 1) containing different species, different mixtures, and different compositions. Both, the ancillary and standard trial contained the same entries and received the same maintenance regimes.The only difference between the two trials was that the ancillary trial received a preemergent application for weeds in the spring of 2016. Sponsors and entries are listed in table 1. A complete randomized block design with 3 replicates of each cultivar was utilized for each study. Plot size is 5' X 5'.

Establishment and Management Practices-
After seeding, plots were covered to aid in germination and to reduce any chances of seed migration. All plots for each study received the same management protocol since establishment.
Mowing (Standard and Ancillary trials) - Plots are maintained at a mowing height of 3.25" inches and mowed when no more than 1/3 of the leaf is removed. Mowing dates are recorded.

Irrigation Regime (Standard and Ancillary trials) - No irrigation

Fertilizer and pesticide applications (2015/2016)

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

Establishment Ratings- Seedling Emergence ratings were evaluated four weeks after planting on October 4, 2015. (table 2 standard test and table 3 ancillary test). Emergence ratings were based on percent emergence and seedling vigor.

Percent Living Ground Cover- Percent living cover ratings are taken twice per year, once in the spring and once in the fall. In 2016, ratings were done on May 31st and October 17th. 2016. (table 2 standard test and table 3 ancillary test).

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

Percent grassy and broadleaf weed encroachment Ratings –
Weed encroachment ratings are taken twice per year, once in the spring and once in the fall. In 2016, ratings were done on June 21st and September 18th. 2016.(table 2 standard test and table 3 ancillary test).

RESULTS & DISCUSSION

The University of Connecticut was chosen as a site for the National Turfgrass Program 2015 Low Input Cool-Season Trials. This trial differs from the typical NTEP trials because each plot contained different grasses and species. Evaluating the different species and grasses for visual quality was challenging. This was especially true when comparing broadleaf entries such as clover with straight grass entries or grass and clover mixes. For visual ratings, "heavier weight" was placed on density. The purpose of this study is to investigate the use of different ground covers for low maintenance environments. The top entries for both the ancillary studies and the standard studies were 7H7 a hard fescue, DLFPS-TFAM a mixture of three tall fescues and microclover. Many of the clovers and fescues performed well (Figure 1). Yaak 100% western yarrow performed extremely well through the early part of the season but the overall quality began to deterioate towards the end of the season. Kenblue Kentucky bluegrass had the poorest rating in both trials. Visual differences between ancillary trial plots (receiving preemergent applications) and non- ancillary plots (not receiving preemergent applications) were minimal for the 2016 season.

While difficult to predict, because it is early in the study, there appear to be good alternatives for low-input ground covers.

Figure 1- 2015 NTEP Low Input Cool Season Trials University of Connecticut
Photo taken August 2016

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

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

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

Table of Contents

Table 2. NTEP Low Input Standard Test results 2016 Ratings for percent establishment, Percent Living cover for spring and fall, percent weed coverage for spring and fall, and monthly visual quality (rating 1-9, where 9 equals the highest turf quality)

	Establish-ment (%)	Percent Living cover			Percent weed coverage			Quality								
Entry	10/4	5/31	10/17	Mean	6/21	9/18	Mean	4/19	5/26	6/21	7/14	8/16	9/18	10/17	11/16	Mean
7H7	50.0	95.0	98.3	96.7	3.0	4.0	3.5	4.3	6.3	7.7	7.7	7.0	6.7	7.0	7.0	6.7
CRS Mix #1	53.3	96.7	95.0	95.8	2.0	2.3	2.2	5.7	6.3	7.7	7.3	7.3	5.7	6.0	6.7	6.6
DLFPS-TFAM	65.0	96.7	93.3	95.0	0.0	0.7	0.3	6.7	6.7	7.7	6.0	5.7	6.3	6.7	6.3	6.5
Yaak	78.3	100.0	88.3	94.2	0.0	0.7	0.3	8.0	7.7	7.3	6.7	7.0	5.0	5.7	4.3	6.5
Vitality Low Maintenance Mix	50.0	95.0	93.3	94.2	2.3	1.7	2.0	4.3	6.0	7.7	6.3	7.0	6.0	6.3	6.7	6.3
Southern Mixture	68.3	96.7	90.0	93.3	0.7	1.0	0.8	6.3	7.0	8.0	5.3	5.3	6.3	5.7	6.0	6.3
CRS Mix #2	40.0	85.0	93.3	89.2	3.3	4.7	4.0	4.3	6.0	7.0	7.0	7.0	5.7	6.0	6.3	6.2
Bullseye	66.7	95.0	86.7	90.8	1.0	1.3	1.2	6.3	7.0	7.0	5.0	6.0	6.7	5.3	5.7	6.1
MNHD-15	50.0	88.3	96.7	92.5	3.3	2.3	2.8	4.0	4.7	7.3	7.7	6.7	5.7	6.3	6.7	6.1
DLFPS TF-A	65.0	96.7	88.3	92.5	0.0	1.3	0.7	6.0	6.3	7.0	6.0	5.3	6.3	6.0	6.0	6.1
Spartan II	46.7	93.3	95.0	94.2	0.7	1.7	1.2	4.7	5.7	6.3	6.7	7.0	6.0	6.0	6.7	6.1
DLFPS TFAStC	61.7	93.3	90.0	91.7	0.3	0.7	0.5	5.7	6.7	7.0	5.7	6.3	6.0	5.3	5.7	6.0
Kingdom	68.3	91.7	91.7	91.7	2.0	3.0	2.5	5.3	5.7	6.7	5.3	5.7	6.7	6.7	5.7	6.0
Quatro	48.3	91.7	93.3	92.5	2.3	2.3	2.3	5.3	6.3	6.0	6.0	6.0	5.3	5.3	6.7	5.9
DTT Tall Fescue Mix	61.7	96.7	88.3	92.5	0.3	2.0	1.2	5.7	6.7	7.7	5.3	5.3	5.7	5.3	5.3	5.9
CRS Mix #3	53.3	98.3	93.3	95.8	1.3	2.3	1.8	6.7	5.7	5.0	6.0	5.7	5.0	6.3	6.3	5.8
DLFPS-ChCrM	61.7	96.7	90.0	93.3	0.0	1.0	0.5	5.7	5.7	7.0	5.0	5.0	5.0	6.0	6.3	5.7
Dutch White Clover	30.0	100.0	90.0	95.0	1.0	1.7	1.3	5.0	5.0	6.3	5.3	6.3	5.7	6.3	5.7	5.7
DLFPS-ShHM	48.3	95.0	88.3	91.7	1.3	6.0	3.7	5.0	5.7	6.7	5.3	6.0	5.3	5.7	5.7	5.7
Vitality Double Coverage Mix	58.3	91.7	86.7	89.2	1.0	1.3	1.2	5.3	4.7	7.0	6.0	5.3	6.7	5.0	5.0	5.6
DLFPS ChCrSH	53.3	90.0	90.0	90.0	1.3	2.0	1.7	4.3	6.0	5.3	5.3	5.0	5.3	6.0	6.7	5.5
BGR-TF3	61.7	83.3	90.0	86.7	23.3	0.7	12.0	6.7	5.7	6.3	5.0	4.7	5.3	5.0	5.0	5.5
Radar	55.0	95.0	88.3	91.7	3.7	5.7	4.7	4.0	6.0	7.0	5.3	4.7	4.7	5.3	6.0	5.4
CS Mix	48.3	91.7	93.3	92.5	2.3	2.0	2.2	4.3	5.7	6.0	6.3	5.7	4.0	5.0	5.7	5.3
DTTHO TF/KBG Mix	56.7	85.0	81.7	83.3	2.0	2.7	2.3	4.3	5.0	5.7	5.3	5.3	6.3	5.3	4.7	5.3
Chantilly	61.7	95.0	86.7	90.8	1.3	5.0	3.2	5.7	7.0	5.0	4.3	4.3	4.0	4.7	5.3	5.0
Ky-31 E+	73.3	91.7	83.3	87.5	0.3	0.3	0.3	6.7	4.7	5.0	5.3	5.0	5.0	4.3	4.3	5.0
Natural Knit®PRG Mix	76.7	98.3	80.0	89.2	0.0	2.0	1.0	6.7	7.3	6.3	3.3	4.0	3.3	5.0	4.0	5.0

Northern Mixture	56.7	88.3	80.0	84.2	1.3	3.3	2.3	5.0	5.3	5.0	4.0	4.7	3.0	4.7	5.0	4.6
Bewitched	36.7	70.0	81.7	75.8	4.3	12.0	8.2	2.7	3.7	5.0	5.0	5.0	5.0	4.7	5.3	4.5
A-SFT	61.7	90.0	81.7	85.8	2.0	3.7	2.8	4.3	5.0	4.7	4.3	4.3	4.3	5.0	4.3	4.5
Kenblue	4.3	56.7	56.7	56.7	5.0	9.3	7.2	2.3	3.3	3.3	2.7	3.7	2.7	3.0	2.0	2.9
$LSD_{0.05}$	10.34	8.51	9.78	7.35	2.36	4.08	2.68	1.13	1.55	1.21	1.09	0.88	0.93	1.13	1.06	0.59
CV%	11.4	5.7	6.8	5.0	63.3	88.2	64.3	13.3	16.3	11.6	12.0	9.6	10.7	12.5	11.6	6.4

Table 3. **NTEP Low Input Ancillary Test results 2016 Ratings for percent establishment, Percent Living cover for spring and fall, percent weed coverage for spring and fall, and monthly visual quality (rating 1-9, where 9 equals the highest turf quality)**

	Establish-ment (%)	Percent Living cover			Percent weed coverage			Quality								
Entry	10/4	5/31	10/17	Mean	6/21	9/18	Mean	4/19	5/26	6/21	7/14	8/16	9/18	10/17	11/16	Mean
DLFPS-TFAM	73.3	96.7	98.3	97.5	1.3	3.3	2.3	7.7	7.7	6.7	7.0	6.3	7.3	7.3	6.3	7.0
DLFPS TFAStC	71.7	98.3	98.3	98.3	2.0	1.3	1.7	7.0	7.7	7.3	7.3	5.7	7.3	7.3	6.3	7.0
DLFPS TF-A	71.7	98.3	95.0	96.7	2.3	4.3	3.3	7.3	7.0	7.3	6.7	6.3	7.3	7.3	6.3	7.0
Bullseye	68.3	98.3	95.0	96.7	1.3	3.0	2.2	7.0	7.3	7.7	6.0	6.0	7.0	7.3	6.0	6.8
MNHD-15	58.3	93.3	96.7	95.0	2.7	3.3	3.0	4.3	6.3	7.0	7.3	7.3	6.7	7.3	7.0	6.7
CRS Mix #2	58.3	93.3	96.7	95.0	3.7	5.7	4.7	5.0	6.3	7.0	6.7	7.0	6.3	8.0	7.0	6.7
CRS Mix #1	58.3	96.7	98.3	97.5	3.7	5.3	4.5	5.3	6.7	7.0	7.0	7.3	6.0	7.0	6.7	6.6
Vitality Low Maintenance Mix	53.3	98.3	100	99.2	1.7	5.0	3.3	5.3	6.7	7.0	6.7	6.3	6.7	7.0	7.0	6.6
Yaak	75.0	100	90.0	95.0	0.0	1.3	0.7	7.7	7.0	7.3	6.7	7.0	5.3	6.0	5.3	6.5
Spartan II	60.0	96.7	96.7	96.7	2.0	4.7	3.3	5.7	6.7	6.3	5.7	6.7	6.7	7.3	6.7	6.5
DTTHO TF/KBG Mix	63.3	96.7	95.0	95.8	2.0	5.0	3.5	6.0	6.0	7.7	6.3	5.7	6.3	7.3	5.7	6.4
7H7	53.3	95.0	96.7	95.8	5.0	8.0	6.5	4.0	5.7	6.7	6.7	7.0	6.3	7.7	7.0	6.4
CS Mix	65.0	98.3	93.3	95.8	2.0	7.0	4.5	6.0	7.3	7.0	5.7	6.3	6.0	6.3	6.3	6.4
Kingdom	65.0	95.0	93.3	94.2	3.0	9.3	6.2	6.0	6.7	7.3	5.7	5.0	6.7	7.7	5.7	6.3
Southern Mixture	71.7	96.7	91.7	94.2	0.7	2.0	1.3	7.0	7.0	6.7	5.7	5.0	6.0	7.0	5.3	6.2
Radar	63.3	100	95.0	97.5	3.3	4.0	3.7	6.0	7.7	6.7	5.3	5.7	5.7	6.7	5.7	6.2
CRS Mix #3	50.0	100	91.7	95.8	0.0	1.0	0.5	6.0	6.0	5.7	6.3	6.0	5.3	6.7	6.7	6.1
Vitality Double Coverage Mix	71.7	95.0	91.7	93.3	1.7	3.7	2.7	6.0	5.7	7.0	6.7	5.3	6.0	6.7	5.0	6.0
DTT Tall Fescue Mix	61.7	96.7	90.0	93.3	1.3	5.0	3.2	6.0	5.7	7.0	5.3	5.3	6.3	6.3	5.7	6.0
DLFPS ChCrSH	63.3	95.0	91.7	93.3	2.0	4.0	3.0	5.7	6.7	5.7	5.3	5.7	5.0	7.3	6.0	5.9
A-SFT	66.7	93.3	96.7	95.0	3.7	4.7	4.2	5.7	6.0	6.7	6.0	4.7	6.7	6.0	5.7	5.9
Natural Knit®PRG Mix	83.3	98.3	88.3	93.3	0.3	6.0	3.2	7.0	7.7	6.3	4.3	4.3	5.3	6.3	5.7	5.9
BGR-TF3	70.0	85.0	88.3	86.7	12.7	18.3	15.5	7.3	5.0	6.0	4.7	4.7	6.3	6.7	5.7	5.8
Chantilly	65.0	95.0	95.0	95.0	1.0	4.3	2.7	6.0	6.7	5.0	4.3	5.0	5.0	7.3	6.0	5.7
Quatro	51.7	93.3	90.0	91.7	4.3	9.3	6.8	6.0	6.0	5.0	5.3	5.7	5.3	6.0	6.0	5.7
DLFPS-ChCrM	65.0	98.3	91.7	95.0	0.0	3.7	1.8	6.3	6.3	5.7	5.7	5.3	4.7	5.7	5.3	5.6
Ky-31 E+	76.7	96.7	85.0	90.8	0.3	3.0	1.7	7.0	6.0	4.7	6.0	5.0	5.7	5.0	4.7	5.5
DLFPS-ShHM	48.3	93.3	93.3	93.3	0.0	4.0	2.0	5.0	6.0	4.7	5.7	5.7	5.0	6.0	5.7	5.5
Dutch White Clover	43.3	100	95.0	97.5	2.7	6.0	4.3	5.0	4.3	4.7	5.3	6.3	4.7	6.7	6.0	5.4

Table of Contents

Northern Mixture	68.3	90.0	80.0	85.0	3.3	16.0	9.7	5.0	5.3	4.7	4.0	4.0	3.7	5.7	4.0	4.5
Bewitched	45.0	66.7	75.0	70.8	7.7	71.7	39.7	3.3	3.7	5.0	4.3	3.7	4.0	4.7	4.7	4.2
Kenblue	12.0	46.7	75.0	60.8	11.3	65.0	38.2	2.0	3.7	3.0	3.0	3.3	3.3	5.3	4.0	3.5
$LSD_{0.05}$	11.44	6.91	10.39	5.93	2.76	14.64	8.14	1.27	1.12	1.27	1.17	1.23	0.96	1.29	1.12	0.57
CV%	11.4	4.5	6.9	3.9	60.9	96.2	82.4	13.4	11.0	12.5	12.4	13.3	10.2	11.9	11.8	5.8

Acknowledgements:
This project is funded by the National Turfgrass Evaluation Program

Efficacy Trials of EPA Minimum Exempt Products

Victoria Wallace[1], Jason Henderson[2], John Inguagiato[2], Kevin Miele[2] and Scott Vose[2]
Department of Extension[1]
Dept. of Plant Science and Landscape Architecture[2]
University of Connecticut

INTRODUCTION

On July 1, 2010, applications of federally registered lawn care pesticides were banned on the grounds of public and private schools from grades K-8 as a result of CT Public Act (P.A. 09-56). Since then, school grounds managers can only use pesticides that meet specific criteria for exemption from federal registration requirements as part of their maintenance programs for turfgrass athletic fields and school grounds. Manufacturers of exempt pesticides, also referred to as "minimum risk" or 25b pesticides are not required to provide information regarding the toxicity and efficacy of their products.

Increased weed pressure affecting field quality and player safety is a primary concern for many school grounds managers. Turf managers often are challenged to identify products that actually control the target pests and regularly express frustration with product effectiveness. CT DEEP has provided a list of products that meet the requirements of minimum exempt pesticides and have been approved for use in Connecticut. However, there is a critical need to evaluate the efficacy of weed control products. The lack of product information often results in multiple or ineffective product applications.

MATERIALS AND METHODS

A field study was conducted at the Plant Science Research and Education Facility in Storrs, CT. 1200 sq. ft. blocks of five weeds: crabgrass, white clover, dandelion, broadleaf plantain, and 'Stellar' perennial ryegrass (PRG) were seeded in September 2014. Seeding rates of the weed species was 2 lb./m sq. ft. A 2 lb./m sq. ft. of 'Stellar' PRG also was overseeded into the weed blocks to reduce erosion. The 'Stellar' PRG block was seeded at 6 lb./m sq. ft. All blocks were maintained at a mowing height of 3" and mowed once a week. Clippngs were returned. The blocks of weeds and PRG were fertilized in May 2015, at the rate of 1 lb. N 1000-ft^2 of 30-0-10 (Polyon). No supplemental irrigation was applied during establishment or in 2015.

Treatment plots measuring 3 x 6 ft. were established on September 11, 2015 in each of the weed and perennial ryegrass blocks. The plots were set out as randomized complete block design with 3 replicates in each block. Treatments were identified as products that were included on the CT DEEP Pesticides Exempt from Federal Registration list or were commercially available with an EPA registration number. Treatments are listed in Table 1.
CapSil, a non-ionic surfactant was included at a rate consistent with label recommendations for products that recommended the use of a surfactant. The broadleaf weed herbicide standard for the three broadleaf weed blocks (white clover, broadleaf plantain, and dandelion) was TZone (triclopyr). For the crabgrass weed block and the perennial ryegrass block, Acclaim (fenoxaprop-p-ethyl) was selected as the herbicide standard.

Treatment plots were evaluated for percent weed cover before treatment evaluation was initiated. Treatments were applied at rates based on percent volume/volume. Plots were sprayed on September 11, 2015 and rated as visual percent weed affected and overall visual percent affected on 1DAT, 2DAT, 3DAT, 4DAT, 5DAT, 6DAT, 7DAT, 10DAT, 13DAT, 17DAT, and 20DAT.

In April 2016, the PRG block was treated with prodiamine at the rate of .5 fl. oz./m. The PRG and crabgrass blocks were treated in May 2016 with 1.4 fl. oz. T-Zone. Also in May 2016, .5 lb./m 45-0-0 was applied to all weed and ryegrass blocks. The crabgrass block was re-seeded with crabgrass seed in June 2016 at the rate of 2 lb./m.

Treatment plots were re-randomized, and percent weed cover was noted before products were applied. Due to weed populations being eradicated or severely reduced in plots previously treated with T-Zone, a treatment was dropped with the re-randomization of the 2016 treatment plots (Table 2). The plots were sprayed on September 8, 2016 and rated as visual percent weed affected on 1DAT, 2DAT, 3DAT, 4DAT, 5DAT, 6DAT, 7DAT, 10DAT, 13DAT, 17DAT, and 20 DAT. Phytotoxicity was also assessed visually on a 0-5 scale, where 0 was equal to no discoloration and 5 represented complete injury to the vegetative canopy.

RESULTS & DISCUSSION

2016 data is being analyzed. To date, no exempt minimum risk product trialed was selective in control of any of the weed blocks without causing injury to the turfgrass. In 2015, severe suppression of crabgrass, clover, dandelion, and plantain weed blocks, along with total suppression of the turfgrass, was exhibited 1-2DAT with Green Match, Nature's Avenger, and Phydura, which contained D-limonene (citric acid) as a component. BurnOut II also contained citric acid, but damage varied with the broadleaf weeds and was not as significant compared to the Green Match, Nature's Avenger, and Phydura. Treatments that contained clove oil has some burndown capacity, but the degree of damage to the vegetative canopy varied. TZone provided a gradual progressive suppression of broadleaf weeds, with control and visual impact after 10DAT (clover) to 17DAT (plantain).

Fiesta and Whitney Farm, which both contained Fe HEDTA as a component, exhibited some selective suppression of white clover. However, re-growth of clover was observed after 10DAT for Fiesta and 5DAT for Whitney Farm. Fiesta also damaged the turfgrass in the crabgrass and broadleaf weed blocks, but not as severely as Green Match, Nature's Avenger and Phydura.

Adios, BurnOut II, Weed Zap, and Matratec had varied degrees of suppression for all the broadleaf weeds. In general, BurnOut II had a higher degree of initial suppression for dandelion and plantain, although there was evidence of re-growth of the weeds after 7DAT.

Comparing the ready-to-use products, Whitney Farm offered better suppression on dandelion than Ecosmart or Ecologic. However, all three offered less suppression and were less effective than the other burndown products on the broadleaf weeds.

At the initiation of this project, products were selected that were approved and on the CT DEEP Pesticides Exempt from Federal Registration list, or were composed of minimum risk products, but were registered with a designated EPA registration number. Products were selected for the project based on distributor availability, as well as marketing and product recognition. All products were referenced to control broadleaf weeds.

The intention of the project was to provide a vehicle for trialing minimum risk products in Connecticut as they are introduced to the turf and ornamental marketplace. However, vetting efficacy of new products approved by CT DEEP and available for commercial sale in CT, as well as adequately confirming the rate of recommended application, was found to have limitations. Few new weed control product introductions that would meet the requirements of inclusion for the CT DEEP Pesticides Exempt from Federal Registration list occurred during the course of the project.

Moreover, shortly after the project began, it was observed that some products that had been promoted on the CT DEEP Pesticides Exempt from Federal Registration list had limitations with product availability. Some ready-to-use products (Whitney Farms, Ecologic, Ecosmart), formerly available at large home center box stores, had been discontinued by the manufacturer. Green Match and BurnOut II had been reformulated. The other products were available at only one or two distributors and would be a challenge to acquire if needed by a turf care professional.

CONCLUSION

The accelerated burndown of the crabgrass vegetative canopy would allow for an early fall overseeding advantage, if renovation without surface disruption of turfgrass areas was necessary. Turfgrass areas treated with burndown products could be scalped and overseeded into the areas treated with the non-selective burndown products with less competition for the new germinating seed.

The strongest damage to the vegetative canopy of the broadleaf weeds occurred with Green Match, Phydura and Nature's Avenger. These products would serve temporarily to suppress weeds along fence rows, infields or other non-turf areas where glyphosate can no longer be used as the preferred option to reduce weeds on school properties. Regrowth of mature perennial broadleaf weeds would occur, but with frequent and repeated applications, it provides an alternative to physical removal.

Efficacy Trials of EPA Minimum Risk Exempt

Table 1. 2015 Minimum Risk Products Applied to Weed and PRG Blocks

#	Product	Treatment lbs. available N/1000ft^2/yr.
1	Adios-liquid	0.0
2	Adios-granular w surfactant	0.2
3	Matratec w surfactant	0.4
4	Weed Zap w surfactant	0.6
5	Green Match w surfactant	0.8
6	Burn Out II-Conc.	1.0
7	Phydura	1.2
8	Fiesta	1.4
9	Nature's Avenger	1.6
10	EcoSmart	1.8
11	Whitney Farm	2.0
12	Ecologic RTU	2.2
13	T-Zone	2.4
14	Untreated	2.6

Table 2. 2016 Minimum Risk Products Applied to Weed and PRG Blocks

#	Product	Treatment lbs. available N/1000ft^2/yr.
1	Adios-liquid	0.0
2	Adios-granular w surfactant	0.2
3	Matratec w surfactant	0.4
4	Weed Zap w surfactant	0.6
5	Green Match w surfactant	0.8
6	Burn Out II-Conc.	1.0
7	Phydura	1.2
8	Fiesta	1.4
9	Nature's Avenger	1.6
10	Whitney Farm	2.0
11	Ecologic RTU	2.2
12	T-Zone	2.4
13	Untreated	2.6
14	Extra Plot	0

Product	**Active Ingredient**	**On DEEP Approved List**
Adios-liquid	35.58% Sodium Chloride, 64% other	Yes
Adios-granular	96.56% Sodium Chloride	Yes
BurnOut II-conc.	24% Citric Acid, 8% Clove Oil, 68% Other	Yes
Fiesta	26.52% Iron-HEDTA, 73.48% Other	No
Matratec	50% Clove Oil	Yes
Green Match	70% D-limonene (citric acid), 30% inert	Yes
Ecologic Weed & Grass Killer-RTU	5% Rosemary Oil, 5% Cinnamon oil, 5% Sodium Lauryl Sulfate, 85% Other	Yes
EcoSmart Weed & Grass Killer-RTU	5% 2-Phenyl Propionate, 5% Eugenol, 0.05% Sodium Lauryl Sulfate, 89.95% Other	Yes
Nature's Avenger -Weed Killer	70% D-limonene (citric acid), 30% inert	No
Phydura	20% Citric Acid, 15% Clove oil, 10% Malic Acid, Oleic Acid, Other	No
Weed Zap	45% Clove Oil, 45% Cinnamon Oil	Yes
Whitney Farm-RTU	1.5% Fe HEDTA, soybean oil	Yes

Table of Contents

TRANSCRIPTOME SEQUENCING OF THE *shadow*-1 PERENNIAL RYEGRASS (*LOLIUM PERENNE*, L.) MUTANT PROVIDES INSIGHT INTO GENETIC MECHANISMS LEADING TO DWARFISM AND SHADE TOLERANCE

Lorenzo Katin-Grazzini, Wei Li, Rania El-Tanbouly, Huseyin Yer, Chandra S. Thammina, and Yi Li

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

INTRODUCTION

Perennial ryegrass (*Lolium perenne* L.) is one of the most widely cultivated cool-season turfgrass species in the world. Known for its fast establishment, perennial ryegrass is favored for ornamental use, as well as for livestock grazing. While perennial ryegrass is incorporated into many seed mixtures due to its positive traits, it is seldom grown by itself because of its sensitivity to a number of environmental stressors (Stier 1999). Perennial ryegrass struggles to grow in overly shady environments, exhibiting the shade avoidance response (SAR), a condition characterized by weak growth, overly elongated leaves, and chlorosis (Franklin 2005). SAR, and other symptoms of shade stress, impact virtually all plant taxa, and high amounts of shade have a negative impact on the growth and development of all plants.

Lack of light is a significant issue when growing plants in any context, from agricultural to ornamental. Low-light conditions greatly impede healthy plant growth, which is especially true for ornamental plants for which SAR can have a drastic impact on plant appearance. Furthermore, in congested areas, whether with buildings in urban areas or with trees in rural areas, it can be difficult to find growing space with adequate light exposure. Understanding the mechanisms behind shade tolerance would make it possible engineer solutions to the challenges of growing plants in low-light environments, thereby dramatically increasing the availability of potential growing spaces. *shadow*-1 is a dwarf, shade-tolerant perennial ryegrass mutant. When subjected to severe shade stress (95% light reduction) *shadow*-1 plants are significantly resistant to SAR in terms of leaf elongation and as well as their ability to maintain healthy color (Li and Katin-Grazzini 2016). The *shadow*-1 mutant line represents a valuable opportunity to study the shade response pathway in monocots.

In an attempt to uncover the genetic mechanisms behind shade response in perennial ryegrass, we have sequenced and analyzed the transcriptome of the *shadow*-1 perennial ryegrass mutant. We have treated *shadow*-1 and wild-type plants with 95% shade and compared their transcriptomes to plants kept under full sunlight. Thorough examination of differential gene expression within the GA biosynthesis and response pathways of *shadow*-1 mutant plants, we demonstrated that a decrease in GA content was the likely mechanism for shade tolerance in these plants. These results provide some insight into the role that gibberellins may play in shade response, as well as possible strategies for the production of shade tolerant plants across all plant taxa.

MATERIALS AND METHODS

Plant Treatment and Tissue Sampling

shadow-1 and wild-type plants were vegetatively propagated. Plant roots and shoots were first cut to a 2.5 cm length, and six groups of two tillers were evenly spread within each pot. Plants were maintained at a five cm height in full light for six weeks. Plants that were selected for shade-stress treatment were placed in a 95% shade environment in the greenhouse which was created by the use of black polyfiber cloth. Plants that were selected for full-sunlight treatment were left out in the open in the greenhouse. After growing for an additional two weeks under either full sunlight or 95% shade, leaf tissues were collected from six pots for each genotype (wild type and *shadow*-1) under each treatment (full sunlight and 95% shade), representing one biological replicate. Three replicates were collected for each genotype under each treatment. Tissues wre collected by cutting young leaves directly into a beaker of liquid nitrogen, in an effort to preserve mRNA. For shade-treated plants, this was done in a darkroom environment to avoid light contamination, which might impact gene expression levels.

RNA Extraction and Library Preparation

Total plant RNA was extracted using the RNeasy Plant Mini Kit including RNase-Free DNase set (Qiagen, Valencia, CA, USA) according to the manufacturer's protocol. RNA purity and concentration were measured using the NanoDrop 2000 spectrophotometer (Thermo Fisher Scientific, Waltham, MA, USA). To further assess RNA quality, total RNA was analyzed on the Agilent TapeStation 2200 (Agilent Technologies, Santa Clara, CA, USA) using the RNA High Sensitivity assay. Ribosomal Integrity Numbers (RINe) were recorded for each sample. Only samples with RINe values above 7.0 were considered for library preparation. Total RNA samples were prepared for mRNA-Sequencing using the Illumina TruSeq Stranded mRNA Sample Preparation kit following the manufacturer’s protocol (Illumina, San Diego, CA, USA). Libraries were validated for length and adapter dimer removal using the Agilent TapeStation 2200 D1000 High Sensitivity assay (Agilent Technologies, Santa Clara, CA, USA) then quantified and normalized using the dsDNA High Sensitivity Assay for Qubit 2.0 (Life Technologies, Carlsbad, CA, USA). Sample libraries were prepared for HiSeq2500 sequencing using version 4 sequencing chemistry in High Output mode (paired end 2 x 100bp read length).

Differential Expression Analysis and Functional Annotation

The generated clean reads were aligned to perennial ryegrass genome assembled by Byrne et al. (Bryne 2015) using Tophat software. Gene expression levels were identified by calculating reads per kilobase of transcript per million mapped reads (RPKM) values. Differentially expressed genes (DEGs) were defined as genes having a false discovery rate (FDR) $\leq$ 0.05 and an absolute $\log_2$ fold change value $\geq$1.

RESULTS

Dwarfism and Shade Tolerance Analysis of *shadow*-1 Mutant Plants

shadow-1 plants kept under full sunlight exhibited dwarfism, categorized by reduced canopy heights compared to wild type (Figure 1a). Following shade treatment, *shadow*-1 plants were found to be more tolerant to shade compared to wild type, as evidenced by a significant reduction in leaf elongation and the retention of healthy, green appearance (Figure 1b). These results are consistent with previously reported analysis of the *shadow*-1 mutant line.

Differentially-Expressed Genes (DEGs) in the GA Biosynthesis Pathway

We sequenced three replicates for each genetic background under each treatment. Transcriptome data were subject to four types of pairwise comparisons (WT-S/WT-L, *S1*-S/ *S1*-L, *S1*-L/WT-L, and *S1*-L/WT-L). WT-S/WT-L and *S1*-S/ *S1*-L showed differentially expressed genes (DEGs) identified by comparisons between shade treatment and full-light in wild-type or *shadow*-1 plants, respectively. *S1*-L/WT-L and *S1*-S/WT-S showed DEGs derived from comparisons between *shadow*-1 and wild-type plants under full-light and shade treatment, respectively

Previously, we have found that the dwarfism and shade tolerance displayed in *shadow*-1 might be due to defects in GA pathway (Li et al., 2016). To uncover any potential differential gene expression within the GA biosynthesis pathway, we used sequence for the GA biosynthesis proteins from bread wheat (*Triticum aestivum*, a close relative of perennial ryegrass) in which GA biosynthesis genes are better categorized than in perennial ryegrass, and blasted them against the translated perennial ryegrass reference genome sequence. GA biosynthesis begins as an offshoot of the diterpenoid biosynthesis. Upstream GA biosynthesis begins with the successive editing of diterponoid products by the enzymes ent-copalyl diphosphate synthase (*CPS*), which was down-regulated 1.2x in *S1*-L/WT-L and 1.4x in *S1*-S/WT-S, followed by ent-kaurene synthase (KS), which was down-regulated 4.2x in *S1*-L/WT-L and 4.7x in *S1*-S/WT-S. The next steps of GA biosynthesis are goverened by ent-kaurene oxidase (*KO*), which was down-regulated 1.5x in *S1*-L/WT-L and 1.6x in *S1*-S/WT-S, followed ent-kaurenoic acid oxidase (*KAO*), which was down-regulated 1.6x in *S1*-L/WT-L and 1.9x in *S1*-S/WT-S. At this point, the GA biosynthesis splits into two pathways, one for GA_1 and another for GA_4, each of which are catalyzed by gibberellin 20 oxidase (*GA20ox*) followed by gibberellin 3 oxidase (*GA3ox*) (Figure 2). *GA20ox* was down-regulated 2.7x in *S1*-L/WT-L and 28.3x in *S1*-S/WT-S. We were unable to uncover putative homologs of *GA3ox*, as it has yet to be identified in bread wheat. These expression data demonstrate that all putative GA biosynthesis genes were down-regulated in *shadow*-1 plants compared to wild type for both *S1*-L/WT-L and *S1*-S/WT-S.

In wild-type plants, GA levels are known to increase following exposure to shade stress, which was reflected in the up-regulation of *KO*, *KAO*, and *GA20ox* in wild-type following shade treatment. However, we identified a reduction in expression of both *CPS* and *KS* in wild-type plants treated with shade compared to wild-type kept under full sunlight (Figure 2). While these genes are a part of the GA-biosynthesis pathway, their activity is not unique to GA biosynthesis, therefore their down-regulation in shade-treated plants could be due to factors outside of the context of GA biosynthesis. The expression levels of GA biosynthesis genes varied wildly, with some, like KO, showing expression levels above 2000, and others, such as *GA20ox*, showing expression levels that never surpassed 100 (Figure 2). However, the expression of all of the GA biosynthesis genes identified in this study were lower in *shadow*-1 mutant plants compared to wild type for either treatment (full-sunlight or shade). These results suggest that there is a global degrease in GA biosynthesis within *shadow*-1 plants. This, combined with the results of previous publications, which demonstrate a direct link between decreased GA signaling and both dwarfism and shade tolerance, demonstrate that the reduced GA biosynthesis within *shadow*-1 plants is likely to play a role in the both the dwarf and shade tolerant phenotypes exhibited by these plants.

DISCUSSION

In this study, we used the Illumina HiSeq platform to explore the differential gene expression of *shadow*-1 mutant perennial ryegrass under shade stress to uncover the molecular mechanisms behind the shade tolerance exhibited by these plants. We found that all GA biosynthesis genes, with the exception of gibberellin 3 oxidase (*GA3ox*) which could not be identified through BLAST, were down-regulated in *shadow*-1 mutant plants compared to wild type regardless of light treatment.

There were a number of interesting results generated in this study. The fact that there was a greater difference in gene expression between plants of the same genotype (*shadow*-1 or wild type) under different treatments (full-sunlight vs shade) than there was between plants of different genotypes under the same treatment suggests that the impact of mutagenesis was relatively small, compared to the impact of shade stress, for *shadow*-1 plants. Gamma radiation is known to have a dramatic impact on genomes, causing large deletions or rearrangements of DNA. This finding demonstrates the large-scale impact that shade stress has on plants, leading to substantially more differential gene expression than the impact of severe mutagenesis. This implies a great deal of complexity in the physiological responses perennial ryegrass to reduced light conditions, with broad-spectrum changes in gene expression implicating the participation of myriad gene pathways, even those outside of the umbrella of gibberellin signaling.

The fact that there was a universal decrease in the expression of GA biosynthesis genes in *shadow*-1 mutant plants, under both full sunlight and shade conditions, strongly suggests that gibberellin signaling plays an important role for both dwarfism and shade tolerance in these plants. These results are not surprising, considering previous reports that both dwarfism and shade tolerance in *shadow*-1 plants can be abolished through exogenous application of gibberellic acid (GA_3) (Li et al., 2016). Interruption of GA biosynthesis, through the application of trinexapac-ethyl (TE), in wild type plants can lead to dwarfism and shade tolerance in these plants. TE blocks GA biosynthesis by disrupting the latter stages of GA biosynthesis, which has now been shown to be down-regulated in *shadow*-1 plants.

The *shadow*-1 mutant line has a great deal of utility as a model plant for the study of molecular mechanisms leading to dwarfism and shade tolerance in plants. Both of these traits have utility for plant scientists and breeders in a number of fields, ranging from agriculture and horticulture to ornamental plant use. Dwarf plants have been shown to have increased crop yields in some cases, and could have reduced requirements for nutrients. Shade tolerant plants are able to thrive in environments that are traditionally unconducive to healthy plant growth, such as under tree canopies or in dense urban areas. Our transcriptome analysis uncovered a possible genetic mechanism behind both the dwarfism and shade tolerance displayed by *shadow*-1 mutant plants in the form of down-regulation across the GA biosynthesis pathway. This information could be valuable to plant geneticists and breeders who are interested in developing new cultivars that have either, or both, of these traits.

REFERENCES

Colebrook, E.H., Thomas, S.G., Phillips, A.L. and Hedden, P., 2014. The role of gibberellin signalling in plant responses to abiotic stress. *Journal of Experimental Biology*, 217(1), pp.67-75.

Franklin, K.A. and Whitelam, G.C., 2005. Phytochromes and shade-avoidance responses in plants. *Annals of Botany*, 96(2), pp.169-175.

Li, W. and Katin-Grazzini, L., Krishnan, S., Thammina, C., El-Tanbouly, R., Yer, H., Merewitz, E., Guillard, K., Inguagiato, J., McAvoy, R.J. and Liu, Z., 2016. A novel two-step method for screening shade tolerant mutant plants via dwarfism. *Frontiers in Plant Science*, 7.

Stier, J.C., 1999. *Growing grass in shade*. Cooperative Extension, University of Wisconsin--Extension.

Toledo-Ortiz, G., Huq, E. and Rodríguez-Concepción, M., 2010. Direct regulation of phytoene synthase gene expression and carotenoid biosynthesis by phytochrome-interacting factors. *Proceedings of the National Academy of Sciences*, 107(25), pp.11626-11631.

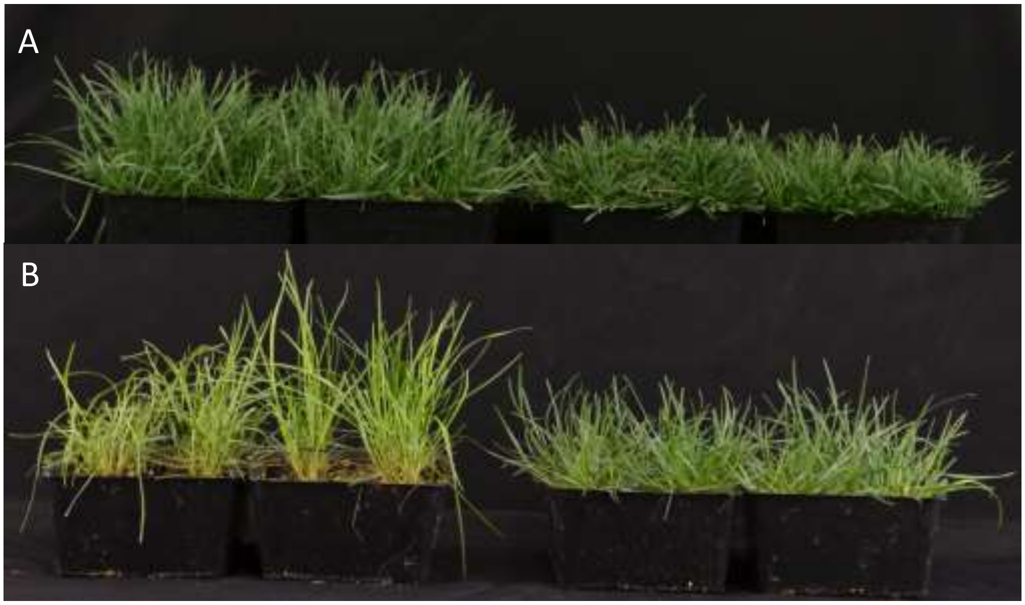


Figure 1: *shadow-1* plants exhibit a dual phenotype of dwarfism and shade tolerance. (A) Wild type (left) and *shadow-1* plants (right) after two weeks under 95% artificial shade (~600 lux) in the greenhouse. (B) Wild type (left) and *shadow-1* plants grown in the greenhouse under full sunlight (~12,000 lux).

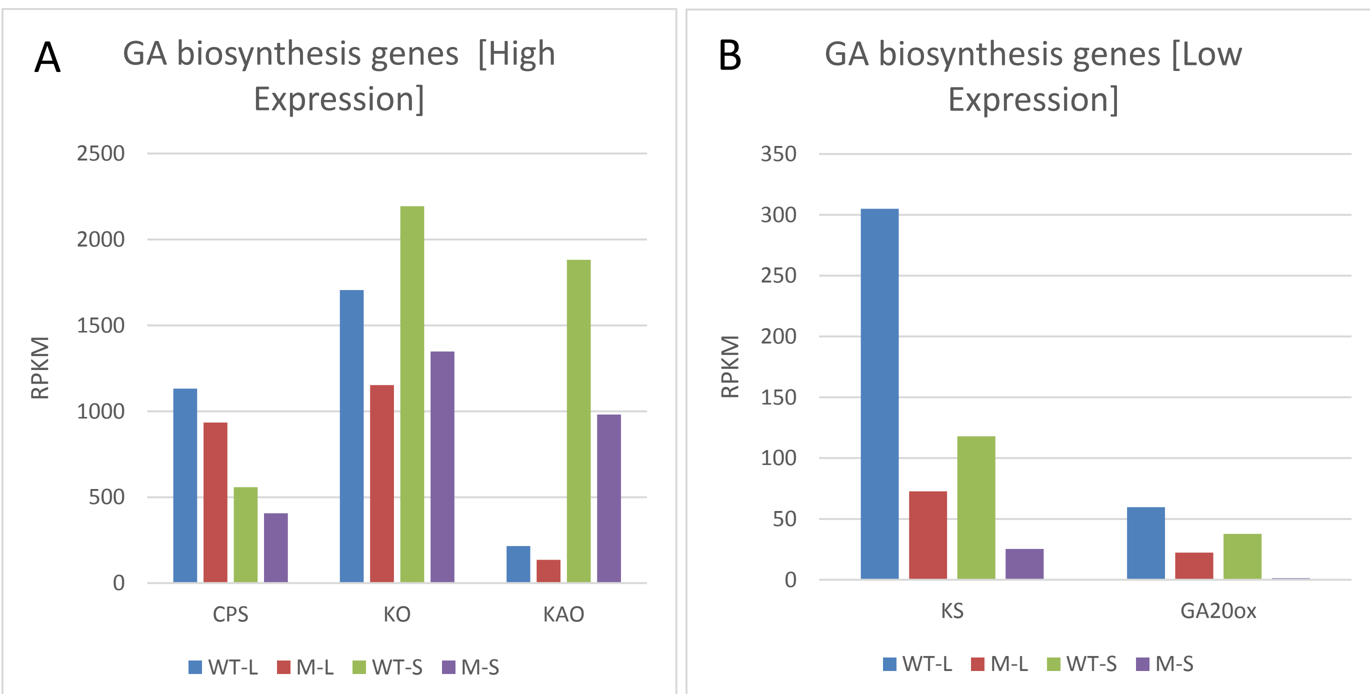


Figure 2: GA biosynthesis genes were downregulated in *shadow-1*. Expression data is split into two graphs for ease of viewing. (A) High expression (~1000 reads). (B) Low expression (~100 reads). Bars represent the expression data (# of mapped reads) for GA biosynthesis genes averages across three replicates. M-L = mutant *shadow-1* plants kept under full sunlight, M-S = mutant *shadow-1* plants treated with 95% shade, WT-L = wild type plants kept under full sunlight, WT-S = wild type plants treated with 95% shade. *CPS* = ent-copalyl diphosphate synthase, *KS* = ent-kaurene synthase, *KO* = ent-kaurene oxidase, *KAO* = ent-kaurenoic acid oxidase.

CAN FREQUENT MEASUREMENT OF NORMALIZED DIFFERENCE VEGETATIVE INDEX AND SOIL NITRATE GUIDE NITROGEN FERTILIZATION OF KENTUCKY BLUEGRASS SOD?

Guillard, K., R.J.M. Fitzpatrick, and H. Burdett. 2016. Can frequent measurement of NDVI and soil nitrate guide nitrogen fertilization of Kentucky bluegrass sod? Crop Sci. 56: 827–836. doi:10.2135/cropsci2015.06.0347

ABSTRACT

Objective approaches to guide N fertilization of turfgrass sod crops are lacking. This study was conducted to determine the relationships among Normalized Difference Vegetative Index (NDVI), frequently-measured soil nitrate (NO_3)-N concentrations, and peak-shear force of predominately Kentucky bluegrass (*Poa pratensis* L) sod, and to evaluate if those relationships could help guide N fertilization. Ramp calibration strips with varying N rates were established within production sod fields in Rhode Island across three consecutive years. At 2-wk intervals during each growing season, soil NO_3-N concentrations and NDVI readings were recorded and correlated. Biweekly relative NDVI readings plateaued when soil NO_3-N concentrations ranged between 5 and 12 mg kg^{-1}. Mean relative NDVI plateaued at 196 kg N ha^{-1} yr^{-1}. Relative sod peak-shear force was negatively correlated to soil NO_3-N concentrations and the total amount of N applied per yr. Relative peak-shear force was maximized when mean relative NDVI readings ranged from 0.969 to 0.982, but declined as mean relative NDVI increased towards 1.0. The results suggest that frequently measured NDVI and soil NO_3-N concentrations show promise as guides for N fertilization of predominately Kentucky bluegrass sod. Further research will be required to validate these approaches on larger-scale sod fields.

EFFECT OF PLANT GROWTH-PROMOTING *BACILLUS* SP. ON COLOR AND CLIPPING YIELD OF THREE TURFGRASS SPECIES

Açikgöz, E., U. Bilgili, F. Sahin, and K. Guillard. 2016. Effect of plant growth-promoting *Bacillus* sp. on color and clipping yield of three turfgrass species. J. Plant Nutr. 39:10, 1404–1411.
doi:10.1080/01904167.2016.1143501

ABSTRACT

A two-year irrigated field study was conducted to determine the effects of plant growth-promoting rhizobacteria (PGPR; *Bacillus subtilis* OSU-142 and *Bacillus megaterium* M3) as biofertilizer, and in combination with a chemical nitrogen (N) fertilizer, on turf color and clipping yield, and interaction of biofertilizer and chemical N fertilizers in perennial ryegrass (*Lolium perenne* L.), tall fescue (*Festuca arundinacea* L. Schreb.), and Kentucky bluegrass (*Poa pratensis* L.). The three turf species were tested separately in split-plot design experiments with three replications. Three fertilizer sources (ammonium nitrate only, ammonium nitrate + *B. megaterium* M3, and ammonium nitrate + *B. subtilis* OSU-142) were the main plots. N applications with monthly applications of 0.0, 2.5, 5.0, and 7.5 g N/m2 were the subplots. Color ratings and clipping yields increased with increasing chemical N fertilizers in all species. Both *Bacillus* sp. significantly increased color ratings and clipping yields in perennial ryegrass and tall fescue. However, there were no significant differences among the three fertilizer sources in color and clipping yield of Kentucky bluegrass. The experiments showed that there is a small but significant benefit from applying biofertilizers for turf color, and that N fertilization may be reduced in some turf species when biofertilization are made for this purpose.

DIGITALLY QUANTIFYING SAND PARTICLE SHAPE AND PARTICLE SIZE DISTRIBUTION: RESULTANT EFFECTS ON ROOT ZONE BEARING CAPACITY

Maxey, G., J. Henderson, J. C. Inguagiato, and D. Basu. 2016. Digitally quantifying sand particle shape and particle size distribution: Resultant effects on root zone bearing capacity. Agron. Abr. p. 102813.

ABSTRACT

The overall objective of this research was to improve sand selection for constructing and maintaining putting greens and athletic fields by more accurately predicting the bearing capacity of sand textured root zone materials. The specific objectives were to: characterize particle size distribution and shape of sands currently used to construct root zones utilizing a novel dynamic digital image analysis technique; quantify performance criteria and bearing capacity of current root zone materials; and utilize a stepwise regression analysis to select the most influential variables that contribute to the California Bearing Ratio and develop a model to predict its value. Fifty three sands were characterized by mechanical sieve analyses and their performance criteria (bulk density, hydraulic conductivity, total porosity, aeration porosity, capillary porosity) were measured. A dynamic, digital imaging machine was used to quantify particle sphericity, symmetry, and aspect ratio. The California Bearing Ratio (CBR) was measured for each sample following vibratory compaction in the laboratory. A stepwise regression analysis indicated that a total six variables significantly contributed to predicting the CBR value (R^2=0.7517). These variables were coefficient of uniformity (Camsizer), coefficient of uniformity (mechanical sieve), sphericity, sand content, coefficient of variation, and percent retained on the 0.15mm screen.

FOLIAR N CONCENTRATION AND REFLECTANCE METERS TO GUIDE N FERTILIZATION FOR ANTHRACNOSE MANAGEMENT OF ANNUAL BLUEGRASS PUTTING GREEN TURF

Inguagiato, J.C. and K. Guillard. 2016. Foliar N Concentration and Reflectance Meters to Guide N Fertilization for Anthracnose Management of Annual Bluegrass Putting Green Turf. Crop Sci. 56: 3328–3337. doi:10.2135/cropsci2015.12.0765

ABSTRACT

Site-specific management using objective assays to determine N requirement based on canopy reflectance could improve current recommendations for cultural control of anthracnose (*Colletotrichum cereale* Manns sensu lato Crouch, Clarke, and Hillman). The objectives of this study were to determine the relationships among foliar sap nitrate–nitrogen (NO_3–N) concentrations, canopy reflectance indices (normalized difference vegetation index [NDVI] and chlorophyll index [CI]), foliar total N concentrations, and N rate on anthracnose severity in annual bluegrass (ABG), *Poa annua* L. f. *reptans* (Hausskn) T. Koyama. A 2-yr field study was conducted on ABG putting green turf in Storrs, CT. Nitrogen treatments were applied as urea at 0.0 to 36.8 kg ha^{-1} every 14 d in spring and summer of 2011 to 2012. Anthracnose severity declined linearly with increasing biweekly N rate from 0 kg ha^{-1} up to the estimated critical level of 12.8 kg ha^{-1}. A minimum critical foliar N concentration of 33.5 g kg^{-1} maintained anthracnose at ≤32% plot area. Canopy reflectance indices were correlated with foliar N concentration. Anthracnose severity decreased linearly as relative NDVI and relative CI increased. Maintaining relative NDVI between 0.94 to 0.98 through N fertility alone would provide a ∼76 to 93% probability of maintaining ≤32% turf area infested, or relative CI range of 0.73 to 0.93 had the same result ∼40 to 98% of the time.

INFLUENCE OF SIMULATED RAINFALL ON EFFICACY OF FLUAZINAM, CHLOROTHALONIL AND IPRODIONE FOR DOLLAR SPOT CONTROL IN CREEPING BENTGRASS

Inguagiato, J.C. and K.M. Miele. 2016. Influence of simulated rainfall on efficacy of fluazinam, chlorothalonil and iprodione for dollar spot control in creeping bentgrass. Crop Protection. 83: 48–55.
doi.org/10.1016/j.cropro.2016.01.017

ABSTRACT

Efficacy of foliar applied fungicides following simulated rainfall for the control of dollar spot (caused by *Sclerotinia homoeocarpa* F.T. Bennett) was assessed in a two-year field study on creeping bentgrass (*Agrostis stolonifera* L.) turf maintained as a golf course fairway. The study was conducted as a randomized complete block design with a factorial arrangement. Fluazinam (0.8 kg a.i. ha^{-1}), chlorothalonil (3.79 kg a.i. ha^{-1}) or iprodione (1.5 kg a.i. ha^{-1}) were applied, then subjected to simulated rainfall (2.54-mm) at intervals of 15-, 30-, 60-min post-application, or no simulated rain. In most cases, simulated rainfall occurring ≤60 min post-application had greater disease than no rain plots; however, few differences occurred among rainfall intervals ≤60 min. Fluazinam provided the greatest dollar spot reduction regardless of simulated rainfall interval throughout the study. Chlorothalonil was most susceptible to losses in efficacy due to simulated rainfall, resulting in the greatest disease incidence of those fungicides evaluated. Iprodione was comparable to chlorothalonil during high disease pressure, although during moderate disease pressure it controlled dollar spot for approximately 7 days before disease increased in plots receiving simulated rain compared to those without simulated rain. These data demonstrate that efficacy of fungicides applied for dollar spot control are affected by rain, and differ in their ability to control disease following post-application rain events. Fluazinam, a recently introduced contact fungicide for use on turfgrass, can provide improved control compared to chlorothalonil or iprodione when rain is eminent.

EFFECT OF PHOSPHITE RATE AND SOURCE ON CYANOBACTERIA COLONIZATION OF PUTTING GREEN TURF

Inguagiato, J.C., J.E. Kaminski, and T.T. Lulis. 2016. Effect of Phosphite Rate and Source on Cyanobacteria Colonization of Putting Green Turf. Crop Sci.
https://dl.sciencesocieties.org/publications/cs/articles/0/0/cropsci2016.06.0469 accessed 2 Mar. 2017
doi:10.2135/cropsci2016.06.0469

ABSTRACT

Cyanobacteria compete with putting green turf, resulting in algal surface crusts that can reduce turf density and quality. The objectives of this study were to assess preventive control of surface cyanobacteria colonization of putting green turf with various phosphite salt sources and formulations. An optimal rate of phosphorous acid to suppress cyanobacteria while minimizing phytotoxicity was also examined. Two field studies were conducted concurrently on an 'L-93' creeping bentgrass (*Agrostis stolonifera* L.) putting green in Storrs, CT, during 2010 and 2011. Study 1 assessed various commercial formulations and sources of phosphite salts, potassium phosphate, and non-phosphonate fungicides on percent plot area infested by algae. Study 2 identified rates of phosphorous or phosphoric acid applied as commercial formulations of potassium phosphite or technical preparations of potassium phosphite and phosphate, which reduce or enhance algae development and turf quality. Potassium phosphite reduced percent plot area infested by 90 to 100% and 52 to 86% compared with potassium phosphate in study 1 during 2010 and 2011, respectively. Few differences in plot area infested were observed among six commercial phosphite formulations and sources or non-phosphonate fungicides throughout study 1. Area under the algae development curve decreased by 52 to 78% as phosphorous acid increased from 2.9 to 5.4 or 8.1 kg ha^{-1} throughout the 2-yr study. Turf quality was reduced in phosphorous acid-treated plots at rates greater than 10.8 kg ha^{-1}. Phosphite products applied at 5.4 to 8.1 kg ha^{-1} every 14 d can be used to suppress cyanobacteria with reduced risk of phytotoxicity for putting green turf.

DOLLAR SPOT CONTROL USING BIOFUNGICIDES AND CONVENTIONAL FUNGICIDES APPLIED BASED ON THE SMITH-KERNS DOLLAR SPOT MODEL IN CREEPING BENTGRASS FAIRWAY TURF

Inguagiato, J.C. and K.M. Miele. 2016. Dollar spot control using biofungicides and conventional fungicides applied based on the Smith-Kerns dollar spot model in creeping bentgrass fairway turf. Presentation 102709 Poster 335-1210. *In* ASA-CSSA-SSSA Abstracts, Madison, WI.
https://scisoc.confex.com/scisoc/2016am/webprogram/Paper102709.html

ABSTRACT

Integrated pest management principles typically include use of action thresholds, although thresholds are infrequently utilized for turfgrass diseases due to our inability to preventively identify biological indicators of disease. Biofungicides applied for dollar spot control have provided inconsistent results, particularly applied alone. However, integration of biofungicides with conventional fungicides applied based on model thresholds may enhance disease control and minimize applications of conventional fungicides. The objectives of this study were to determine whether fungicides applied based on the Smith-Kerns dollar spot model could provide comparable disease control as conventional 21-d fungicide timings, and whether biofungicides could help improve disease control of fungicides applied at high risk forecast model thresholds on creeping bentgrass fairway turf throughout the season. Treatments were arranged in a 4 × 4 factorial with main effect factors being fungicide application interval and biofungicide. Fungicide application intervals consisted of Smith-Kerns dollar spot forecast model risk action thresholds of 30% (high risk) or 20% (moderate risk), 21-d calendar based, or a non-fungicide treated control. Biofungicides evaluated included TurfShield Plus, Companion, Rhapsody and a non-biofungicide control. Conventional fungicide application intervals initiated for 21-d calendar-based fungicide treatment and 20% risk action threshold treatments on 14 May, and 30% risk action threshold on 1 June. Model-based treatments were reapplied when specified risk thresholds were reached; although re-applications were withheld for 21-d following fungicide application regardless of model forecast.

INFLUENCE OF PLANT GROWTH REGULATORS ON WINTER HARDINESS OF ANNUAL BLUEGRASS PUTTING GREEN TURF

Bernstein, R. K.M. Miele, J.C. Inguagiato, M. DaCosta, and J.S. Ebdon. 2016. Influence of plant growth regulators on winter hardiness of annual bluegrass putting green turf. Presentation 102645 Poster 167-1625. *In* ASA-CSSA-SSSA Abstracts, Madison, WI.
https://scisoc.confex.com/scisoc/2016am/webprogram/Paper102645.html

ABSTRACT

Low temperature injury and winterkill are major limitations in the management of annual bluegrass on putting greens and fairways in New England. The objectives of this research were to (i) conduct a field experiment to examine the responses of different fall application rates of trinexapac-ethyl (TE) and prohexadione-calcium (PC) on freezing tolerance of annual bluegrass through winter and early spring months; and (ii) conduct a controlled environment experiment to examine the effects of TE, PC, and abscisic acid (ABA) on freezing tolerance of annual bluegrass. In the controlled environment experiment, plants were subjected to cold acclimation at -2°C for 2 weeks, and then placed at 8°C to induce deacclimation. After 1 d at 8°C, chemical treatments were applied and plants were evaluated for their freezing tolerance (lethal temperature resulting in 50% mortality, LT50) at 3 d deacclimation. Overall, untreated or plants sprayed with TE exhibited the highest freezing tolerance compared to other treatments. For field experiments, monthly freezing tolerance assessments of annual bluegrass from December through March will be reported.

A NOVEL TWO-STEP METHOD FOR SCREENING SHADE TOLERANT MUTANT PLANTS VIA DWARFISM

Li, W., L. Katin-Grazzini, S. Krishnan, C. Thammina, R. El -Tanbouly, H. Yer, E. Merewitz, K. Guillard, J. Inguagiato., R.J. McAvoy, Z. Liu., and Y. Li. 2016. A novel two-step method for screening shade tolerant mutant plants via dwarfism. Front. Plant Sci. 7:1495. doi:10.3389/fpls.2016.01495

ABSTRACT

When subjected to shade, plants undergo rapid shoot elongation, which often makes them more prone to disease and mechanical damage. Shade-tolerant plants can be difficult to breed; however, they offer a substantial benefit over other varieties in low-light areas. Although perennial ryegrass (*Lolium perenne* L.) is a popular species of turf grasses because of their good appearance and fast establishment, the plant normally does not perform well under shade conditions. It has been reported that, in turfgrass, induced dwarfism can enhance shade tolerance. Here we describe a two-step procedure for isolating shade tolerant mutants of perennial ryegrass by first screening for dominant dwarf mutants, and then screening dwarf plants for shade tolerance. The two-step screening process to isolate shade tolerant mutants can be done efficiently with limited space at early seedling stages, which enables quick and efficient isolation of shade tolerant mutants, and thus facilitates development of shade tolerant new cultivars of turfgrasses. Using the method, we isolated 136 dwarf mutants from 300,000 mutagenized seeds, with 65 being shade tolerant (0.022%). When screened directly for shade tolerance, we recovered only four mutants from a population of 150,000 (0.003%) mutagenized seeds. One shade tolerant mutant, *shadow-1*, was characterized in detail. In addition to dwarfism, *shadow-1* and its sexual progeny displayed high degrees of tolerance to both natural and artificial shade. We showed that endogenous gibberellin (GA) content in *shadow-1* was higher than wild-type controls, and *shadow-1* was also partially GA insensitive. Our novel, simple and effective two-step screening method should be applicable to breeding shade tolerant cultivars of turfgrasses, ground covers, and other economically important crop plants that can be used under canopies of existing vegetation to increase productivity per unit area of land.

ISOLATION OF PROSTRATE TURFGRASS MUTANTS VIA SCREENING OF DWARF PHENOTYPE AND CHARACTERIZATION OF A PERENNIAL RYEGRASS PROSTRATE MUTANT

Chen, J., C. Thammina, W. Li, H Yu, H. Yer, R. El-Tanbouly, M. Marron, L. Katin-Grazzini, Y. Chen, J. Inguagiato, R.J. McAvoy, K. Guillard, X. Zhang and Y. Li. 2016. Isolation of prostrate turfgrass mutants via screening of dwarf phenotype and characterization of a perennial ryegrass prostrate mutant. Hort. Res. 3:16003; doi:10.1038/hortres.2016.3

ABSTRACT

Prostrate turf varieties are desirable because of their increased low mowing tolerance, heat resistance, traffic resistance and ground coverage compared with upright varieties. Mutation breeding may provide a powerful tool to create prostrate varieties, but there are no simple, straightforward methods to screen for such mutants. Elucidation of the molecular basis of the major 'green revolution' traits, dwarfism and semi-dwarfism, guided us to design a simple strategy for isolating dwarf mutants of perennial ryegrass (*Lolium perenne* L.). We have shown that gamma-ray-mediated dominant dwarf mutants can be easily screened for at the three-leaf stage. About 10% of dwarf mutant lines also displayed a prostrate phenotype at mature stages (> 10 tillers). One prostrate line, Lowboy I, has been characterized in detail. Lowboy I had significantly shorter canopy, leaf blade and internode lengths compared with wild type. Lowboy I also exhibited greater tolerance to low mowing stress than wild type. Exogenous gibberellic acid (GA) restored Lowboy I to a wild-type phenotype, indicating that the dwarf and prostrate phenotypes were both due to GA deficiency. We further showed that phenotypes of Lowboy I were dominant and stably inherited through sexual reproduction. Prostrate turfgrass mutants are difficult to screen for because the phenotype is not observed at young seedling stages, therefore our method represents a simple strategy for easily isolating prostrate mutants. Furthermore, Lowboy I may provide an outstanding germplasm for breeding novel prostrate perennial ryegrass cultivars.

TURF MANAGER RESPONSE TO CHANGING PESTICIDE REGULATIONS

Wallace, V., C. Bartholomew, and J.H. Campbell. 2016. Turf manager response to changing pesticide regulations. HortScience. 51:394-397.

ABSTRACT

A mail survey was distributed to school turfgrass managers throughout Connecticut focusing on the differences between turfgrass management practices for kindergarten through eighth-grade (K-8) school grounds before, during, and after a 2010 ban on pesticide use at these facilities. The results indicate that as turf care protocol transitioned from an integrated pest management (IPM) program to new pesticide-free regulatory requirements, school grounds/athletic field managers did not significantly adjust their management programs. The percentage of managers applying pesticides on K-8 grounds decreased, as expected, with the implementation of the new pesticide ban; however, pesticide applications on high school grounds/athletic fields also decreased. Furthermore, it was observed that there had been minimal adoption of minimum risk 25(b) products, the suggested alternative to traditional synthetic pesticides. With respect to other cultural practices, we found that few changes have been made to other cultural practices that would improve turf quality. Budgetary issues facing school grounds/athletic field managers may have limited their ability to implement potentially costly management practices necessary to offset the loss of pesticides. Educational efforts to promote new management practices have the potential to inform school grounds/athletic field managers about new methods, thereby, potentially increasing adoption.