PENNSTATE

2007
Turfgrass Research Report

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Pennsylvania Turfgrass Council

TABLE OF CONTENTS

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Creeping Bentgrass Conversion to Perennial Ryegrass using A12738

J. A. Borger and M. B. Naedel[1]

Introduction

Phytotoxicity and control evaluations were conducted on a stand of mature 'Penn-Eagle' creeping bentgrass (*Agrostis stolonifera*). On a separate site, the percent cover of newly seeded 'Amazing GS' perennial ryegrass (*Lolium perenne*, L.) was evaluated. Both of these studies were conducted at the Valentine Turfgrass Research Center, Penn State University, University Park, Pa and received the same rates and application schedule of the test materials. The overall objective of these studies was to determine the phytotoxicity/control of the creeping bentgrass and the reestablishment of perennial ryegrass.

Methods and Materials

The studies were a randomized complete block design with three replications. Treatments were applied on June 29 (4 WBS), July 12 (2 WBS), July 26 (SEED), August 24 (3 WAS), and September 6 (5 WAS), 2007 using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using one, flat fan, 11004E nozzle at 40 psi.

The creeping bentgrass site was mowed at one half of an inch with a five-plex fairway mower with clippings collected and maintained similar to a golf course fairway with respect to irrigation, fertility, and mowing. The perennial ryegrass seedbed site had Glyphosate applied, prior to the application of test materials, at a rate of 3 qts/A on June 6, 2007 and was seeded July 26, 2007. Perennial ryegrass germination was first noted on the test site September 1, 2007. Once established, the new turf was mowed once weekly at 2 inches with a rotary mower with clipping returned to the site.

Results and Discussion

Creeping bentgrass phytotoxicity was evaluated seven times during the study (Table 1). All treated turfgrass revealed some level of phytotoxicity during the study. On the final rating date, September 18th, no phytotoxicity was found.

Creeping bentgrass control was evaluated seven times during the study (Table 2). All treated turfgrass revealed some level of control during the study. On the final rating date, September 18th, all treated turfgrass had significantly less creeping bentgrass than non treated turfgrass. Turfgrass treated with A12738 with X-77, at the 2 WBS/SEED/3 WAS timing had significantly more creeping bentgrass than all other treated turfgrass.

Perennial ryegrass cover was evaluated four times during the study (Table 3). All treated turfgrass revealed some level of perennial ryegrass growth during the study. On the final rating date, September 19th, the A12738 with X-77, at the 2 WBS/SEED/3 WAS timing and 4/2 WBS/SEED/3 WAS timing had significantly less perennial ryegrass cover than non treated turfgrass.

Finally, it was noted that there was a differential germination of annual bluegrass in the perennial ryegrass test site. The percent cover of annual bluegrass was rated on September 25th. All treated turfgrass had significantly less annual bluegrass cover when compared to non treated turfgrass.

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Table 1. Evaluations of creeping bentgrass phytotoxicity where 0 = worst, 7 = acceptable, and 10 = no phytotoxicity taken in 2007.

Treatment	Form	Rate	Timing	Phytotoxicity						
		oz ai/A		7/11	7/18	7/26	8/8	8/22	9/5	9/18
A12738	4SC	2	2 WBS/SEED/3 WAS	10.0	5.0	4.7	5.0	10.0	5.7	10.0
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS							
A12738	4SC	2.5	2 WBS/SEED/3 WAS	10.0	5.0	4.0	4.7	10.0	5.8	10.0
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS							
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0
A12738	4SC	2	2 WBS/SEED/3/5 WAS	10.0	5.0	4.7	5.3	10.0	6.2	10.0
X-77	L	0.25 %v/v	2 WBS/SEED/3/5 WAS							
A12738	4SC	2	4/2 WBS/SEED/3 WAS	3.0	1.3	3.8	10.0	10.0	10.0	10.0
X-77	L	0.25 %v/v	4/2 WBS/SEED/3 WAS							

Table 2. Evaluations of the percent control of creeping bentgrass in 2007.

Treatment	Form	Rate	Timing	% Control [1]						
		oz ai/A		7/11	7/18	7/26	8/8	8/22	9/5	9/18
A12738	4SC	2	2 WBS/SEED/3 WAS	0.0a	0.0b	0.0b	33.3b	43.3b	55.0b	61.7b
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS							
A12738	4SC	2.5	2 WBS/SEED/3 WAS	0.0a	0.0b	0.0b	40.0b	66.7ab	71.7ab	81.7a
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS							
CHECK				0.0a	0.0b	0.0b	0.0c	0.0c	0.0c	0.0c
A12738	4SC	2	2 WBS/SEED/3/5 WAS	0.0a	0.0b	0.0b	36.7b	56.7b	66.7b	78.3a
X-77	L	0.25 %v/v	2 WBS/SEED/3/5 WAS							
A12738	4SC	2	4/2 WBS/SEED/3 WAS	0.0a	20.0a	25.0a	80.0a	88.3a	91.7a	95.0a
X-77	L	0.25 %v/v	4/2 WBS/SEED/3 WAS							

1 - Means followed by same letter do not significantly differ (P=0.05, Duncan's New MRT)

Table 3. Evaluations of the percent cover of perennial ryegrass taken in 2007.

Treatment	Form	Rate oz ai/A	Timing	(---% Ryegrass Cover [1]--- 8/8	8/22	9/5	9/19)
A12738	4SC	2	2 WBS/SEED/3 WAS	48.3a	76.7b	83.3a	90.0b
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS				
A12738	4SC	2.5	2 WBS/SEED/3 WAS	53.3a	76.7b	86.3a	93.0ab
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS				
CHECK				65.0a	88.3a	93.3a	97.7a
A12738	4SC	2	2 WBS/SEED/3/5 WAS	55.0a	78.3b	88.0a	94.7ab
X-77	L	0.25 %v/v	2 WBS/SEED/3/5 WAS				
A12738	4SC	2	4/2 WBS/SEED/3 WAS	48.3a	76.7b	86.7a	90.0b
X-77	L	0.25 %v/v	4/2 WBS/SEED/3 WAS				

1 - Means followed by same letter do not significantly differ (P=0.05, Duncan's New MRT)

Table 4. Evaluations of the percent cover of *Poa annua* in the perennial ryegrass seedbed taken in 2007.

Treatment	Form	Rate oz ai/A	Timing	(-----% Poa [1]------) 9/25
A12738	4SC	2	2 WBS/SEED/3 WAS	1.0b
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS	
A12738	4SC	2.5	2 WBS/SEED/3 WAS	1.0b
X-77	L	0.25 %v/v	2 WBS/SEED/3 WAS	
CHECK				46.7a
A12738	4SC	2	2 WBS/SEED/3/5 WAS	1.0b
X-77	L	0.25 %v/v	2 WBS/SEED/3/5 WAS	
A12738	4SC	2	4/2 WBS/SEED/3 WAS	1.0b
X-77	L	0.25 %v/v	4/2 WBS/SEED/3 WAS	

1 - Means followed by same letter do not significantly differ (P=0.05, Duncan's New MRT)

Seedhead Suppression of Annual Bluegrass on a Putting Green

J. A. Borger and M. B. Naedel[1]

Introduction

This study was conducted on a mixed stand of 'Penncross' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) at the Penn State Blue Golf Course in State College, PA. The objective of the study was to evaluate selected growth regulators, with and without adjuvants, for the seedhead suppression of annual bluegrass.

Methods and Materials

This study was a randomized complete block design with three replications, and a plot size of 21 ft^2. Treatments were applied on April 3 (GU), April 21 (BT), and May 15 (3 WAT), 2007, respectively, using a three-foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using one 11004E even tip/flat fan nozzle at 40 psi.

Boot stage of the annual bluegrass was observed April 27, 2007.

The site was maintained using cultural practices for irrigation, mowing, and fertilization that would be typical for a putting green. The test area was mowed three times with a Toro Triplex with an eleven blade reel, bench set to 0.115", before the April 3, 2007 application of selected materials. Prior to the initiation of the study, the site was fertilized with a Nature Safe 8-3-5 fertilizer at a rate of 1 lb N/M in February and again with Anderson's Contec DG 18-9-18 at a rate of 1lb N/M on May 10, 2007.

Results and Discussion

Turfgrass phytotoxicity was rated seven times during the study (Table 1). Unacceptable phytotoxicity was only found on the May 8th, 2007 rating date. This unacceptable phytotoxicity was a result of applications of: Embark T&O at 40 oz/A alone or combined with Ferromec, Embark T&O at 40 oz/A plus Eco-N, Primo MAXX plus Embark T&O at 40 oz/A plus Eco-N, and Proxy plus Embark T&O at 30 oz/A plus Ferromec.

Annual bluegrass seedhead suppression was rated twice during the study (Table 2). On the final rating date, June 1st, 2007, all treated turfgrass had significantly more seedhead suppression than non treated turfgrass. On this date, turfgrass treated with Embark T&O at 40 oz/A plus Ferromec plus Eco-N, Embark T&O at 30 oz/A plus Primo MAXX plus Eco-N with or with out Ferromec, Embark T&O at 40 oz/A plus Primo MAXX plus Eco-N plus Ferromec had significantly less annual bluegrass seedhead suppression than all other treated turfgrass. It should be noted that the test site had relatively "light seedhead production" during the 2007 season. In 2007 the untreated turfgrass only had about 35% coverage of annual bluegrass seedheads in contrast to prior years when the site had 90% or more coverage in non treated areas. The relatively "light pressure" of 2007 may have lead to the increase of suppression that had not previously been observed.

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Table 1. Ratings of phytotoxicity of an annual bluegrass/creeping bentgrass putting green on a scale of 0 to 10 where 0 = complete phytotoxicity, 7 = acceptable, and 10 = no phytotoxicity in 2007.

				(--------------------Phytotoxicity-----------------)						
Treatment	**Form**	**Rate oz/M**	**Timing**	**4/10**	**4/17**	**4/30**	**5/8**	**5/15**	**5/24**	**6/1**
EMBARK T&O	0.2SL	40 oz/A	BT	10.0	10.0	7.0	6.8	9.0	10.0	10.0
EMBARK T&O	0.2SL	40 oz/A	BT	10.0	10.0	10.0	6.3	9.0	10.0	10.0
FERROMEC	L	5	BT							
EMBARK T&O	0.2SL	40 oz/A	BT	10.0	10.0	9.0	6.5	8.0	10.0	10.0
ECO-N (24-0-0)	2.2L	0.25 lb N/M	BT							
PRIMO MAXX	1MEC	0.125	BT/3 WAT	10.0	10.0	7.3	8.2	8.3	9.3	10.0
PROXY	2SL	5	BT/3 WAT							
PRIMO MAXX	1MEC	0.125	BT/3 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0
PROXY	2SL	5	BT/3 WAT							
ECO-N (24-0-0)	2.2L	0.25 lb N/M	BT/3 WAT							
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	10.0	10.0	10.0	7.2	8.7	10.0	10.0
EMBARK T&O	0.2SL	40oz/A	BT							
FERROMEC	L	5	BT							
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	10.0	10.0	8.7	7.7	9.0	10.0	10.0
PRIMO MAXX	1MEC	0.125	GU							
EMBARK T&O	0.2SL	30 oz/A	BT							
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	10.0	10.0	10.0	9.0	10.0	10.0	10.0
PRIMO MAXX	1MEC	0.125	GU							
EMBARK T&O	0.2SL	30 oz/A	BT							
FERROMEC	L	5	BT							
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	10.0	10.0	9.0	6.2	8.0	10.0	10.0
PRIMO MAXX	1MEC	0.125	GU							
EMBARK T&O	0.2SL	40 oz/A	BT							
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	10.0	10.0	10.0	8.0	10.0	10.0	10.0
PRIMO MAXX	1MEC	0.125	GU							
EMBARK T&O	0.2SL	40 ozA	BT							
FERROMEC	L	5	BT							
PROXY	2SL	5	GU	10.0	10.0	9.7	6.8	9.0	10.0	10.0
EMBARK T&O	0.2SL	30 oz/A	BT							
FERROMEC	L	5	BT							
PROXY	2SL	5	GU/BT/3 WAT	10.0	10.0	7.3	8.3	9.3	9.0	10.0
PRIMO MAXX	1MEC	0.125	BT/3 WAT							
QUALI-PRO T-NEX	1MEC	0.125	BT/3 WAT	10.0	10.0	9.0	9.2	9.0	9.3	10.0
ETHEPHON	2SL	5	BT/3 WAT							
QUALI-PRO T-NEX	1MEC	0.125	BT/3 WAT	10.0	10.0	10.0	10.0	9.7	10.0	10.0
ETHEPHON	2SL	5	BT/3 WAT							
ECO-N (24-0-0)	2.2L	0.25 lb N/M	BT/3 WAT							
ETHEPHON	2SL	5	GU/BT	10.0	10.0	7.0	7.5	7.7	9.7	10.0
QUALI-PRO T-NEX	1MEC	0.125	BT							

Table 2. Ratings of the percent seedhead suppression of an annual bluegrass/creeping bentgrass putting green in 2007.

Treatment	**Form**	**Rate oz/M**	**Timing**	**(-----%Suppression[1]-----) 5/24**	**6/1**
EMBARK T&O	0.2SL	40 oz/A	BT	89.2a	90.6a
EMBARK T&O	0.2SL	40 oz/A	BT	89.2a	86.4a
FERROMEC	L	5	BT		
EMBARK T&O	0.2SL	40 oz/A	BT	79.2ab	85.3a
ECO-N (24-0-0)	2.2L	0.25 lb N/M	BT		
PRIMO MAXX	1MEC	0.125	BT/3 WAT	48.6ab	93.9a
PROXY	2SL	5	BT/3 WAT		
PRIMO MAXX	1MEC	0.125	BT/3 WAT	58.3ab	93.9a
PROXY	2SL	5	BT/3 WAT		
ECO-N (24-0-0)	2.2L	0.25 lb N/M	BT/3 WAT		
CHECK				0.0c	0.0c
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	76.7ab	58.3b
EMBARK T&O	0.2SL	40oz/A	BT		
FERROMEC	L	5	BT		
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	75.3ab	63.9b
PRIMO MAXX	1MEC	0.125	GU		
EMBARK T&O	0.2SL	30 oz/A	BT		
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	55.6ab	65.3b
PRIMO MAXX	1MEC	0.125	GU		
EMBARK T&O	0.2SL	30 oz/A	BT		
FERROMEC	L	5	BT		
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	80.8ab	89.4a
PRIMO MAXX	1MEC	0.125	GU		
EMBARK T&O	0.2SL	40 oz/A	BT		
ECO-N (24-0-0)	2.2L	0.25 lb N/M	GU	51.4ab	56.9b
PRIMO MAXX	1MEC	0.125	GU		
EMBARK T&O	0.2SL	40 ozA	BT		
FERROMEC	L	5	BT		
PROXY	2SL	5	GU	89.2a	90.6a
EMBARK T&O	0.2SL	30 oz/A	BT		
FERROMEC	L	5	BT		
PROXY	2SL	5	GU/BT/3 WAT	62.5ab	93.9a
PRIMO MAXX	1MEC	0.125	BT/3 WAT		
QUALI-PRO T-NEX	1MEC	0.125	BT/3 WAT	47.2ab	93.9a
ETHEPHON	2SL	5	BT/3 WAT		
QUALI-PRO T-NEX	1MEC	0.125	BT/3 WAT	40.3b	97.2a
ETHEPHON	2SL	5	BT/3 WAT		
ECO-N (24-0-0)	2.2L	0.25 lb N/M	BT/3 WAT		
ETHEPHON	2SL	5	GU/BT	75.0ab	92.8a
QUALI-PRO T-NEX	1MEC	0.125	BT		

1 - Means followed by same letter do not significantly differ (P = 0.05 Duncan's New MRT)

Annual Bluegrass Prevention on a Newly Established Putting Green

J. A. Borger, and M. B. Naedel[1]

Introduction

This study was conducted on a mixed stand of 'Penncross' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) at the Valentine Turfgrass Research Center, University Park, PA. The objective of the study was to evaluate selected materials for the suppression of annual bluegrass encroachment into a newly established area maintained similar to a putting green.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on September 4 (FALL), September 16 (14 DAT), October 1, 2003 (28 DAT), August 25 (FALL), September 7 (14 DAT), September 21, 2004 (28 DAT), September 2 (FALL), September 20 (14 DAT), October 10, 2005 (28 DAT), August 23 (FALL), September 7 (14 DAT), and September 21, 2006 (28 DAT) using a three-foot CO_2 powered boom sprayer calibrated to deliver 80 gpa using two 11004 flat fan nozzles at 40 psi.

The test area was established in July of 2002. Normal practices for a putting green establishment were conducted. Subsequently, the turf was maintained using cultural practices for irrigation, mowing, and fertilization that would be typical for a putting green.

Results and Discussion

None of the treatments caused discernable phytotoxicity to the turf (Table 1). Ratings for annual bluegrass encroachment in 2004 revealed that the untreated turf had the greatest percent increase, but the amount was not significantly different from that found as a result of any of the treatments (Table 2). Annual bluegrass encroachment rated in the spring of 2005 revealed some significant differences. Turfgrass treated with Betasan at 9.2 oz/M followed by Rubigan at 2 oz/M (applied twice) and Rubigan at 2 oz/M alone applied three times had significantly less annual bluegrass encroachment than untreated turfgrass. The percent annual bluegrass found in the spring of 2006 revealed an overall increase in the population compared to previous populations. All treated turfgrass had significantly less annual bluegrass than untreated on the April 13, 2006 rating date. On the May 15th, 2007 rating date, annual bluegrass populations again increased from the previous year. On this date, turfgrass treated with Batasan at any rate plus Rubigan at any timing and Rubigan alone had significantly less annual bluegrass than non treated turfgrass.

On August 15th , 2006 the study area was rated for the amount of moss cover (Table 3). All treated turfgrass had significantly less moss than non treated turfgrass.

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Table 1. Phytotoxicity ratings of a simulated 'Penncross' creeping bentgrass/annual bluegrass putting green on a scale of 0 to 10 where 0 =most, 7 = acceptable, and 10 = none. Ratings were taken in 2003.

Treatment	Form	Rate oz/M	Timing	9/5	9/8	9/11	9/16	9/18	9/23	9/30	10/7
BETASAN	4EC	9.2	FALL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2/4	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
RUBIGAN	AS	2	FALL /14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Table 1 (continued). Phytotoxicity ratings of a simulated 'Penncross' creeping bentgrass/annual bluegrass putting green on a scale of 0 to 10 where 0 =most, 7 = acceptable, and 10 = none. Ratings were taken in 2004.

Treatment	Form	Rate oz/M	Timing	9/1	9/8	9/16	9/22	9/29	10/18	11/3	11/17
BETASAN	4EC	9.2	FALL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2/4	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
RUBIGAN	AS	2	FALL /14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Table 1 (continued). Phytotoxicity ratings of a simulated 'Penncross' creeping bentgrass/annual bluegrass putting green on a scale of 0 to 10 where 0 =most, 7 = acceptable, and 10 = none. Ratings were taken in 2005.

Treatment	Form	Rate oz/M	Timing	9/9	9/16	9/23	9/30	10/7	10/14	10/21	10/28
BETASAN	4EC	9.2	FALL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2/4	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
RUBIGAN	AS	2	FALL /14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Table 1 (continued). Phytotoxicity ratings of a simulated 'Penncross' creeping bentgrass/annual bluegrass putting green on a scale of 0 to 10 where 0 =most, 7 = acceptable, and 10 = none. Ratings were taken in 2006.

Treatment	Form	Rate oz/M	Timing	8/30	9/7	9/14	9/21	9/28	10/5	10/12	10/19
BETASAN	4EC	9.2	FALL	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
BETASAN RUBIGAN	4EC AS	9.2 2/4	FALL 14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
RUBIGAN	AS	2	FALL /14DAT/28DAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Table 2. Percent annual bluegrass ratings of a simulated 'Penncross' creeping bentgrass/annual bluegrass putting green from 2003, 2004, 2005, 2006, and 2007.

Treatment	Form	Rate oz/M	Timing	9/4/03	4/21/04	5/2/05	4/13/06	5/15/07
BETASAN	4EC	9.2	FALL	1.0a[1]	1.3a	15.0ab	16.7b	33.3ab
BETASAN	4EC	9.2	FALL	1.0a	1.7a	13.3ab	16.7b	25.0bc
RUBIGAN	AS	2	14DAT					
CHECK				1.0a	2.7a	18.3a	28.3a	38.3a
BETASAN	4EC	9.2	FALL	1.0a	1.7a	8.3b	20.0b	21.7c
RUBIGAN	AS	2	14DAT/28DAT					
BETASAN	4EC	9.2	FALL	1.0a	1.0a	13.3ab	21.7ab	21.7c
RUBIGAN	AS	2/4	14DAT/28DAT					
RUBIGAN	AS	2	FALL /14DAT/28DAT	1.0a	1.0a	8.3b	15.0b	26.7bc

1 - Means followed by same letter do not significantly differ (P = 0.05 Duncan's New MRT)

Table 3. Percent moss cover in the test area of a simulated 'Penncross' creeping bentgrass/annual bluegrass putting green in 2006.

Treatment	Form	Rate oz/M	Timing	8/15/06
BETASAN	4EC	9.2	FALL	15.0ab
BETASAN	4EC	9.2	FALL	18.3ab
RUBIGAN	AS	2	14DAT	
CHECK				30.0a
BETASAN	4EC	9.2	FALL	13.3b
RUBIGAN	AS	2	14DAT/28DAT	
BETASAN	4EC	9.2	FALL	6.7b
RUBIGAN	AS	2/4	14DAT/28DAT	
RUBIGAN	AS	2	FALL /14DAT/28DAT	20.0ab

1 - Means followed by same letter do not significantly differ (P = 0.05 Duncan's New MRT)

Seedhead Suppression of Annual Bluegrass on a Putting Green

J. A. Borger and M. B. Naedel[1]

Introduction

This study was conducted on a mixed stand of 'Penncross' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) at the Penn State Blue Golf Course in State College, PA. The objective of the study was to evaluate selected growth regulators, with and without adjuvants, for the seedhead suppression of annual bluegrass.

Methods and Materials

This study was a randomized complete block design with three replications, and a plot size of 21 ft^2. Treatments were applied on April 21 (BT), and May 15 (3 WAT), 2007 using a three-foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using one 11004E even tip/flat fan nozzle at 40 psi.

The site was maintained using cultural practices for irrigation, mowing, and fertilization that would be typical for a putting green. The test area was mowed with a Toro Triplex with an eleven blade reel, bench set to 0.115". Prior to the initiation of the study, the site was fertilized with a Nature Safe 8-3-5 fertilizer at a rate of 1 lb N/M in February and again with Anderson's Contec DG 18-9-18 at a rate of 1lb N/M on May 10, 2007. Boot stage of the annual bluegrass was observed April 27, 2007.

Results and Discussion

Turfgrass phytotoxicity was rated five times during the study (Table 1). There was no phytotoxicity below acceptable (7.0) observed on any rating date.

The percent annual bluegrass seedhead cover was rated once on June 1, 2007 (Table 2). All treated turfgrass had significantly fewer seedhead cover than non treated turfgrass except for the Eco-N only treated turfgrass. It should be noted that turfgrass treated with Primo MAXX plus Proxy alone and Proxy alone were not significantly different than turfgrass treated with Embark T&O. This type of seedhead suppression is unusual and not typical of data observed in prior years at this site. Additionally, it should be noted that the test site had relatively "light seedhead production" during the 2007 season. In 2007 the non treated turfgrass only had 20% coverage of annual bluegrass seedheads in contrast to prior years when the site had 90% or more coverage in non treated areas. The relatively "light pressure" of 2007 may have lead to the increase of suppression that had not previously been observed.

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Table 1. Ratings of phytotoxicity of an annual bluegrass/creeping bentgrass putting green on a scale of 0 to 10 where 0 = complete phytotoxicity, 7 = acceptable, and 10 = no phytotoxicity in 2007.

Treatment	**Form**	**Rate oz/M**	**Timing**	**(-----Phytotoxicity-----)** 4/30	5/8	5/15	5/24	6/1
EMBARK T&O	0.2SL	40 oz/A	BT	7.7	7.8	7.3	10.0	10.0
EMBARK T&O	0.2SL	40 oz/A	BT	10.0	7.8	9.3	10.0	10.0
FERROMEC	L	5	BT					
EMBARK T&O	0.2SL	40 oz/A	BT	9.7	7.5	8.3	10.0	10.0
ECO-N (24-0-0)	2.2L	0.065 lb N/M	BT					
EMBARK T&O	0.2SL	40 oz/A	BT	9.7	7.3	8.3	10.0	10.0
GARY’S GREEN ULTRA	L	6	BT					
EMBARK T&O	0.2SL	40 oz/A	BT	8.0	8.0	8.3	10.0	10.0
GARY’S GREEN ULTRA	L	5	BT					
AMINOPLEX	L	4	BT					
CHECK				10.0	10.0	10.0	10.0	10.0
EMBRARK T&O	0.2SL	20 oz/A	BT	7.3	7.3	8.0	10.0	10.0
EMBRARK T&O	0.2SL	20 oz/A	BT	9.7	7.7	7.0	10.0	10.0
GARY’S GREEN ULTRA	L	5						
AMINOPLEX	L	4						
PRIMO MAXX	1MEC	0.125	BT/3 WAT	8.3	8.7	9.3	10.0	10.0
PROXY	2SL	5	BT/3 WAT					
PRIMO MAXX	1MEC	0.125	BT/3 WAT	10.0	8.5	10.0	10.0	10.0
PROXY	2SL	5	BT/3 WAT					
GARY’S GREEN ULTRA	L	6	BT/3 WAT					
PROXY	2SL	5	BT	10.0	8.2	8.3	10.0	10.0
PROXY	2SL	5	BT	10.0	7.7	9.7	10.0	10.0
GARY’S GREEN ULTRA	L	5	BT					
AMINOPLEX	L	4	BT					
ECO-N (24-0-0)	2.2L	0.065 lb N/M	BT	10.0	10.0	10.0	10.0	10.0

Table 2. Ratings of the percent seedhead cover of an annual bluegrass/creeping bentgrass putting green in 2007.

Treatment	**Form**	**Rate oz/M**	**Timing**	**(-%cover[1]-) June 1, 2007**
EMBARK T&O	0.2SL	40 oz/A	BT	5.0ef
EMBARK T&O	0.2SL	40 oz/A	BT	6.7def
FERROMEC	L	5	BT	
EMBARK T&O	0.2SL	40 oz/A	BT	6.7def
ECO-N (24-0-0)	2.2L	0.065 lb N/M	BT	
EMBARK T&O	0.2SL	40 oz/A	BT	11.7cd
GARY’S GREEN ULTRA	L	6	BT	
EMBARK T&O	0.2SL	40 oz/A	BT	10.0cde
GARY’S GREEN ULTRA	L	5	BT	
AMINOPLEX	L	4	BT	
CHECK				20.0a
EMBRARK T&O	0.2SL	20 oz/A	BT	10.0cde
EMBRARK	0.2SL	20 oz/A	BT	13.3bc
GARY’S GREEN ULTRA	L	5		
AMINOPLEX	L	4		
PRIMO MAXX	1MEC	0.125	BT/3 WAT	2.3f
PROXY	2SL	5	BT/3 WAT	
PRIMO MAXX	1MEC	0.125	BT/3 WAT	1.0f
PROXY	2SL	5	BT/3 WAT	
GARY’S GREEN ULTRA	L	6	BT/3 WAT	
PROXY	2SL	5	BT	2.3f
PROXY	2SL	5	BT	5.0ef
GARY’S GREEN ULTRA	L	5	BT	
AMINOPLEX	L	4	BT	
ECO-N (24-0-0)	2.2L	0.065 lb N/M	BT	17.4ab

1 - Means followed by same letter do not significantly differ (P = 0.05 Duncan's New MRT)

Preliminary Evaluation of Materials Applied to Perennial Ryegrass For Symptom Suppression of Etiolated Tiller Syndrome

M.B. Naedel, P. J. Landschoot, and J. A. Borger[1]

Introduction

Symptom presence, phytotoxicity, and disease severity evaluations were conducted on a mature stand of 'Jet-Eilte' perennial ryegrass (*Lolium perenne* L.) at the Valentine Turfgrass Research Center, Penn State University, University Park, Pa. The objective of the study was to determine the symptom presence, phytotoxicity, and disease severity of perennial ryegrass following applications of selected compounds.

Methods and Materials

The study was a randomized complete block design with three replications. All treatments were applied using a three foot CO_2 powered boom sprayer calibrated to deliver 80 gpa using one, flat fan, 11008E nozzle at 40 psi. SIGNATURE, ZEROTOL, 26GT, COCS, ACTIGARD, and CLEARY'S 3336 were applied as the turf began to green up (GU) on April 10, 2006 and were reapplied every two weeks, April 26 (2 WA GU), May 9 (4 WA GU), May 22 (6 WA GU), June 5 (8 WA GU), June 28 (10 WA GU), July 11 (12 WA GU), and July 25, 2006 (14 WA GU). BANNER MAXX and HERITAGE were applied at green up (GU), April 10, 2006 and reapplied every four weeks, May 9 (4 WA GU), June 5 (8 WA GU), and July 11, 2006 (12 WA GU). PRIMO MAXX, PROXY, PRIMO MAXX+PROXY, AND PRIMO MAXX+TRIMMIT were applied April 17, 2006 at the boot stage timing (BS) to mimic an annual bluegrass seedhead suppression application and treatments were reapplied every four weeks, May 12 (4 WA BS), June 13 (8 WA BS), and July 11, 2006 (12 WA BS). TRIMMIT was applied on May 12, 2006 at an annual bluegrass seedhead shatter timing (SHTR) to mimic annual bluegrass control program and reapplied every four weeks, June 13 (4 WA SHTR), and July 11, 2006 (8 WA SHTR). The test plot size was 21 ft^2.

Symptoms of Etiolated Tiller Syndrome were first recorder on the test area on April 13, 2006. The test site was mowed first on April 12, 2006, at one and one half inches, and then twice weekly with a Toro 228-D Groundsmaster rotary mower with clippings returned to the site. The test site was fertilized twice during the trial with 1 lb of N/M from IBDU on April 27, 2006 and again on May 24, 2006 2. The test area was irrigated to prevent moisture stress.

Results and Discussion

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Table 1. Quantitative evaluations of perennial ryegrass symptoms using a 1ft^2 grid to count affected tillers with three sub samples per plot in 2006.

Treatment	Form	Rate oz/M	Timing	(------------Tiller Counts [1]----------) 7/26	8/28
PRIMO MAXX	1MEC	1	BS/4/8 WA BS	2.8f	3.8ab
TRIMMIT	2SC	0.5 lb ai/A	SHTR/4/8 WA SHTR	17.0d	3.8ab
PROXY	2SL	5	BS/4/8 WA BS	27.8abc	6.0ab
PRIMO MAXX PROXY	1MEC 2SL	0.25 5	BS/4/8 WA BS BS/4/8 WA BS	3.4ef	5.0ab
SIGNATURE	80WP	8	GU/2/4/6/8/10/12/14 WA GU	19.7cd	4.4ab
BANNER MAXX	1.3L	4	GU/4/8/12 WA GU	21.6bcd	4.6ab
CHECK				19.6cd	4.4ab
PRIMO MAXX TRIMMIT	1MEC 2SC	0.125 0.25 lb ai/A	BS/4/8 WA BS BS BS/4/8 WA BS	12.1de	4.7ab
ZEROTOL	L	12	GU/2/4/6/8/10/12/14 WA GU	19.0cd	2.8b
26GT	2L	8	GU/2/4/6/8/10/12/14 WA GU	31.9a	3.1ab
COCS	WP	2.5 lb/A	GU/2/4/6/8/10/12/14 WA GU	21.4bcd	4.2ab
ACTIGARD	50WG	1 oz/A	GU/2/4/6/8/10/12/14 WA GU	20.3cd	2.3b
CLEARY'S 3336	50WP	8	GU/2/4/6/8/10/12/14 WA GU	18.6cd	4.2ab
HERITAGE	50WG	0.4	GU/4/8/12 WA GU	30.2ab	6.9a

1 - Means followed by same letter do not significantly differ (P = 0.05 Duncan's New MRT

Table 2. Visual evaluations of perennial ryegrass phytotoxicity where 0 = dead turf, 7 = acceptable, and 10 = no phytotoxicity in 2006.

Treatment	Form	Rate oz/M	Timing	(------------Phytotoxicity-----------) 5/18	6/5
PRIMO MAXX	1MEC	1	BS/4/8 WA BS	5.8	10.0
TRIMMIT	2SC	0.5 lb ai/A	SHTR/4/8 WA SHTR	8.7	10.0
PROXY	2SL	5	BS/4/8 WA BS	10.0	10.0
PRIMO MAXX PROXY	1MEC 2SL	0.25 5	BS/4/8 WA BS BS/4/8 WA BS	7.5	10.0
SIGNATURE	80WP	8	GU/2/4/6/8/10/12/14 WA GU	10.0	10.0
BANNER MAXX	1.3L	4	GU/4/8/12 WA GU	10.0	10.0
CHECK				10.0	10.0
PRIMO MAXX TRIMMIT	1MEC 2SC	0.125 0.25 lb ai/A	BS/4/8 WA BS BS BS/4/8 WA BS	6.5	10.0
ZEROTOL	L	12	GU/2/4/6/8/10/12/14 WA GU	9.3	10.0
26GT	2L	8	GU/2/4/6/8/10/12/14 WA GU	10.0	10.0
COCS	WP	2.5 lb/A	GU/2/4/6/8/10/12/14 WA GU	8.3	10.0
ACTIGARD	50WG	1 oz/A	GU/2/4/6/8/10/12/14 WA GU	9.0	10.0
CLEARY'S 3336	50WP	8	GU/2/4/6/8/10/12/14 WA GU	8.7	10.0
HERITAGE	50WG	0.4	GU/4/8/12 WA GU	10.0	10.0

Table 3. Visual evaluations of disease severity of perennial ryegrass where 0 = no incidence and 9 = severe incidence in 2006.

Treatment	**Form**	**Rate oz/M**	**Timing**	**Severity [1] 4/27**	**5/18**	**6/12**	**6/27**	**8/28**
PRIMO MAXX	1MEC	1	BS/4/8 WA BS	4.3b	1.7d	1.3d	1.3f	2.0b
TRIMMIT	2SC	0.5 lb ai/A	SHTR/4/8 WA SHTR	5.0ab	4.7abc	3.3c	4.7cd	3.0b
PROXY	2SL	5	BS/4/8 WA BS	5.0ab	5.3ab	5.0bc	7.0ab	3.3b
PRIMO MAXX PROXY	1MEC 2SL	0.25 5	BS/4/8 WA BS BS/4/8 WA BS	4.7ab	1.3d	3.3c	2.3ef	3.0b
SIGNATURE	80WP	8	GU/2/4/6/8/10/12/14 WA GU	5.7a	5.7ab	5.0bc	6.0bcd	3.7b
BANNER MAXX	1.3L	4	GU/4/8/12 WA GU	5.3ab	4.3bc	4.0c	4.7cd	3.7b
CHECK				5.3ab	5.7ab	4.3c	7.0ab	3.3b
PRIMO MAXX TRIMMIT	1MEC 2SC	0.125 0.25 lb ai/A	BS/4/8 WA BS BS BS/4/8 WA BS	5.3ab	3.0cd	3.7c	4.0de	3.7b
ZEROTOL	L	12	GU/2/4/6/8/10/12/14 WA GU	5.3ab	5.3ab	4.3c	6.3bc	3.7b
26GT	2L	8	GU/2/4/6/8/10/12/14 WA GU	5.7a	6.3a	6.7a	8.7a	3.7b
COCS	WP	2.5 lb/A	GU/2/4/6/8/10/12/14 WA GU	5.7a	5.0ab	4.7c	6.7abc	3.0b
ACTIGARD	50WG	1 oz/A	GU/2/4/6/8/10/12/14 WA GU	6.0a	4.0bc	3.7c	6.3bc	2.3b
CLEARY'S 3336	50WP	8	GU/2/4/6/8/10/12/14 WA GU	6.0a	5.0ab	4.7c	6.3bc	3.7b
HERITAGE	50WG	0.4	GU/4/8/12 WA GU	6.0a	5.3ab	6.3ab	6.7abc	5.7a

1 - Means followed by same letter do not significantly differ (P = 0.05 Duncan's New MRT

Annual Bluegrass Control in Fairway Height Creeping Bentgrass

J. A. Borger and M. B. Naedel [1]

Introduction

This study was conducted on a mature stand of 'Penneagle' creeping bentgrass (*Agrostis stolonifera*) and annual bluegrass (*Poa annua*) at the Valentine Turfgrass Research Center, Penn State University, University Park, PA. The objective of the study was to determine if selected materials could reduce the annual bluegrass population under simulated fairway conditions.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on May 30 (MAY), June 5 (1 WAT), June 12 (2 WAT), June 19 (3 WAT), June 30 (4 WAT), July 6 (5 WAT), July 25 (8 WAT), September 20 (16 WAT), October 19 (20 WAT), November 15 (NOV), and December 14, 2006 (DEC) using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using one, flat fan, 11004E nozzle at 40 psi. The test area was maintained at 0.5 inch using a five-plex reel mower that collected clippings. Turfgrass was irrigated on an as needed basis to prevent moisture stress. The study was fertilized prior to green up (April 25, 2006) with 1 lb N/M from IBDU and again on May 16, 2006 with 1 lb N/M from urea. The test area received maintenance fungicide applications to control disease.

The test site consisted of approximately 65 percent creeping bentgrass and 35 percent annual bluegrass at the initiation of the study. The annual bluegrass population was visually evaluated on May 23, 2006 and May 15, 2007, on a plot by plot basis, to determine the baseline population and percent change of the population in each plot.

Results and Discussion

Turfgrass discoloration was rated four times during the study (Table 1). On the last two rating dates, October 23, 2006 turfgrass treated with Trimmit combined with any other material except Prograss had unacceptable discoloration and on November 20, 2006, turfgrass treated with Trimmit combined with any other material except Rubigan at 0.75 oz/M plus 18-3-1 or Prograss had unacceptable discoloration.

Turfgrass spring green-up was rated twice during the study (Table 2). On April 11, 2007 turfgrass treated Prograss alone or in combination revealed a delay in green-up.

The percent population change of annual bluegrass was rated on May 15, 2007 (Table 3). Only turfgrass treated with Velocity at 45 g ai/A twice did not significantly reduce the population of annual bluegrass compared to non treated turfgrass.

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Table 1. Discoloration of a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass in 2006.

Treatment	Form	Rate	Timing	(------------------------Discoloration [1]			--------------------)
		(lb ai/A)		**6/7**	**7/15**	**10/23**	**11/20**
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	8.7	10.0	6.3	5.8
RUBIGAN	1AS	0.75 oz/M	MAY/4/8/16/20 WAT				
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	9.0	10.0	6.5	7.7
RUBIGAN	1AS	0.75 oz/M	MAY/4/8/16/20 WAT				
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT				
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	8.3	10.0	6.7	6.0
RUBIGAN	1AS	1.5 oz/M	MAY/4/8/16/20 WAT				
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	9.0	10.0	6.0	6.2
RUBIGAN	1AS	1.5 oz/M	MAY/4/8/16/20 WAT				
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT				
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	9.3	10.0	6.3	6.2
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT				
VELOCITY	80SP	30 g ai/A	MAY/2 WAT	8.3	10.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0
VELOCITY	80SP	45 g ai/A	MAY/2 WAT	8.0	10.0	9.0	10.0
VELOCITY	80SP	60 g ai/A	MAY/4 WAT	8.0	7.0	10.0	10.0
VELOCITY	80SP	10 g ai/A	MAY/1/2/3/4/5 WAT	7.0	8.0	10.0	10.0
PROGRASS	1.5EC	0.75	NOV/DEC	10.0	10.0	10.0	10.0
PROGRASS	1.5EC	0.75	NOV/DEC	10.0	10.0	10.0	10.0
TRIMMIT	2SC	0.75	NOV/DEC				
PROGRASS	1.5EC	0.375	NOV/DEC	10.0	10.0	10.0	10.0
TRIMMIT	2SC	0.375	NOV/DEC				

1 – Discoloration rated on a scale of 0 to 10 where 0= worst, 7 = acceptable, and 10 = no discoloration.

Table 2. Spring green up of a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass in 2006.

Treatment	Form	Rate (lb ai/A)	Timing	(-------Spring Green Up [1]--------) 4/11	4/30
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	8.7	10.0
RUBIGAN	1AS	0.75 oz/M	MAY/4/8/16/20 WAT		
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	9.0	10.0
RUBIGAN	1AS	0.75 oz/M	MAY/4/8/16/20 WAT		
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT		
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	8.3	10.0
RUBIGAN	1AS	1.5 oz/M	MAY/4/8/16/20 WAT		
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	9.0	10.0
RUBIGAN	1AS	1.5 oz/M	MAY/4/8/16/20 WAT		
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT		
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	9.0	10.0
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT		
VELOCITY	80SP	30 g ai/A	MAY/2 WAT	8.0	10.0
CHECK				7.0	10.0
VELOCITY	80SP	45 g ai/A	MAY/2 WAT	8.0	10.0
VELOCITY	80SP	60 g ai/A	MAY/4 WAT	7.7	10.0
VELOCITY	80SP	10 g ai/A	MAY/1/2/3/4/5 WAT	8.3	10.0
PROGRASS	1.5EC	0.75	NOV/DEC	6.0	7.8
PROGRASS	1.5EC	0.75	NOV/DEC	5.3	7.5
TRIMMIT	2SC	0.75	NOV/DEC		
PROGRASS	1.5EC	0.375	NOV/DEC	6.3	9.3
TRIMMIT	2SC	0.375	NOV/DEC		

1 – Green up rated on a scale of 0 to 10 where 0= no green up and 10 = full green up.

Table 3. Percent annual bluegrass population change in a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass. Ratings taken on May 15, 2007.

Treatment	Form	Rate (lb ai/A)	Timing	(-------Population Change [1, 2]-----) 5/15/07
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	36.1cd
RUBIGAN	1AS	0.75 oz/M	MAY/4/8/16/20 WAT	
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	47.2bcd
RUBIGAN	1AS	0.75 oz/M	MAY/4/8/16/20 WAT	
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT	
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	58.3a-d
RUBIGAN	1AS	1.5 oz/M	MAY/4/8/16/20 WAT	
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	66.7a-d
RUBIGAN	1AS	1.5 oz/M	MAY/4/8/16/20 WAT	
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT	
TRIMMIT	2SC	0.4	MAY/4/8/16/20 WAT	66.7a-d
18-3-1	1.8L	0.2 lb N/M	MAY/4/8/16/20 WAT	
VELOCITY	80SP	30 g ai/A	MAY/2 WAT	47.2bcd
CHECK				-11.1e
VELOCITY	80SP	45 g ai/A	MAY/2 WAT	25.0de
VELOCITY	80SP	60 g ai/A	MAY/4 WAT	81.7ab
VELOCITY	80SP	10 g ai/A	MAY/1/2/3/4/5 WAT	95.8a
PROGRASS	1.5EC	0.75	NOV/DEC	78.3abc
PROGRASS	1.5EC	0.75	NOV/DEC	96.1a
TRIMMIT	2SC	0.75	NOV/DEC	
PROGRASS	1.5EC	0.375	NOV/DEC	36.1cd
TRIMMIT	2SC	0.375	NOV/DEC	

1 – Means followed by the same letter do not significantly differ (P = 0.05, Duncan's New MRT).

2 – Negative numbers indicate an increase in annual bluegrass populations.

Preemergence Control of Smooth Crabgrass

J. A. Borger and M. B. Naedel[1]

Introduction

Preemergence control of smooth crabgrass (*Digitaria ischaemum*) was evaluated on a mature stand of 'Jet Elite' perennial ryegrass (*Lolium perenne* L.) at the Valentine Turfgrass Research Center, Penn State University, University Park, PA. The objective of the study was to determine the efficacy of selected preemergence herbicides for the control of smooth crabgrass and safety to desired species.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on April 25, 2007 (PRE) and June 21, 2007 (8 WAT)) using a three foot CO_2 powered boom sprayer calibrated to deliver 80 gpa using one, flat fan, 11008E nozzle at 40 psi and granular treatments were applied to wet turf using a shaker box. After each application the entire test site received approximately 0.5 inch of water. On May 8, 2007 0.5 lb N/M was applied from urea and 0.5 lb N/M from a 31-0-0 IBDU fertilizer was applied to plots that did not contain a fertilizer treatment. The site was mowed once per week with a rotary mower at one inch with clippings returned to the site.

The test site was overseeded with a native source of smooth crabgrass seed in the fall of at least two of the pervious growing seasons. The test site had approximately 90% cover of smooth crabgrass in the non treated areas at the conclusion of the study.

Smooth crabgrass germination was first noted in the non treated areas of the test site on May 1, 2007.

Results and Discussion

Turfgrass phytotoxicity was rated seven times during the study (Table 1). No phytotoxicity was found on any rating date that was below the acceptable level of 7.

The percent control of smooth crabgrass was rated on August 6, 2007 (Table 2). On this date, only turfgrass treated with Dimension Ultra 2EW at 0.38 and 0.5 lb ai/A PRE, Barricade 65WDG at 0.75 lb ai/A PRE, Quali-Pro Dithiopyr 40WP at 0.25 lb ai/A PRE and 8 WAT, Dimension Ultra 40WP at 0.25 lb ai/A PRE and 8 WAT, Quali-Pro Dithiopyr 40WP at 0.5 lb ai/A PRE, Dimension Ultra 40WP at 0.5 lb ai/A PRE, and D FERT 0.163G at 0.5 lb ai/A PRE provided commercially acceptable smooth crabgrass control (85% or greater).

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Table 1. Evaluations of turfgrass phytotoxicity where 0 = worst, 7 = acceptable, and 10 = no phytotoxicity taken in 2007.

Treatment	Form	Rate lb ai/A	Timing	(-------------------Phytotoxicity----------------) 5/9	5/30	6/14	7/5
DIMENSION ULTRA	2EW	0.125	PRE	10.0	10.0	10.0	10.0
DIMENSION ULTRA	2EW	0.25	PRE	10.0	10.0	10.0	10.0
DIMENSION ULTRA	2EW	0.38	PRE	10.0	10.0	10.0	10.0
DIMENSION ULTRA	2EW	0.5	PRE	10.0	10.0	10.0	10.0
BARRICADE	65WDG	0.25	PRE	10.0	10.0	10.0	10.0
BARRICADE	65WDG	0.5	PRE	10.0	10.0	10.0	10.0
BARRICADE	65WDG	0.75	PRE	10.0	10.0	10.0	10.0
QUALI-PRO DITHIOPYR	40WP	0.25	PRE/8 WAT	10.0	10.0	10.0	10.0
DIMENSION ULTRA	40WP	0.25	PRE/8 WAT	10.0	10.0	10.0	10.0
QUALI-PRO DITHIOPYR	40WP	0.5	PRE	10.0	10.0	10.0	10.0
DIMENSION ULTRA	40WP	0.5	PRE	10.0	10.0	10.0	10.0
DIMENSION ULTRA	40WP	0.125	PRE	10.0	10.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0
D-150 SGN	0.25G	0.25	PRE	10.0	10.0	10.0	10.0
D-150 SGN	0.125G	0.125	PRE	10.0	10.0	10.0	10.0
D-150 SGN	0.25G	0.125	PRE	10.0	10.0	10.0	10.0
P-150 SGN	0.48G	0.75	PRE	10.0	10.0	10.0	10.0
P-150 SGN	0.48G	0.5	PRE	10.0	10.0	10.0	10.0
P-150 SGN	0.48G	0.25	PRE	10.0	10.0	10.0	10.0
D FERT	0.163G	0.5	PRE	10.0	10.0	10.0	10.0
D FERT	0.163G	0.25	PRE	10.0	10.0	10.0	10.0
D FERT	0.163G	0.125	PRE	10.0	10.0	10.0	10.0

Table 2. Evaluations of the percent control of smooth crabgrass in 2007. Commercially acceptable control was considered to be 85% and above.

Treatment	Form	Rate lb ai/A	Timing	(----% Control----) 8/6
DIMENSION ULTRA	2EW	0.125	PRE	53.3
DIMENSION ULTRA	2EW	0.25	PRE	80.0
DIMENSION ULTRA	2EW	0.38	PRE	94.3
DIMENSION ULTRA	2EW	0.5	PRE	97.7
BARRICADE	65WDG	0.25	PRE	70.0
BARRICADE	65WDG	0.5	PRE	79.3
BARRICADE	65WDG	0.75	PRE	88.0
QUALI-PRO DITHIOPYR	40WP	0.25	PRE/8 WAT	89.3
DIMENSION ULTRA	40WP	0.25	PRE/8 WAT	92.7
QUALI-PRO DITHIOPYR	40WP	0.5	PRE	99.0
DIMENSION ULTRA	40WP	0.5	PRE	99.0
DIMENSION ULTRA	40WP	0.125	PRE	56.7
CHECK				0.0
D-150 SGN	0.25G	0.25	PRE	75.0
D-150 SGN	0.125G	0.125	PRE	50.0
D-150 SGN	0.25G	0.125	PRE	10.0
P-150 SGN	0.48G	0.75	PRE	78.3
P-150 SGN	0.48G	0.5	PRE	46.7
P-150 SGN	0.48G	0.25	PRE	21.7
D FERT	0.163G	0.5	PRE	93.3
D FERT	0.163G	0.25	PRE	50.0
D FERT	0.163G	0.125	PRE	21.7

2007 FIELD TRIAL: LIQUID FERTILIZER PROGRAMS AND CREEPING BENTGRASS 'PENN A4' OR 'PENN G2' PUTTING GREEN QUALITY

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Objectives

To compare commercial and basic liquid fertilizer programs in a frequent, spoon-feeding nitrogen fertilization putting green protocol using creeping bentgrass growth, shoot density, disease resistance, and canopy color parameters as measures of putting green quality.

General Methods and Data Collection

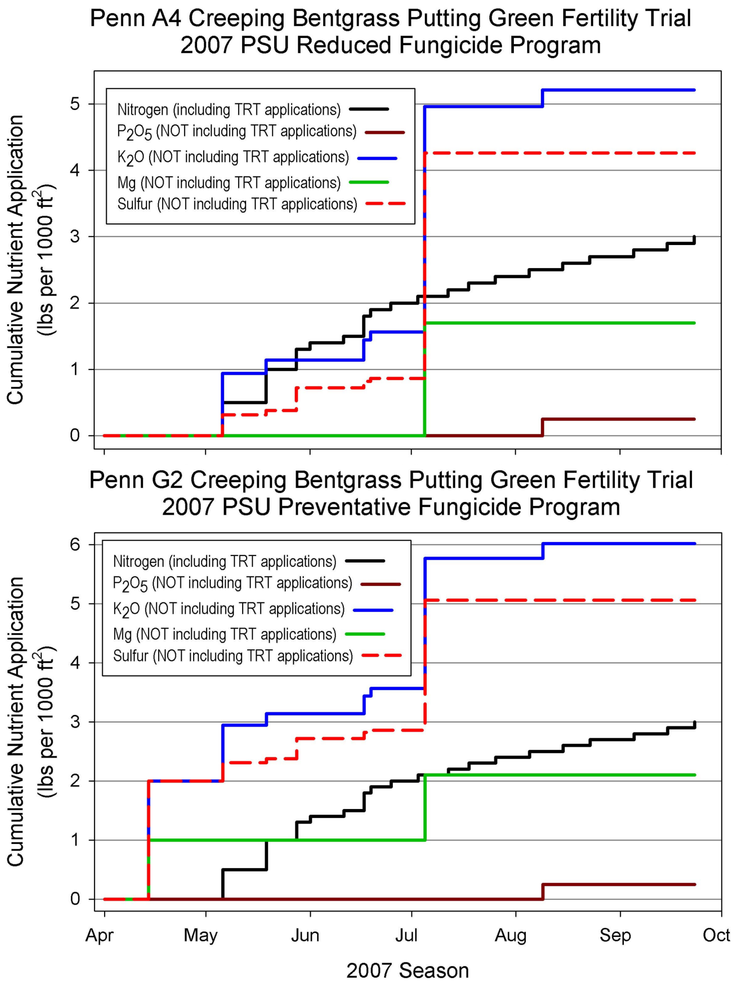
The 2007 fertility trial was conducted on Penn A4 (Exp. 1) and Penn G2 (Exp. 2) creeping bentgrass (*Agrostis palustris*) putting greens, established in 2005 to a 'push-up' root zone maintained within the PSU Joseph Valentine Turfgrass Research Center, University Park, PA. Preliminary soil fertility levels were evaluated (Table 1) and optimized throughout the season (Fig. 1). Plots were mowed 6-7 times weekly at a height of ⅛" over the 18-week studies (June 1 to October 5, 2007). Clippings were not returned to the putting greens. Minimum and maximum air temperature, relative humidity, and daily rainfall were recorded on site (Fig. 2).

Liquid fertilizers were applied at a standard rate of 0.1 lbs N/1000 ft^2. These treatments were made in a 2 gal/1000 ft^2 spray volume using a CO_2–pressurized, single nozzle wand (Tee-Jet TP11008E, Spraying Systems Co., Wheaton, IL). The reapplication interval averaged 8 days, but ranged from 5 to 13 d (Fig. 1). Delivery rates of other nutrients varied by fertilizer program (Table 2) and experimental putting green (Fig. 1). A digital metronome was employed during spray applications to ensure precise nozzle travel rate across each 3 x 6 ft plot. Potable irrigation water was used to replace evapotranspiration losses over the duration of the study, but fertilizer treatments were not watered in. Total N fertilizer application amounted to 3.0 lbs N/1000 ft^2 in 2007, with 1.3 lbs N equally applied to all plots prior to initiation of the trial (Fig. 1).

Table 1. Mean soil fertility level (n=3) measured in the 0-4" soil depth, by experimental putting green; May 20, 2007.

Experiment and bentgrass variety	Soil pHw	CEC meq / 100g	Phosphorus lbs / acre	Potassium	Calcium	Magnesium
				lbs / acre (% saturation of CEC)		
Exp. 1 Penn A4	7.1	8.9	178	130 (1.9%)	2707 (76%)	452 (21%)
Exp. 2 Penn G2	7.3	6.4	154	161 (3.2%)	1891 (74%)	337 (22%)

Duplicate simultaneous measures of 660– and 850–nm light reflectance from the canopy of each bentgrass putting green plot were recorded 2–6 days per week using an ambient light-excluding FieldScout TCM–500 turfgrass chlorophyll meter (Spectrum Technologies Inc., Plainfield, IL). Reflectance data were used to calculate normalized differential vegetative indices (NDVI). A turfgrass color meter (FieldScout TCM-500-RGB) collected duplicate measures of percent green, red, and blue canopy reflectance; 2–6 days per week. Data were converted to hue, saturation, and brightness levels to determine dark green color index (DGCI; Karcher & Richardson, 2003).



These indices, NDVI and DGCI, provide dependably-reproducible measures of turfgrass canopy density and dark green color, respectively; and are used to quantify creeping bentgrass putting green quality response to fertilizer treatments in the following results and discussion section.

Dependent variables were modeled by fertilizer program treatment and either day after treatment (DAT) or day of year using the mixed procedure (SAS Institute, v. 8.2). Significant pre-planned treatment mean comparisons were determined by Fisher's least significant difference. An orthogonal contrast statement measured variation between the UAP Signature and UAP Signature + Eximo Soil Conditioner treatments for each dependent variable modeled. For clarity, the two treatments are pooled for analysis of variables not showing a significant contribution of Eximo inclusion [where: $P\ (F_{Contrast} < F_{Crit}) > 0.05$].

Figure 1. Preparatory and maintenance nutrient deliveries; by date and experiment (Exp. 1, top; Exp. 2, bottom). Treatment applications of N are shown (black line), whereas concomitant deliveries of P_2O_5, K_2O, Mg and S by fertilizer program treatments are not (see Table 2).

Experiment 1: Penn A4 Reduced Fungicide Program

Experiment 1 was established as a single randomized Latin square of six (6) liquid fertilizer programs (Table 2) by 6 replications. Plant growth regulators, insecticides, herbicides, and wetting agents were applied as necessary and in accordance with label directions (Table 3). Excepting the pre-trial propiconazole treatment made equally across all plots (May 28), a fungicide was curatively-applied to the Exp. 1 Penn A4 putting green only on Aug. 9 (Table 3). On July 27 and 30, Aug. 8 and 28, and Sept. 10, 19, and 29; high-resolution JPEG-formatted plot images (2560 x 1920 pixels, 8.9–mm focal length, various exposures and apertures) were collected at identical orientation to the sun and successively by experimental block using a hand-held digital camera (Nikon E8800, Nikon Corp., Melville, NY). During this extended period of disease incidence, plot images were used to quantify % green cover of the putting green canopy (Richardson et al., 2001). Shoot growth and tissue nutritional data were not collected in Exp. 1.

Experiment 2: Penn G2 Preventative Fungicide Program

Experiment 2 was established as a randomized complete block design of ten (10) liquid fertilizer programs by 4 replications. These ten liquid fertilizer programs include the fertilizer products

Table 2. Experiment 1 liquid program formulations, shown fertilizer grades reported from respective labels or reference publications (when available).

M.J. Schlossberg, 2007 **Emerald Isle**	**Application** **oz./1000**	% N	% P_2O_5	% K_2O	% Fe	% Mn	Density lbs/gallon	lbs N per 1000	lbs P_2O_5 per 1000	lbs K_2O per 1000	lbs Fe per 1000	lbs Mn per 1000
CPR	7.0	4	0	1	2	0.25	10.00	0.0219	0.000	0.005	0.0109	0.001
TrueFoliar	4.5	10	0	10	0.95	2	10.68	0.0375	0.000	0.038	0.0036	0.008
TrueFoliar	3.0	3	0	10	0	0	9.75	0.0069	0.000	0.023	0.0000	0.000
TrueFoliar	3.0	8	0	4	0	0	11.68	0.0219	0.000	0.011	0.0000	0.000
TrueFoliar	3.0	6	0	0	0	5	11.18	0.0157	0.000	0.000	0.0000	0.013
					Emerald Isle Single App. Total →			0.1039	0.000	0.077	0.0145	0.022
Floratine												
Perk Up*	3.0	0.66	0.02	0.28	0.051	<0.001	11.28	0.0017	<0.001	0.001	0.0001	<0.001
Carbon PK (label)	3.0	0	22	28	0	0	13.36	0.0000	0.069	0.088	0.0000	0.000
Renaissance*	1.0	0.34	0	0.33	3.665	1.072	9.60	0.0003	0.000	0.000	0.0027	0.001
Protesyn*	3.0	0.72	3.5	14.7	0.157	0.003	9.60	0.0016	0.008	0.033	0.0004	<0.001
Carbon N (label)	5.3	23	0	0	0	0	10.20	0.0971	0.000	0.000	0.0000	0.000
	* F. Rossi, Ph.D. (GCM, Sept. 2006)				Floratine Prog. Single App. Total →			0.1008	0.077	0.122	0.0033	0.001
Grigg Bros.												
Gary's Green	4.0	18	3	4	1	0.1	10.60	0.0596	0.010	0.013	0.0033	<0.001
Ultraplex	3.0	5	0	3	2	0.4	10.77	0.0126	0.000	0.008	0.0050	0.001
SilCalB	3.0	8	0	4	0	0	12.43	0.0233	0.000	0.012	0.0000	0.000
PK Plus	3.0	3	21	18	0.4	0.1	11.52	0.0081	0.057	0.049	0.0011	<0.001
					Grigg Bros. Single App. Total →			0.1036	0.067	0.081	0.0094	0.002
UAP Signature†												
Sirius	5.30	17	0	11	0	0	12.60	0.0887	0.000	0.057	0.0000	0.000
SilStar	3.00	0	0	26	0	0	12.60	0.0000	0.000	0.077	0.0000	0.000
Feature Prof.	0.2945 lbs	0	0	0	4	2	**na**	0.0000	0.000	0.000	0.0118	0.006
AlphaNova	4.50	4	0	2	0	0	10.30	0.0145	0.000	0.007	0.0000	0.000
Regulas	4.00	0	0	6	1	0	10.56	0.0000	0.000	0.020	0.0033	0.000
					UAP Signature Single App. Total →			0.1032	0.000	0.161	0.0151	0.006
Urea + Fe	**lbs/1000**											
Urea	0.2198	46	0	0	0	0	**na**	0.1011	0.000	0.000	0.0000	0.000
$FeCl_2 + 4H_2O$	0.0589	0	0	0	28	0	**na**	0.0000	0.000	0.000	0.0165	0.000
					Urea + Iron Single App. Total →			0.1011	0.000	0.000	0.0165	0.000

† The 6th Exp. 1 treatment applied was the UAP Signature liquid program in combination with 3 applications of Eximo Soil Conditioner (6/1, 7/18, 8/21).

Table 3. Maintenance fertilizer and plant protectant applications by experiment and date.

<table>
<tr><th>2007</th><th>Exp. 1 Penn A4</th><th></th><th>Exp. 2 Penn G2 (preventative fungicide program)</th></tr>
<tr><td>4/14</td><td>None</td><td></td><td>Granular fertilizer application: *0-0-22</td></tr>
<tr><td>5/6</td><td colspan="3">Granular fertilizer application: *16-0-30</td></tr>
<tr><td>5/19</td><td colspan="3">Spray application: *Urea, *K_2SO_4, paclobutrazol (0.006 lbs. /1000 ft^2)</td></tr>
<tr><td>5/28</td><td colspan="3">Spray application: *$(NH_4)_2SO_4$, micronutrient package, propiconazole (0.36 oz./1000 ft^2)</td></tr>
<tr><td>6/1</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.1 lbs)</td></tr>
<tr><td>6/11</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.2 lbs)</td></tr>
<tr><td>6/13</td><td colspan="3">Light verticutting followed by sand topdressing (600 lbs sand/1000 ft^2)</td></tr>
<tr><td>6/17</td><td colspan="3">Spray application: *Urea, *K_2SO_4, paclobutrazol (0.006 lbs. /1000 ft^2)</td></tr>
<tr><td rowspan="2">6/19</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.3 lbs)</td></tr>
<tr><td colspan="3">Spray application: *K_2SO_4, carfentrazone-ethyl (0.033 oz. /1000 ft^2)</td></tr>
<tr><td>6/25</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.4 lbs)</td></tr>
<tr><td>6/28</td><td>None</td><td></td><td>Spray app. (all per 1000 ft^2): chlorothalonil (2.5 oz.), triadimefon (0.2 oz.)</td></tr>
<tr><td>7/3</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.5 lbs)</td></tr>
<tr><td>7/5</td><td colspan="3">Granular fertilizer application: *0-0-22</td></tr>
<tr><td>7/11</td><td colspan="3">Spray application: carfentrazone-ethyl (0.033 oz. /1000 ft^2)</td></tr>
<tr><td>7/12</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.6 lbs)</td></tr>
<tr><td>7/18</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.7 lbs)</td></tr>
<tr><td>7/19</td><td colspan="3">Spray application: paclobutrazol (0.0045 lbs. /1000 ft^2)</td></tr>
<tr><td>7/26</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.8 lbs)</td></tr>
<tr><td>7/31</td><td colspan="3">Spray application: carfentrazone-ethyl (0.033 oz. /1000 ft^2)</td></tr>
<tr><td>8/3</td><td>None</td><td></td><td>Spray application (all per 1000 ft^2): fenarimol (0.1 oz.), iprodione (1 oz.), chlorothalonil (2 oz.), flutolanil (1.5 oz.)</td></tr>
<tr><td>8/5</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=0.9 lbs)</td></tr>
<tr><td>8/9</td><td colspan="3">Spray app. (all per 1000 ft^2): cyfluthrin (4 g), flutolanil (2 oz.), paclobutrazol (0.006 lbs.), *KCl, *H_3PO_4</td></tr>
<tr><td>8/13</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=1.0 lbs)</td></tr>
<tr><td>8/21</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=1.1 lbs)</td></tr>
<tr><td>8/24</td><td>None</td><td></td><td>Spray application: (all per 1000 ft^2): chlorothalonil (1.5 oz.), myclobutanil (0.4 oz.), iprodione (1 oz.), paclobutrazol (0.005 lbs.)</td></tr>
<tr><td>9/3</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=1.2 lbs)</td></tr>
<tr><td>9/5</td><td>None</td><td></td><td>Spray application (per 1000 ft^2): triadimefon (0.3 oz.)</td></tr>
<tr><td>9/13</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=1.3 lbs)</td></tr>
<tr><td>9/21</td><td colspan="3">Liquid Fertilizer Treatments Applied (cumulative N/1000 ft^2=1.4 lbs)</td></tr>
</table>

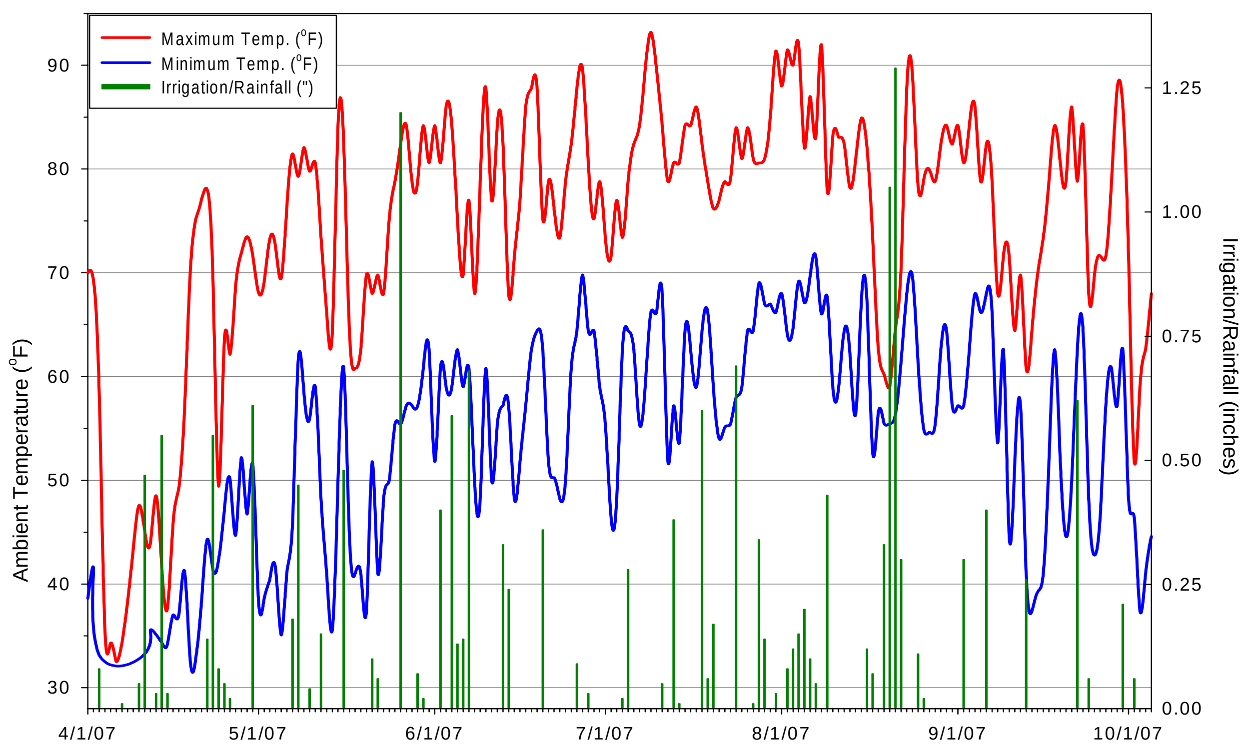
* See Figure 1 for nutrient application rates by experiment.

shown in Table 4 (below) and the six (6) programs evaluated in Exp. 1 (Table 2). Plant protectants, growth regulators, herbicides, and wetting agents were applied as necessary and in accordance with label directions (Table 3). Shoot growth rate was calculated from clipping yields collected July 20, Aug. 10, Sept. 7, and Oct. 5, 2007. Shoot biomass was measured following a 48 hour period of forced-air drying @ 70 ^{o}C. Dry tissue was ground to pass a 40-mesh sieve, then split for medium temperature furnace combustion (Horneck & Miller, 1998) or microwave digestion and inductively coupled plasma (ICP) spectroscopic analysis of nutrient concentrations (Miller, 1998). Multiplication of clipping yield by associated nutrient concentration provided nitrogen or potassium offtake (in lbs N or K per 1000 ft^2), permitting subsequent analysis of each as a dependent variable (Schlossberg & Schmidt, 2007).

Table 4. Yet unspecified Experiment 2 liquid fertilizer program formulations (from labels).

Fertilizer	Weekly rate	N	P_2O_5	K_2O	Fe	Mn	Density	N	P_2O_5	K_2O	Fe	Mn
	per 1000 ft^2	%	%	%	%	%	lbs. / gal.	lbs. / 1000 ft^2				
Urea	0.217 lbs.	46	0	0	0	0	na	0.10	0	0	0	0
4-Iron	0.115 lbs.	10	0	0	4	2	na	0.01	0	0	0.005	0.002
LebanonTurf NF	12.00 oz.	10	0	10	1.2	0.1	10.7	0.10	0	0.1	0.012	0.001
LebanonTurf NF	6.73 oz.	18	2	5	1	0.1	10.6	0.10	0.01	0.03	0.006	<0.001

Figure 2. Measured environmental conditions in 2007; PSU Valentine Turfgrass Res. Center.



Field Results:

Weather conditions over the 18-week study were typical for the central Pennsylvania region (Fig. 2). Over the period of June 1 to Aug. 31, 2007; mean maximum or minimum daily temperature was 80.5 or 60.1 ^{o}F, respectively. Average maximum daily relative humidity was 96%. Summer precipitation was dependable, yet supplemental irrigation was applied throughout September.

Experiment 1: Penn A4 Reduced Fungicide Program

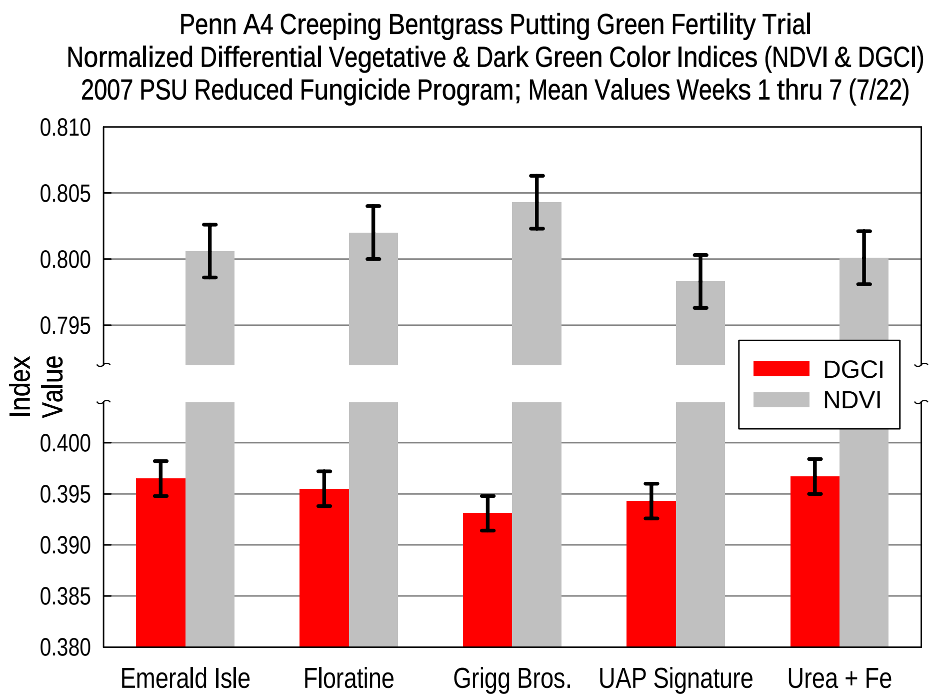
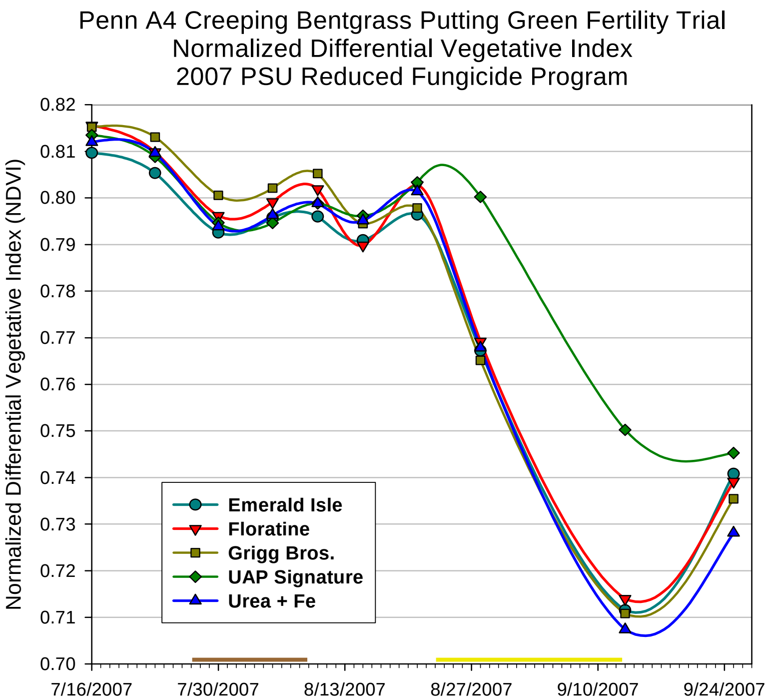


Figure 3. Penn A4 NDVI and DGCI data weeks 1 through 7. Fertilizer treatment mean values having overlapping error bars are not significantly different (α = 0.05).

No disease activity was observed in the reduced fungicide trial through the 3rd week of July. As temperatures increased over the first 7 weeks, consistently increasing canopy density (NDVI) and color (DGCI) values were measured. However, few differences in putting green NDVI or DGCI were detected between the liquid programs during this initial experimental period (Fig. 3).

Just as the density of the bentgrass green canopies reached their maximum values observed over the experimental period to date, pathogenic fungi became active. Signs of brown patch fungus (*Rhizoctonia solani*) were first observed July 27 as rainfall accumulated to 1.2" over the 5-d period ending July 29 (Fig. 2). Warm temperatures broke temporarily from July 28 through the 30th, but temperatures >90 °F returned on July 31st and persisted through Aug. 5th (Figure 2). Over this period of high temperatures and humidity levels, brown patch activity became increasingly widespread. Classic 'smoke rings' remained visible at the outer margins of the diseased areas well into the afternoon hours. Interestingly, no significant association of brown patch activity and liquid fertilizer program(s) was observed (Figure 4). All plots were initially and similarly afflicted with patches 12- to 18-inches in diameter. Air temperatures reached 92 °F and 'smoke rings' developed on Aug. 8th. With heavy rains predicted for Aug. 9, a decision to arrest continued advancement of the disease was made. Following 0.4" of morning and early afternoon rainfall on Aug. 9, 2007; a curative dose of flutolanil (2 oz./1000 ft^2) was applied to the Penn A4 putting green (Table 3).



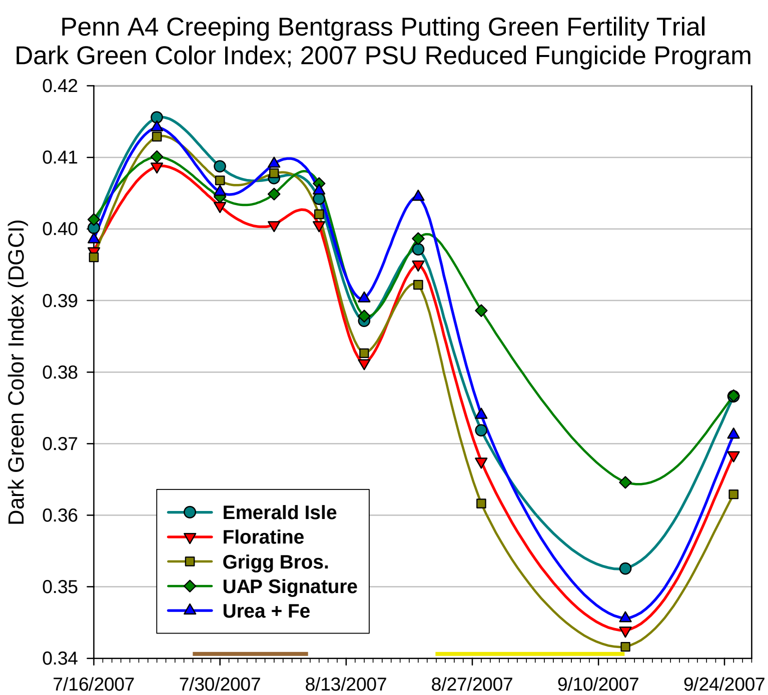


Figure 4. Penn A4 density (NDVI, top); and color (DGCI, bottom); by fertilizer program and date. Periods of disease activity are designated by colored lines on x-axis; brown patch=brown line; dollar spot=yellow line.

The NDVI and DGCI values recorded during the middle 2-weeks of July on the reduced fungicide Penn A4 putting green fertility trial were the highest measured to that date and the highest of the remaining experimental period (Figure 4).

Visual quality of the Penn A4 putting green improved over a 10-d period following the Aug. 9 curative fungicide application. However, nearly 2.5" of rain fell over the period of Aug. 19 to 22, while fertilizer applications were made on Aug 21 (cumulative treatment N=1.1 lbs N/M). Despite the N application, declining quality measures of the putting green ensued in the seven days following the Aug. 21 spray (Fig. 4). While Aug. 28 percent cover data (from digital image analysis) did not show significant decline (Fig. 5), symptoms of dollar spot

(*Sclerotinia homoeocarpa*) infection were readily apparent in the Exp. 1 plot borders. Cool evening temperatures; warm, humid daytime conditions; and the 13 day period that elapsed since the last fertilizer program application were all potential contributors to the widespread development of dollar spot infection on Sept. 2, 2007. Fertilizer treatments were reapplied Sept. 3, yet the severity of the dollar spot epidemic worsened, resulting in the lowest experiment-wide percent green canopy cover measured-to-date on Sept. 10 (Fig. 6).

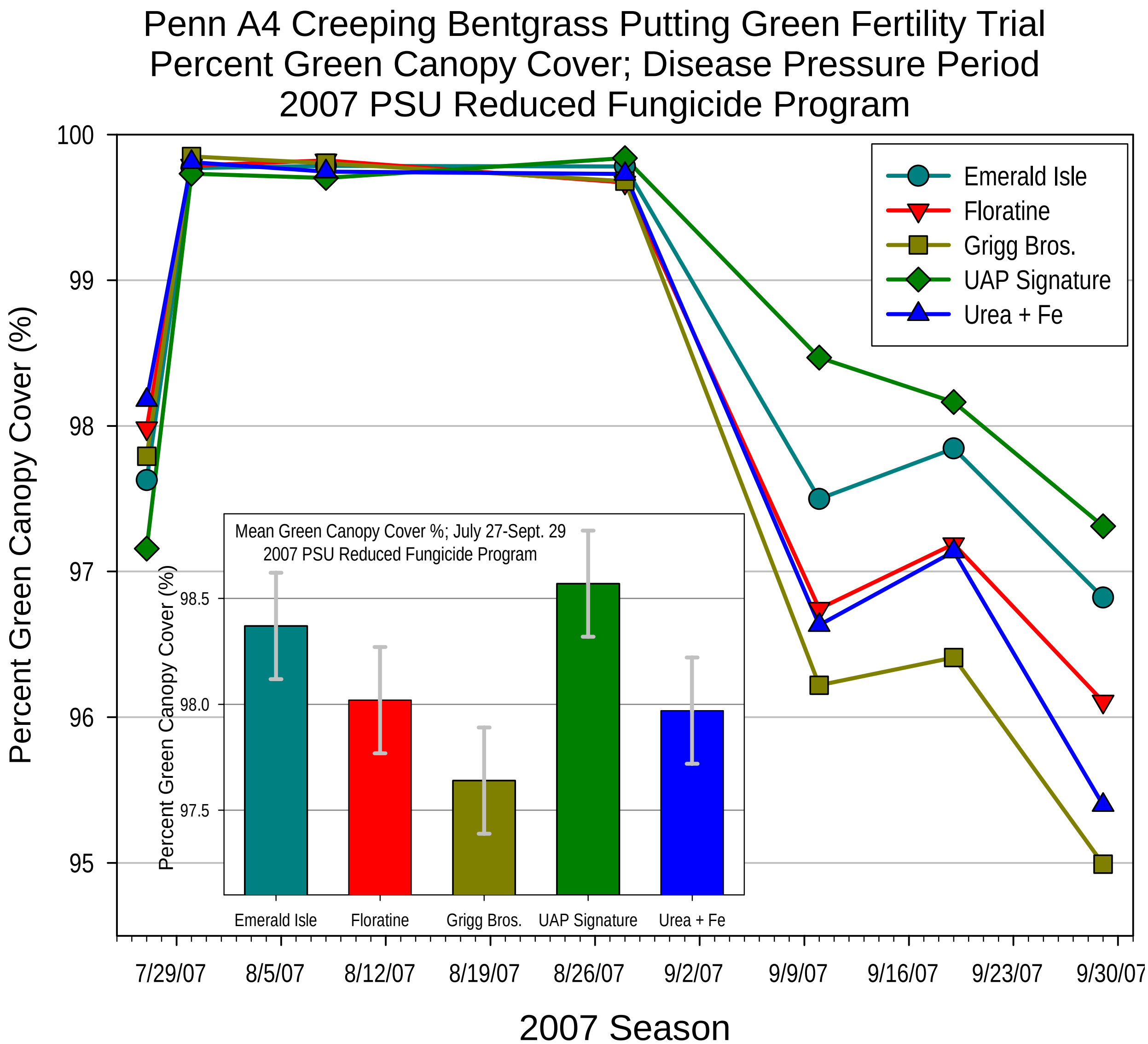
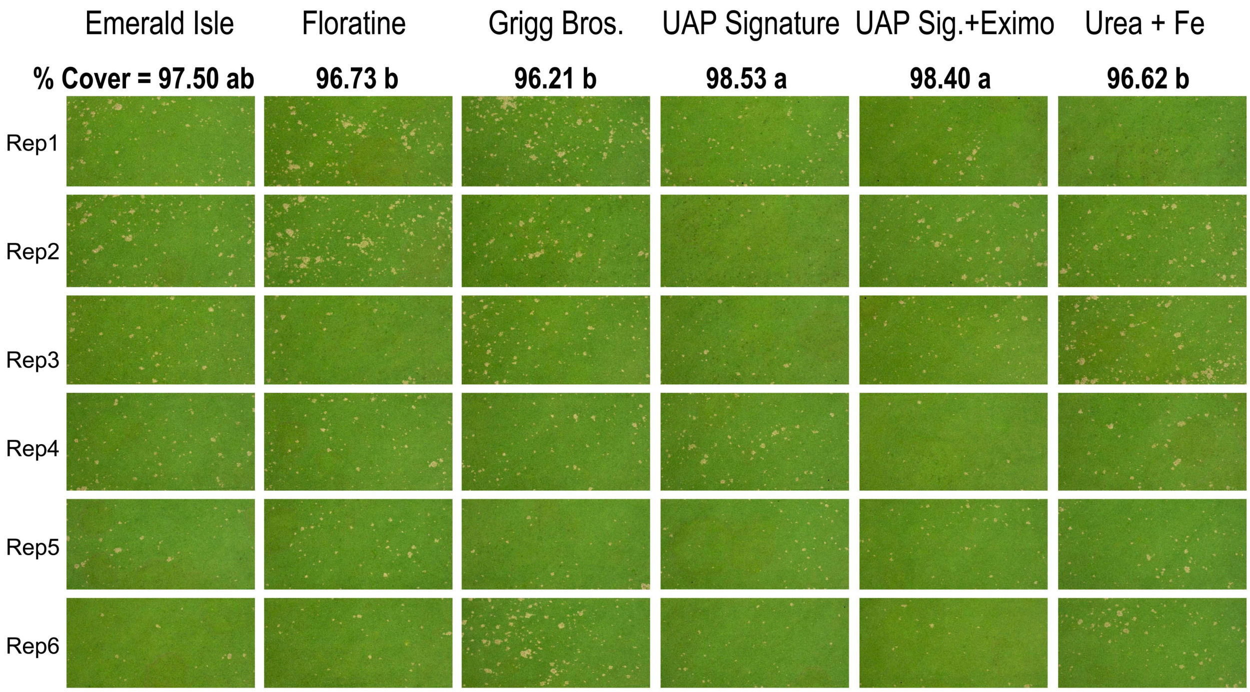


Figure 5. Penn A4 percent green canopy cover; by liquid fertilizer program and date. The bar graph (inset) shows main fertilizer program effects over the period of disease activity (Mean percent cover; July 25 through Sept. 29, 2007). Fertilizer program treatment mean values having overlapping error bars are not significantly different ($\alpha = 0.05$).

Cooler temperatures facilitated recovery of the Penn A4 putting green in mid-September (Fig. 2). Marginal improvements in DGCI, NDVI, and percent green canopy cover were observed after Sept. 13 (Figs. 4 and 5), the day of the next subsequent fertilizer program application (cumulative treatment N=1.3 lbs N/M).

Figure 6. Digital images of originally-randomized Penn A4 creeping bentgrass putting green plots (n=36), collected Sept. 10, 2007. Alphabetically-arranged liquid fertilizer program treatments (left to right) shown above with percent green cover means (Sept. 10 ONLY). Fertilizer mean values sharing a similar letter are not significantly different (α = 0.05).



Penn A4 putting green canopy density and color varied by fertilizer treatment in August and September (Figs. 4 and 5).While earlier brown patch infection showed no correlation to fertilizer treatments, severity of dollar spot occurrences were significantly influenced by the liquid fertilizer program treatments (Fig. 6). Dollar spot, a primary limitation of creeping bentgrass putting green quality (Walsh et al., 1999), is effectively managed through integration of culture and chemical control. Nitrogen sufficiency of turfgrass limits dollar spot susceptibility simply by fostering natural shoot/leaf elongation (Couch, 1973). In times of reduced pathogenicity, sustained vegetative growth facilitates ‘mowing-off’ of necrotic tissue and latent mycelium.

From July 27 to Aug. 29, the liquid fertilizer programs residing in the highest statistical grouping of percent green cover were Emerald Isle and both UAP Signature programs (Fig. 5). Similar observations were collected Sept. 10, when overall percent green cover of the Penn A4 plots was at the experiment-wide low (Fig. 6). Upon evaluating the feasibility of no-fungicide management programs in New York, Grant and Rossi (2004) identified dollar spot as a highly-dependable saboteur of putting green quality over the mid- to late-summer period. Dollar spot control is likely the most common objective of fungicide applications to golf course putting greens in the US. As the potential for dollar spot to reduce putting green quality both exists and reportedly correlates to creeping bentgrass fertility/nutritional status; generation of data showing frequent applications of N-standardized liquid fertilizer programs to significantly affect Penn A4 disease susceptibility is relatively exciting. However, lack of supporting Exp. 1 tissue nutrient concentration data precludes meaningful correlation of nutritional parameters to these observed responses. Interestingly, 4 of the 6 liquid fertilizer programs (Emerald Isle, Floratine, and the UAP Signatures) contained naturally-occurring organic N compounds (e.g. active culture, kelp extracts, and/or amino acids). Yet in a long and increasingly-predictable tradition of turfgrass nutritional research, wide variations in disease susceptibility across the four ‘natural-organic-fortified’ liquid programs has again thwarted definitive linkage of natural organic fertilizer use and turfgrass disease suppression.

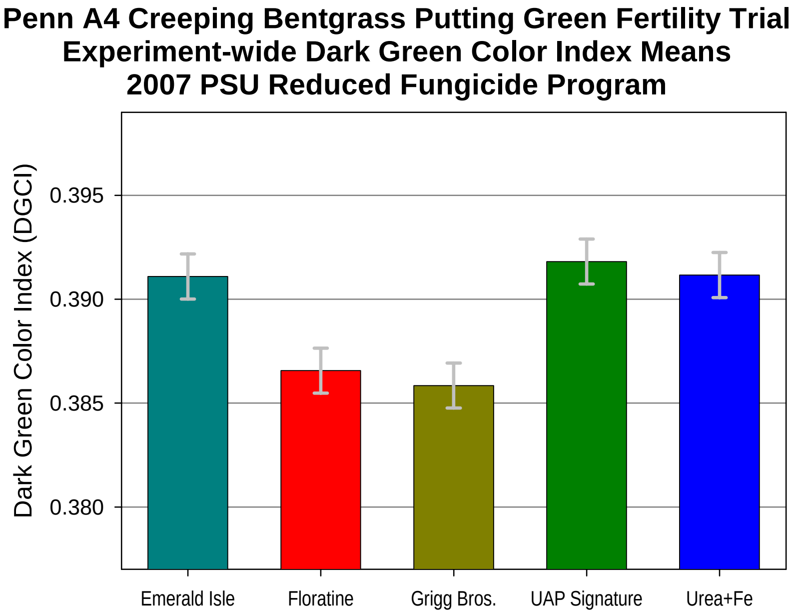


Figure 7. (above) Experiment 1 mean canopy DGCI by Fertilizer program. Mean values having overlapping error bars are not significantly different (α=0.05).

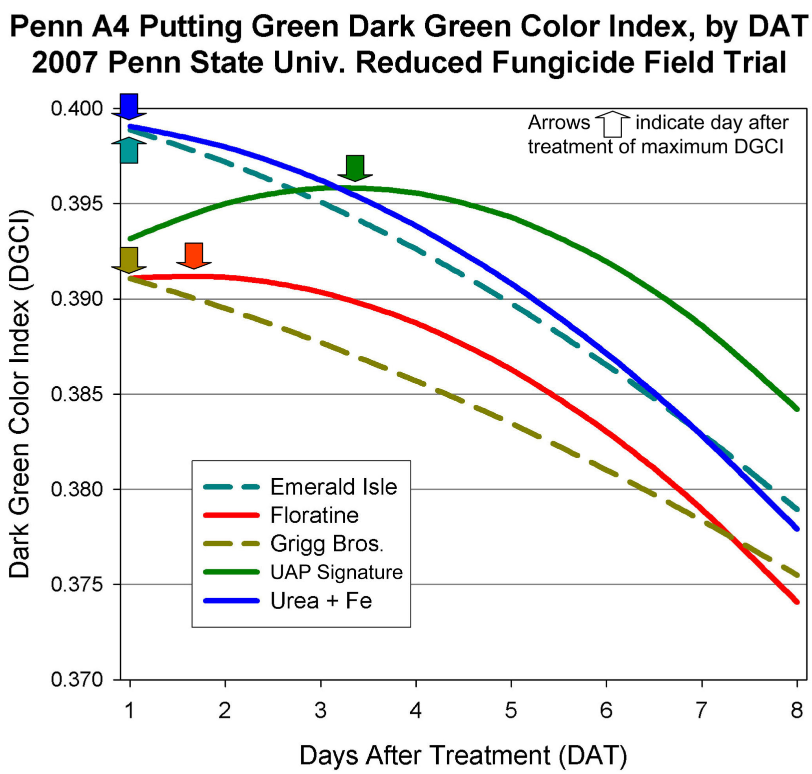


Figure 8. (right) Experiment 1 predicted mean canopy DGCI by days after treatment (DAT) and fertilizer program. Arrows indicate DAT of maximum DGCI.

Penn A4 bentgrass DGCI values averaged across 39 collection dates (Fig. 7) summarize the experiment-wide canopy color differences by liquid fertilizer. Polynomial regression estimates of the intra-application daily dark green color indices by day after treatment (DAT) were derived from 6 replicate plots over 39 observation dates, and show specific time-response of each fertilizer program (Fig. 8). As one might expect, the fertilizer programs showing the darkest green canopy color immediately following treatment in the image taken July 3 (p. 6), also show the greatest DGCI values 1-2 DAT in Fig. 8. The derivative of each prediction equation was used to identify the precise DAT of maximum DGCI observation (arrows; Fig. 8). Predicted DGCI values and the difference between the predicted maxima and minima values are shown for each liquid fertilizer program (Table 5).

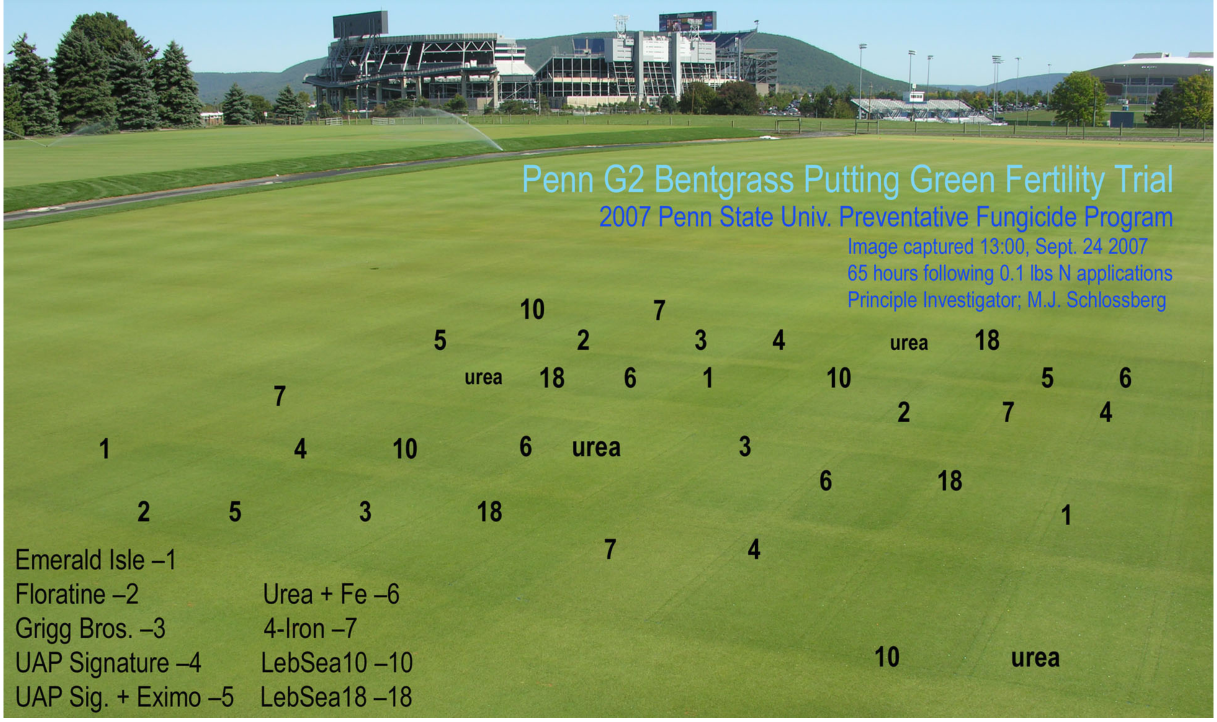
Table 5. Polynomial regression estimates of Penn A4 creeping bentgrass putting green canopy dark green color index (DGCI) by fertilizer program and 1 to 8 days after treatment (DAT).

Dark Green Color Indices (DGCI)	Emerald Isle	Floratine	Grigg Bros.	UAP Signature (avg. both TRTs)	Urea + Fe
Predicted minimum	0.3789	0.3741	0.3755	0.3842	0.3779
Predicted maximum	0.3989	0.3911	0.3911	0.3958	0.3991
Difference (max.–min.)	0.2000	0.0170	0.0156	0.0116	0.0212

While the magnitude of bentgrass DGCI values indicate darker green canopy color, golf course superintendents are wise to base their own canopy color preference on conditions and experience. Yet most superintendents will agree on the importance of consistent canopy color throughout the fertilizer reapplication interval. At a given monthly N rate, Bowman (2003) showed frequent N delivery to turfgrass fostered greater leaf tissue chlorophyll concentrations than infrequently fertilized turfgrass. Likewise, steady N-supply recipients demonstrated more consistent shoot growth and greater root-to-shoot ratios than less frequently fertilized turves. While whole plant response was not measured in our field studies, intensity and duration of canopy color response varied by fertilizer program over the average 8-day interval spanning liquid fertilizer program reapplications (Table 5).

Experiment 2: Penn G2 Preventative Fungicide Program

No signs or symptoms of disease were observed over the course of this 18-week Penn G2 preventative fungicide program trial. Consistently increasing canopy density (NDVI) and color (DGCI) values were measured over the first 6 weeks, followed by a leveling-off through August and September. Compared with Exp. 1, less week-to-week variability in canopy density and color was observed in this trial. While differences between the two experiments were observed, similarities also emerged. Canopies of both varieties showed a notable darkening in green color



as few as 20 minutes after application of certain fertilizer programs. Other programs showed more a subtle early-greening response that often intensified later and lasted longer.
Clipping yield was measured once each month of the Penn G2 fertility trial. Clipping yield was statistically influenced by liquid fertilizer program but not by fertilizer interactions with day of year or days after treatment (DAT). Essentially, the observed growth response to any fertilizer program was consistent over the months of July, August, Sept. and October. While absolute values of all shoot biomass production varied over these months, relative differences between fertilizer programs did not. From this it can be inferred that despite the uniquity of each liquid fertilizers program's components, nutrient delivery associated with each fertilizer treatment more significantly governed shoot growth than environmental conditions and/or time elapsed from last treatment. This result supports the effectiveness of frequent fertilizer applications in maintaining consistent performance of intensively managed creeping bentgrass putting greens.

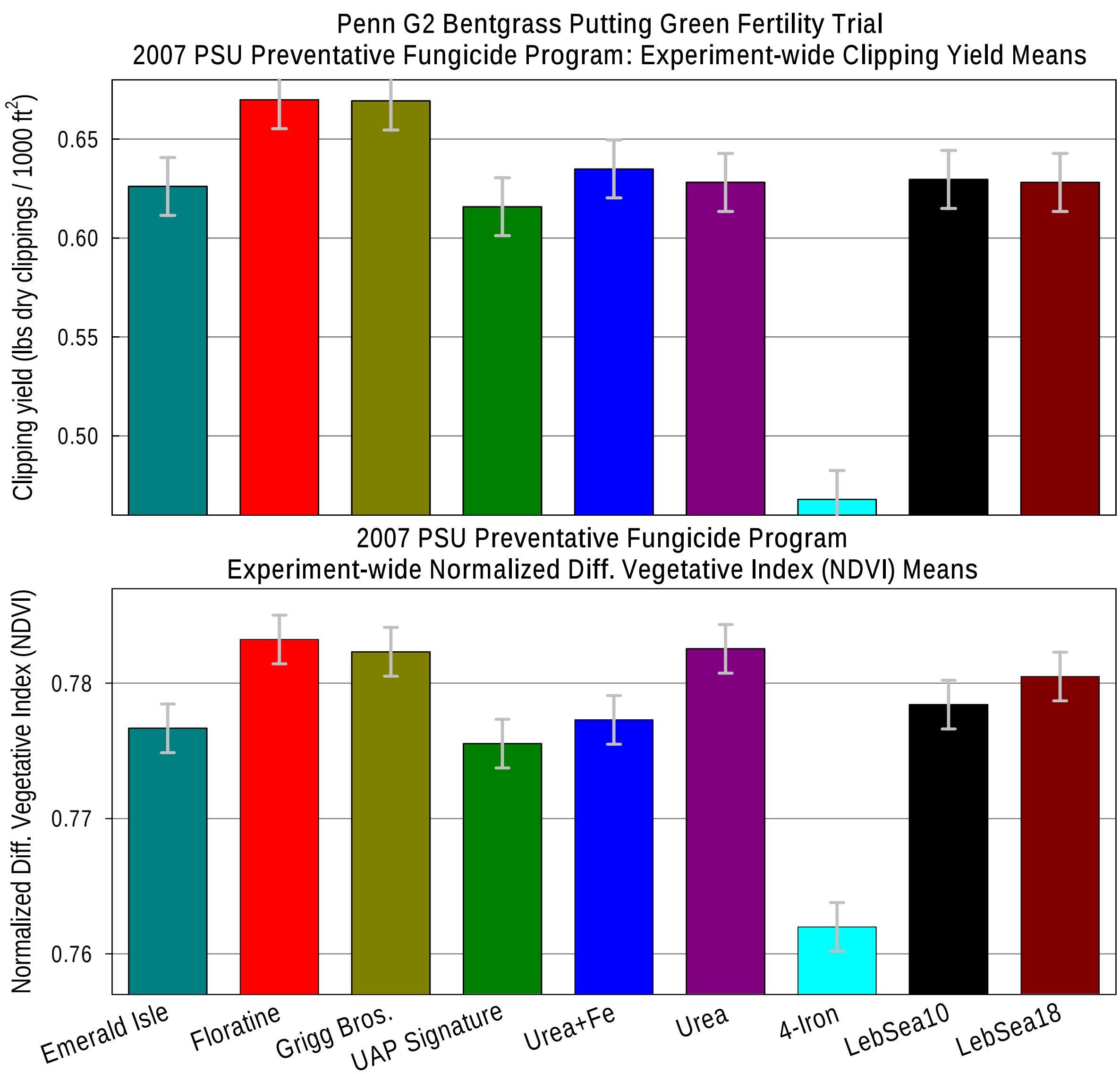


Figure 9. (a; top) Experiment-wide mean Penn G2 shoot growth rate (clipping yield) and (b; bottom) normalized differential vegetative index (NDVI); by fertilizer program. Treatment means having overlapping error bars are not significantly different ($\alpha = 0.05$).

All fertilizer programs (excepting 4-Iron) supplied 0.1011 to 0.1039 lbs N / 1000 ft^2, per application. Yet across the seven fertilizer programs, variation in Penn G2 shoot growth exceeded the slight disparity in N delivery rates (±1.4%) in either direction from the mean (Fig. 9a). The experiment-wide clipping yield grand mean (all fertilizer programs) was 0.637 lbs per 1000 ft^2, nearly the exact mean growth observed of the Urea + Fe treatment. Floratine and Grigg Bros. treatments fostered significantly more daily growth than all others, and no significant differences were observed between the remaining (0.1 lbs N) treatment programs (Fig. 9a).

The normalized differential vegetative index (NDVI) is an indirect measure of vegetative biomass residing between the ground and a multi-spectral radiometer. Contrary to popular opinion, NDVI is not the same as canopy color or DGCI. A remotely significant correlation of the two measures was observed in 1,866 pairs of Penn G2 putting green NDVI and DGCI data collected in 2007 (r = 0.248). These data reveal a much stronger correlation between putting green canopy NDVI measures and clipping yield than DGCI (Figs. 9a & b). Moreover, similarly ostensible associations of canopy NDVI and clipping yield have emerged from additional, independent field studies of creeping bentgrass putting greens conducted in 2006 and 2007.

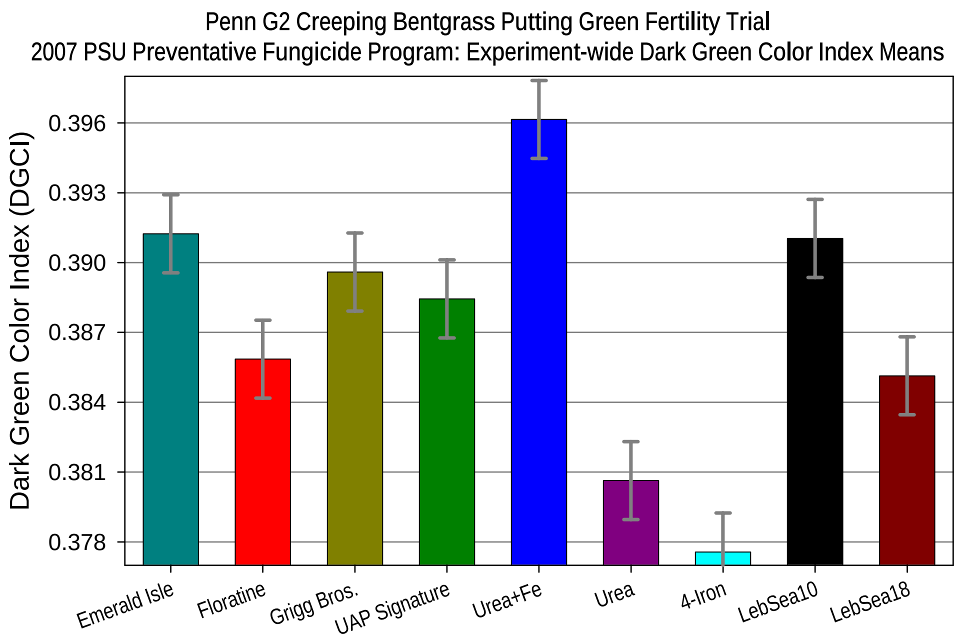


Figure 10. Exp. 2 mean canopy DGCI by fertilizer program. Program treatment means showing overlapping error bars are not significantly different (α = 0.05).

For most turfgrass field researchers, the potential substitution of field clipping yield collections by this rapid and repeatable application could be the most exciting development since personal computers. Apart from these ridiculously mundane things we researchers get excited about, the NDVI measurement is much more sensitive to biomass accumulation in putting green canopies than the human eye. In theory, a maximum lateral shoot density, or carrying capacity, exists for each and every intensively-managed turfgrass cultivar. It is the professional opinion of the principle investigator that this upper-threshold of Penn G2 lateral density was reached by the first clipping yield (7/20). Thus, the remaining source of NDVI variation among the fertilizer programs was vertical extention of vegetation occuring between the last mowing event and NDVI measurement (Fig. 9).

Experiment-wide Penn G2 DGCI values pooled across 47 collection dates (Fig. 10) summarize canopy color differences by fertilizer program. As in Exp. 1, mean DGCI of common fertilizer programs (sans both LebanonTurf products, urea, and 4-iron) ranged from 0.385 to 0.395. Experiment-wide Penn G2 DGCI values of most commercial fertilizer programs fell in the second statistical grouping, having significantly less dark green color than the urea + Fe treatment (Fig. 10).

As mentioned, many superintendents prioritize consistent canopy color over a rapid, intense, dark greening of canopy color that is not retained more than 3-4 days. As in Exp. 1, polynomial regression estimates of the intra-application daily dark green color indices were developed by day after treatment (DAT). More Penn G2 data was available in this experimental model than in Exp. 1; four replicate plots over 47 dates of observation. Regression derivatives identified the specific DAT of maximum DGCI observation (arrows; Fig. 11). While, the disparity in canopy DGCI between fertilizer programs over an average 8-day fertilizer reapplication interval was more pronounced in Exp.1 (Penn A4), differences in canopy color consistency were observed in Exp. 2 (Fig. 11). For each fertilizer program, the range of predicted DGCI values and the difference between the maximum and minimum predicted values are shown (Table 6).

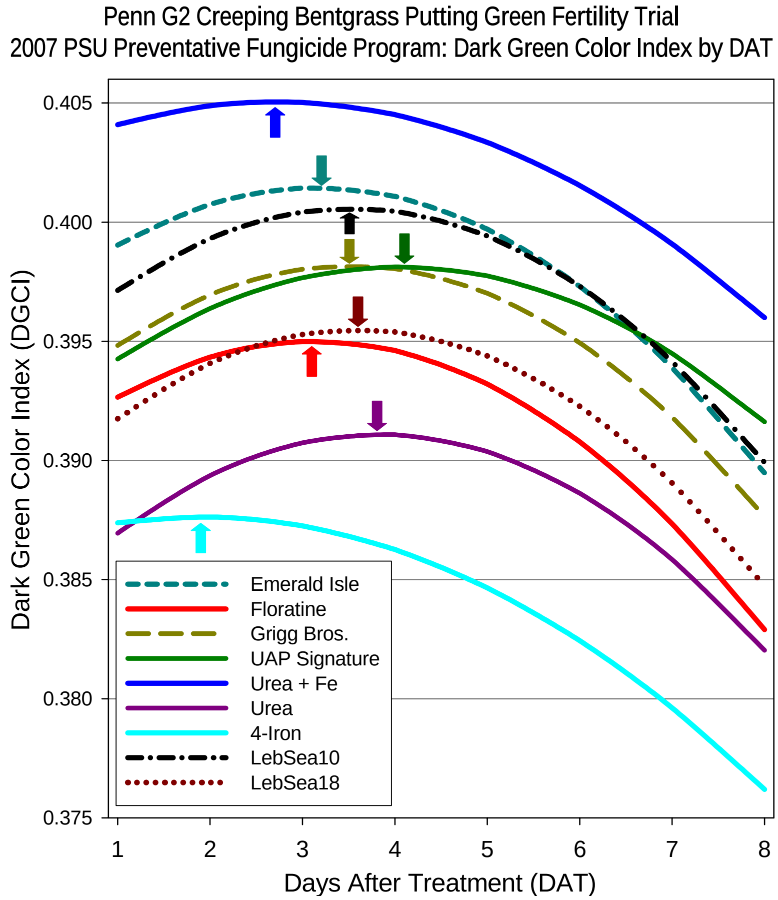


Figure 11. Experiment 2 predicted mean canopy DGCI by days after treatment (DAT) and fertilizer program. Arrows indicate DAT of maximum DGCI.

Penn G2 bentgrass tissue collected in clipping yield measurements was analyzed for nutritional content. As with NDVI, DGCI, and shoot growth data; the frequently-applied liquid fertilizer programs significantly affected tissue nutrient concentrations of Penn G2. However, no significant interactions between

Table 6. (right) Polynomial regression estimates of Penn G2 creeping bentgrass putting green canopy dark green color index (DGCI) by fertilizer program and 1 to 8 days after treatment (DAT).

Fertilizer Program	Maximum DGCI	DAT Max. DGCI	Minimum DGCI	DGCI Diff. Max–Min
Emerald Isle	0.4014	3.2	0.3894	0.01196
Floratine	0.3950	3.1	0.3829	0.01210
Grigg Bros.	0.3982	3.5	0.3877	0.01050
UAP Signature	0.3981	4.1	0.3916	0.00651
Urea + Fe	0.4051	2.7	0.3960	0.00906
Urea	0.3911	3.8	0.3820	0.00906
4-Iron	0.3876	1.9	0.3762	0.01143
LebSea-10	0.4006	3.5	0.3900	0.01065
LebSea-18	0.3955	3.6	0.3848	0.01073

fertilizer programs and day of year or days after treatment (DAT) were statistically identified. Thus for discussion, nutrient offtake and tissue nutrient concentrations are pooled across four and three collection dates, respectively. The N offtake levels demonstrated by fertilizer treatments (Fig. 12b) mirrors the clipping yield data in Fig. 9a. A distribution of nutrient offtake levels that closely resembles associated clipping yield data provides evidence of similar nutrient concentrations across treatments. This proved to be true of Penn G2 tissue N content (Fig. 12a),

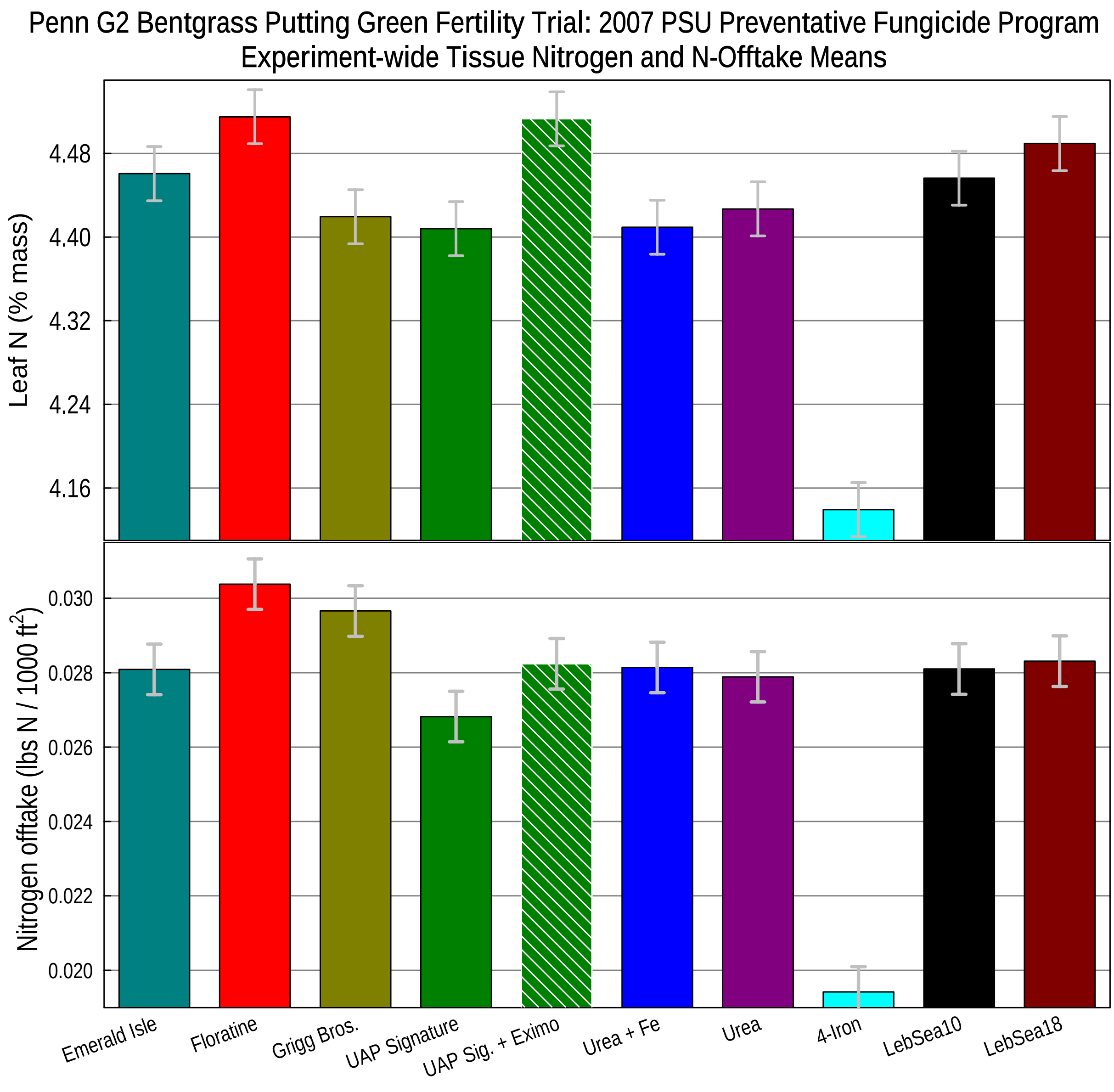


Figure 12. (a; top) Experiment 2 mean tissue nitrogen by fertilizer program; and (b; bottom) mean N offtake by fertilizer program. Offtake is nutrient mass debits from the system through removal of clippings. Fertilizer program treatment mean values having overlapping error bars are not significantly different ($\alpha = 0.05$).

particularly because the putting green was supported by fertilizer treatment applications formulated to deliver a standard N rate (0.1 lb /1000 ft^2) on 8-d intervals over the 18-week study. Across this time frame, Penn G2 plots fertilized by nearly all programs showed similar tissue N levels in clippings, but significantly less tissue N than Floratine and the UAP Signature + Eximo treatment programs (LebanonTurf 18-2-5 also resided in the highest statistical grouping; Fig. 12a). Across all programs, the greatest tissue N levels (4.81–4.91 %) were detected 8/10. This was likely due to sustained high soil temperatures favoring mineralization of the soil organic matter present. In early October the lowest tissue N levels were registered (4.00–4.12 %) and no significant differences by fertilizer programs were observed. This was likely due to the 14-d period between spray and yield collection and the occurrence of the coolest temperatures recorded in the study. It is important to note that the four clipping yields were measured 2 days after treatment (DAT; 7/20), 4 DAT (9/7), 5 DAT (8/10), and 14 DAT (10/5), and that clipping yield collections (with tissue nutrient analyses) quickly followed fertilizer spray applications. As stimulation of bentgrass shoot growth increases with delivery of plant available N, large N offtake levels in this early interval are less than desireable (Fig. 12).

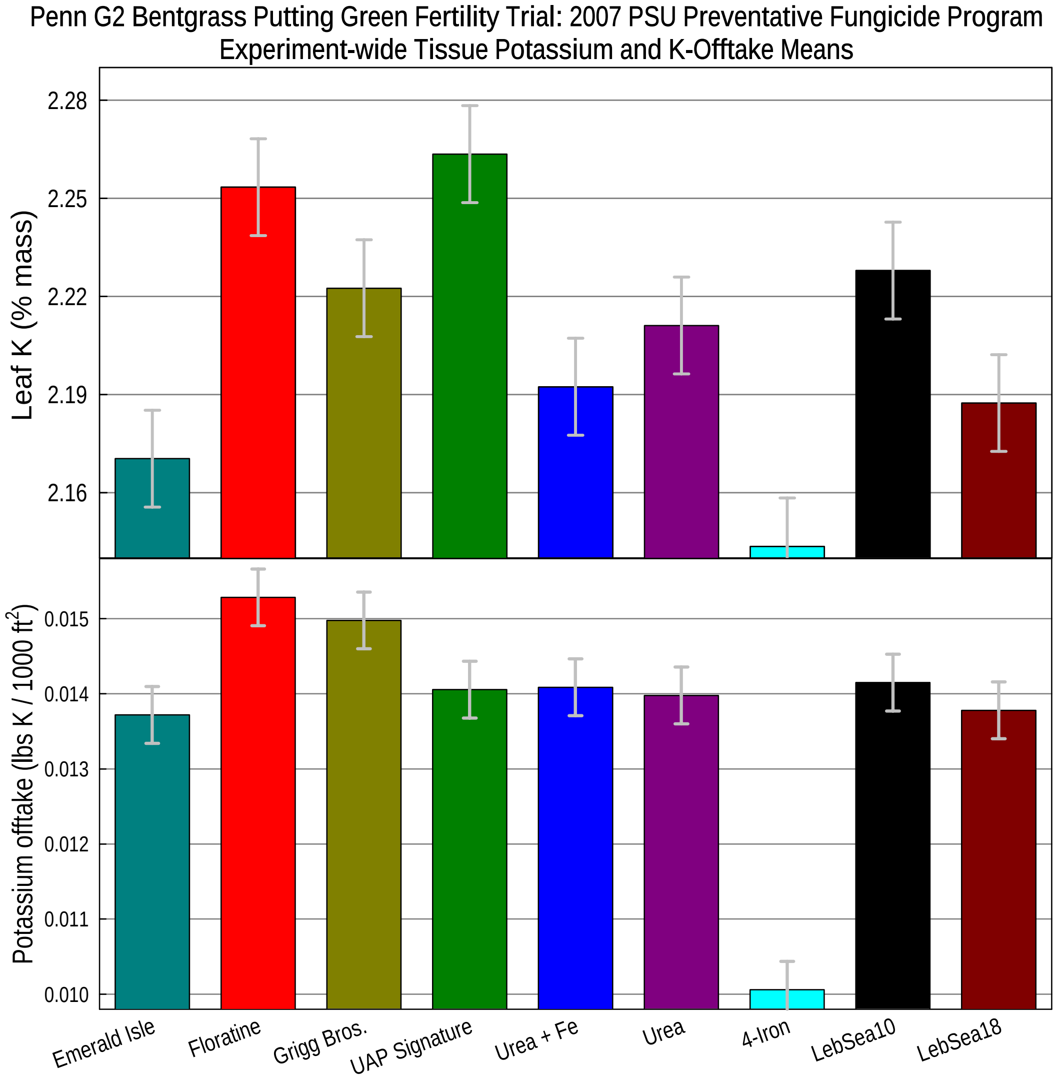


Figure 13. (a; top) Exp. 2 mean tissue potassium by fertilizer program; and (b; bottom) mean K offtake by fertilizer program. Fertilizer program treatment mean values having overlapping error bars are not significantly different (α = 0.05).

As potassium (K) serves as a critical osmoregulant of leaf and shoot tissue, the improtance of K sufficiency in intensively managed turfgrasses really cannot be over-emphasized. The general K sufficiency threshold of creeping bentgrass is 2.2 %. Many historic references list the bentgrass tissue K sufficiency level as 2.8-3.0 %, yet more recent research proves this threshold is nearly impossible to attain and more accurate of other cool season turfgrass species. For example, mean leaf K levels in the UAP Signature, Floratine, LebanonTurf 10-0-10, Grigg Bros., and Emerald Isle; rank by K_2O delivery rates associated with their formulations (Tables 2 and 3). In the case of both UAP Signature and Floratine, K_2O delivery rates exceeded those of N; yet tissue N exceeded tissue K by nearly 2X. Were creeping bentgrass capable of assimilating K to tissue levels near 3.0%, greater K levels in Exp. 2 Penn G2 clippings would have been reported. Application of LebanonTurf 18-2-5 delivered the least amount of K_2O (0.028 lbs K_2O / 1000 ft^2) among the 8 commercial program treatments. Turfgrass vegetation generally requires 5 and 9 times more K than Ca and Mg, respectively. Fertilizer programs showing the greatest clipping yield generally resided in the highest statistical grouping of K offtake. Over the four monthly data collections, UAP Signature treatments were the only resident of both the top statistical grouping of leaf K (Fig. 13a) and the bottom statistical grouping of K offtake (Fig. 13b). As plant water regulation and drought tolerance are critical functions of resident tissue K, large K offtake

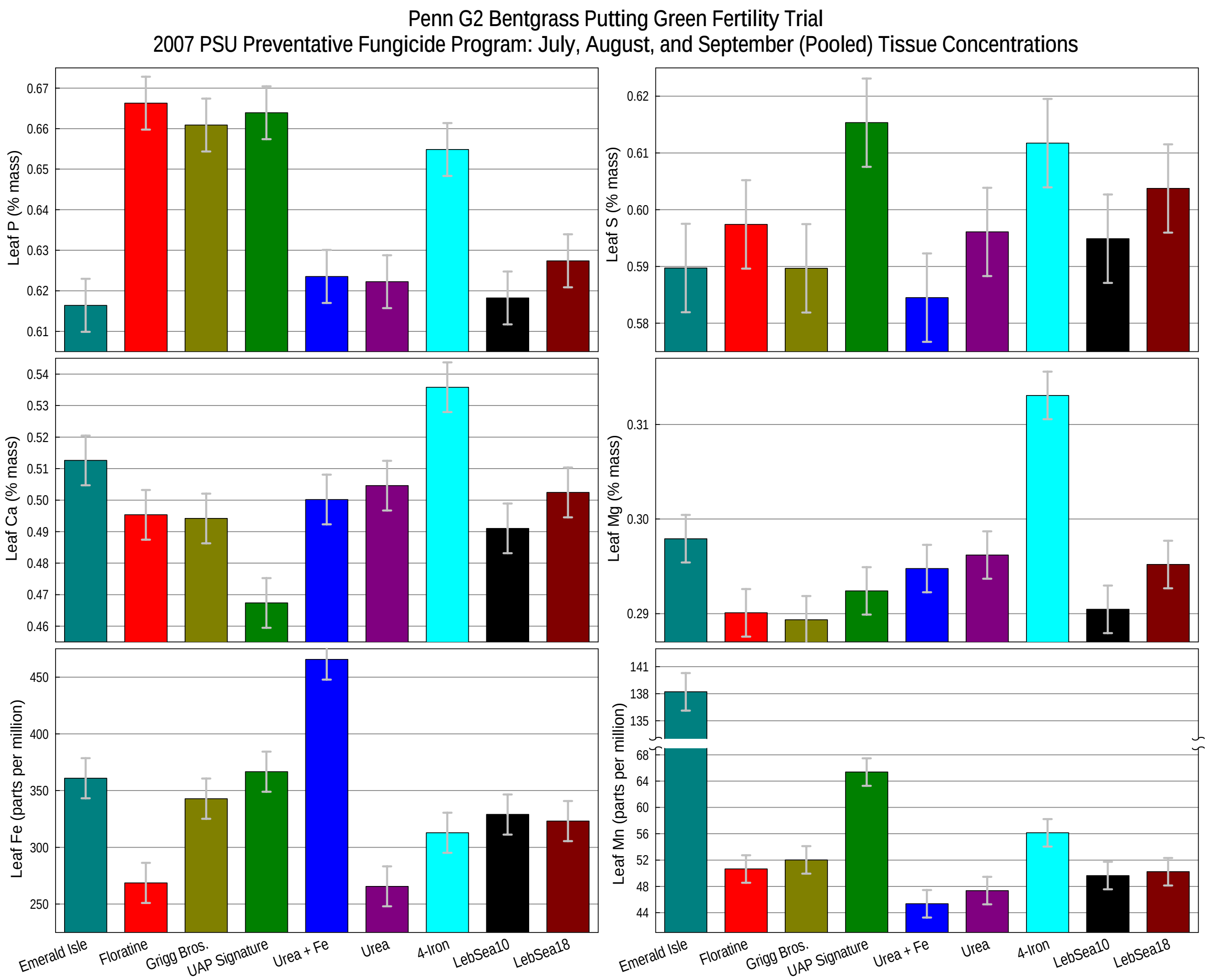


Figure 14. Exp. 2 mean leaf/shoot tissue concentration of P (top, left); S (top, right); Ca (middle, left); Mg (middle, right); Fe (bottom, left); and Mn (bottom, right), by treatment. Data pooled over the first 3 collection dates (July, Aug., and Sept.; 2-5 DAT). For any nutrient, fertilizer program mean values having overlapping error bars are not significantly different ($\alpha = 0.05$).

levels in the 2-5 DAT interval are considered undesireable (Fig. 13b). Loss of K through clipping removal is particularly problematic in systems where clippings are not returned, and/or during periods of drought or supraoptimal soil temperatures.

Under the conditions of Exp. 2, nearly all fertilizer programs fostered sufficient nutrient concentrations in Penn G2 creeping bentgrass vegetation (Fig. 14). Tissue nutrient concentrations mirrored delivery rates associated with the fertilizer programs. In the immediate time frame following fertilizer applications (2-5 DAT), tissue N levels departed from the standard delivery rate across all programs as shown in Fig. 12a. This is likely a response to immediately available N forms, but variability between program N delivery and associated tissue N levels preclude relationships from being definitively developed. The tissue K disparity between the urea + Fe or urea treatments (devoid of K_2O) and commercial programs (containing K_2O) is likely to be the result of the commercial programs' loading of Ca, and subsequent competition with K for uptake. Across all of Exp. 2, general nutrient sufficiency of Penn G2 creeping bentgrass was high. The leaf S levels measured in this study challenge conventional S interpretations of creeping bentgrass putting green tissue levels and justify future evaluation.

Discussion:

While the two experiments described herein represent two popular creeping bentgrass cultivars currently surfacing golf course putting greens worldwide, both experiments were conducted in a common location, under identical environmental conditions, and on a common root zone medium. Beneath the 2.5" topdressing layer, the underlying 'push-up' root zones were both neutral and relatively fertile silt loams having high organic matter content, despite the subtle differences shown in Table 1. Likewise, these experiments were managed similarly to golf course putting greens but likely endured comparatively less foot traffic. Mowing, growth regulation, and topdressing practices were employed, but under less-intense regimes than conducted on most golf course putting greens. Conversely, the reduced fungicide program employed in Exp. 1 facilitated observations of a condition proven difficult to reproduce on operational putting greens, and provides new information to the many interested stewards of integrated pest management programs.

While fertilizer efficacy under reduced- and zero-fungicide programs has been evaluated on a golf course, Grant and Rossi (2004) reported the experimental conditions to be challenging. The scope and effort associated with their ambitious evaluation was most admirable, but the psuedo-replicated design weakened its statistical power. Furthermore, frequent applications of numerous biological control agents confound strict interpretation of the results. Overall, the concensus among turfgrass researchers is that the Grant and Rossi study ingeniously produced unique and invaluable results when they were needed most. Their results single-handedly provided the evidence necessary to rapidly reverse enactment of numerous county/municipal ordinances restricting all pesticide applications. While the purpose of the research described herein is more limited in scope; it provides simple, objective, and useful information to practitioners. A Latin square experimental design was employed for its inference power and advantageous reduction of spatial variability. Furthermore a second year of Exp. 1 (reduced fungicide program) data collection is scheduled for 2008. Skeptics are free to brand the described experimental conditions as ‘limited’ or ‘unrepresentative of actual golf course conditions’, but the imposed features of the Exp. 1 reduced fungicide program could not be easily reproduced elsewhere. For instance, multiple ‘no pesticide’ putting greens were closed to play for portions of each year in the Grant and Rossi (2004) study.

Conclusions:

Under the environmental and cultural conditions described in Experiment 1 (Penn A4–reduced fungicide program), and:

- During a 2-month period of severe disease activity, plots treated with the UAP Signature liquid fertilizer programs showed significantly greater percent canopy cover than all programs except Emerald Isle (July 27 to Sept. 29, 2007).
- During a 3-week period of severe disease activity (dollar spot), plots treated with the UAP Signature liquid fertilizer programs showed significantly greater canopy density (NDVI) than all programs (Aug. 23 to Sept. 13, 2007).
- Of the fertilizer programs evaluated over the 18-week study, the UAP Signature treated plots demonstrated the highest predicted minimum dark green color index (DGCI) over the average reapplication interval of 8 days.

Under typical putting green culture and the environmental conditions described in Experiment 2 (Penn G2–preventative fungicide program), and of the ten fertilizer programs evaluated:

- Experiment-wide leaf/shoot growth response to the Floratine and Grigg Bros. fertilizer programs was significantly greater than all other programs.
- After the Urea + Fe treatment; UAP Signature, LebanonTurf 10-0-10, Grigg Bros., and Emerald Isle treatments resided within the second-highest statistical grouping of Penn G2 experiment-wide putting green canopy dark green color index (DGCI) response.
- Fertilizer nutrient recovery and retention varied over the 0.1 lbs N /1000 ft^2 programs; yet only the UAP Signature fertilizer program resided in the top statistical grouping for experiment-wide leaf/shoot tissue P, K, and S concentration, while residing in the bottom statistical grouping of experiment-wide N and K offtake by clippings.

The following observations are common to the putting green culture and the environmental conditions described in both 18-week experiments (Penn A4 and G2):

- Predicted dark green color index (DGCI) response to UAP Signature treatments demonstrated the least predicted daily variation over the 8-day reapplication intervals.
- Maximum predicted dark green color index (DGCI) response to the UAP Signature fertilizer program occurred latest over the 8-day reapplication intervals; 3.2 and 4.1 days after treatment in Exp. 1 and 2, respectively.
- Of the 5 commercial programs evaluated, only UAP Signature and Emerald Isle treatments resided within the top statistical grouping of both experiment-wide putting green canopy dark green color index (DGCI) responses.

Disclaimer: Trade and/or manufacturer's names mentioned in this report are for information only and do not constitute endorsement, recommendation, or exclusion by the author or PSU. Above-mentioned turfgrass responses resulted from treatment applications to specific sites SOLELY AS DESCRIBED herein, as allowed by regulations governing agronomic use of such materials.

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Figure 15. Halfway done with Penn G2 clipping yields, Aug. 10, 2007.

THATCH DECOMPOSITION BY SYSTEMATIC SURFACE APPLICATIONS OF I-MOL™

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Introduction: Accumulation of thatch is generally undesirable yet inherent to intensively-managed turfgrass systems. Thatch accumulation has become a more serious concern with the increased use of new, high-density and aggressively-growing turfgrass varieties. Though thatch accumulation is traditionally mitigated through cultural practice, such as topdressing and/or physical cultivation techniques (e.g. verticutting and/or core aerification), these procedures are labor-intensive and disrupt playing quality. Moreover, the recognized long-term benefits of physical cultivation can be offset by increased susceptibility to tissue desiccation and/or cutworm infestation in the short-term, and/or intensified weed pressure through long-term surface redistribution of the soil seed bank.

For these reasons, there has long been interest in products that can effectively control thatch without causing the physical disruptions. Over the last several decades, products containing 'bioactive' ingredients like enzymes, active cultures, and/or plant hormones have been introduced for this purpose. Application of active culture, like most biological control methods, has not been proven sustainable under field conditions. Similarly, use of organically-fortified liquid meal has demonstrated mixed results. Following a 2-year study of regularly core-aerated and topdressed Crenshaw and Penn A-1 bentgrass putting greens, Willis et al. (2006) reported systematic application of several commercially-available biological thatch control products (Thatch-X, CPR, or molasses) to significantly reduce thatch layer depth (measured at 0.1-mm resolution with a ruler). Conversely, McCarty et al. (2005, 2007) reported exclusive use of Thatch-X, a biological thatch-control agent, to be an ineffective control of thatch-mat depth in respective L-93 and Penn A-1 creeping bentgrass putting greens. Research conducted on thatched bentgrass/annual bluegrass cohabited golf course putting greens did not show systematic application of two biological dethatching agents to effectively reduce thatch (Gibeault et al., 1976; Lancaster et al., 1977).

Undoubtedly, the best way to investigate accumulation or decomposition of thatch is by standardizing all contributing factors that share even a minor association with the treatments of interest. Edaphic factors and their influence on thatch are fairly straightforward. All things equal, and assuming a functional microbial population to be present, thatch decomposition rate correlates positively with: activity of macrofauna (primarily earthworms), pH level (up to slightly alkaline), temperature, and oxygen availability in soil. Likewise, the influence of certain cultural factors (species/cultivar selection, mechanical cultivation, fungicide/insecticide use, etc.) is relatively predictable. Effects of other cultural factors are more widely interpreted; i.e. mowing height and/or frequency, pre-emergent herbicide use, topdressing, and/or fertilization practice (particularly N). To better clarify the point at hand, and avoid reinventing the wheel, I paraphrase Waddington (1992):

> *In thatch studies, researchers may want to control certain factors to eliminate indirect effects. For instance, Potter et al. (1985) showed N fertilization rate increased thatch, while decreasing pH of soil and thatch, as well as earthworm activity. Since previous reports associate increased thatch*

with both soil acidity and reduced earthworm populations, it is difficult to determine whether the increase in thatch was due to N-induced shoot growth (organic matter production), less decomposition due to lowering of earthworm and microbial activity caused by the low pH, or both. Thus, in future research, liming could be used to eliminate the variation in pH due to N rate and appropriate chemicals could be used to control earthworms.

Considering present accumulation of thatch and conditions governing its decomposition are spatially variable in the field, effective measure of any biologically-facilitated and subtle process requires careful planning. The most suitable approach that comes to mind is real-time laboratory measurement of the primary byproduct evolved from microbial thatch decomposition (CO_2). While this technique of measuring biological degradation of thatch was first reported over 30 years ago (Martin and Beard, 1975), it continues to provide a highly resolute measure of soil microbial activity. Evolution rates of 11 lbs C per 1000 ft^2 (500 ft^3) over a 5- to 6-week period of room temperature incubation may appear excessive, yet have been measured in high-OM soils incubated under ambient conditions (Martinez and Tabatabai, 1997). Moreover, as most superintendents can attest, even 'unbelievably' high rates of soil OM decomposition are no match for the OM-deposition rates regularly occurring in managed turfgrass systems.

Use of nutrient-rich, labile, carbon substrate sources, a true cultural control method, has been shown to naturally enhance the population and activity of indigenous soil microbes. In a recent field study, these applications significantly increased decomposition rate of lignified, cellulose-rich organic residues (Boopathy et al., 2001). I-MOL™, From The Ground Up Inc.'s proprietary liquid blend of molasses and iron sulfate, is a non-living, labile carbon substrate containing numerous essential plant macro- and micro-nutrients that serve as a food source for microbial populations.

Experimental Objective: To accurately determine the effectiveness of systematic I-MOL™ treatments on thatch decomposition rate under controlled laboratory conditions, and to measure any influence of fungicide tank mixing on the overall effectiveness of I-MOL treatment.

Table 1. Preliminary Soil Properties	Experiment 1: Sand Putting Green (NJ)	Experiment 2: Mineral Soil Fairway (ME)
Turfgrass Species	*Agrostis palustris* cv. 'Penn A4'	*Agrostis palustris* / *Poa annua* mixture
Mowing Height (inches)	0.15	0.63
Years from Establishment	3.5	~28
Soil Taxonomic Subgroup Designations	Mesic, coated Lamellic Quartzipsamment	Fine, illitic, frigid Typic Epiquept
Soil pH (1:1 H_2O)	7.22	5.04
Bulk Density (g/cm^3)	1.54	0.84

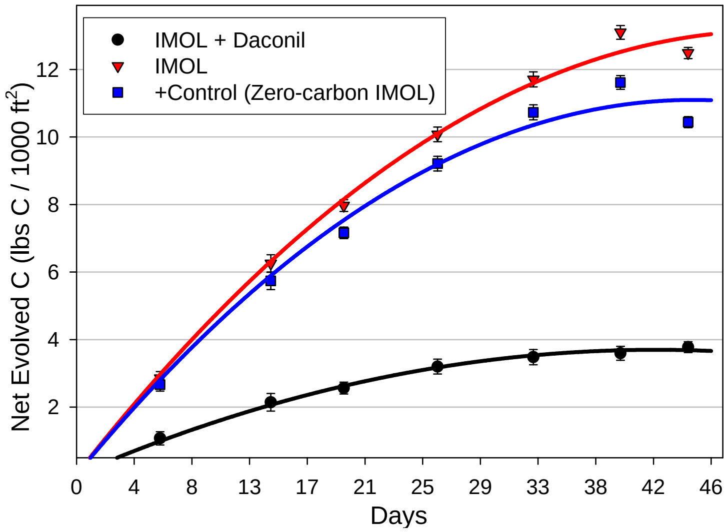
Methods: Soil cores (8" by 4.25" diam.) were collected from a sand-based putting green nursery (Cape May County, NJ, USA; Sept. 2005) and a mineral soil fairway (Cumberland County, ME, USA; Nov. 2006), each exhibiting severe thatch accumulation layers. Following expedited transport to Penn State University, the core surfaces were treated with a 5% Roundup Ultra herbicide solution spray application (½ gal. / 1000 ft^2 or M). After a 2-week drying period, aerial tissues (leaves, tillers, shoots) were removed, and one core destructively sampled to characterize preliminary soil properties (Table 1). Three experimental units were randomly selected from the remaining NJ putting green soil cores (photo, top-right p. 3) and surface-treated with either 3 oz I-MOL / 1000 ft^2 (M), I-MOL + Daconil Ultrex (3 and 1 oz. / M, respectively), or a carbonless positive control containing mineral nutrient concentrations of I-MOL (3% Fe, K; 2% S; 0.5% N & Ca; others <0.2% by mass). Treatments were sprayed at 3 gal. / M volume and irrigated (0.04").

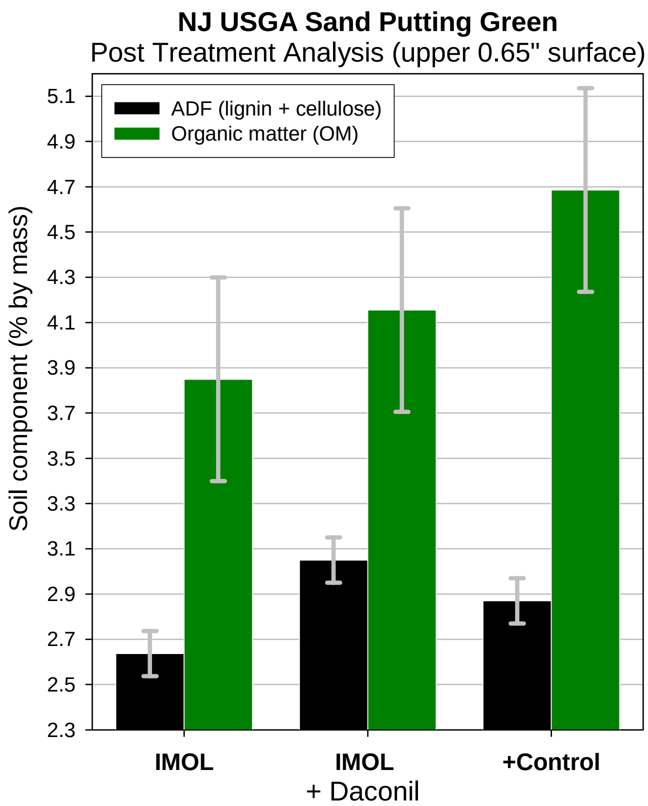
Accurate thatch measurement is prone to spatial and sampling error that often renders data from field experiments inconclusive. A method of measuring thatch decomposition by encapsulating each treated plug in a respective flow cell (Soil Measurement Systems, AZ) was elected, enabling measurement of CO_2 evolution over 7-days at 0.1 mg-carbon accuracy (Strotmann et al., 2004). Cores in Exp. 1 were retreated by five weekly applications in each run. New plugs were randomly selected, prepared, and treated as described in subsequent Exp. 1 runs; totaling 3 replicated 6-wk runs.

The low-flux system used pressurized ultra-pure (CO_2-free) air to prevent anoxic and/or CO_2–rich conditions. Except the gaseous CO_2 residing within pores of the plug (assumed to be equal across all cores removed from the identical green on the same day), microbial respiration comprised the sole future source of CO_2 evolution from each plug. In soil devoid of viable root tissue, microbial respiration is a direct measure of microbial activity, which in turn relates to microbial assimilation of carbon. Under aerobic conditions, soil microbial respiration rate quantifies OM degradation. Considering treatments were all surface-applied, recorded levels of CO_2 evolution then correlate with microbial OM decomposition rate in the surface thatch/mat of the putting green. Further, CO_2 evolution rates from I-MOL and I-MOL + Daconil cells were adjusted assuming total oxidation of weekly labile carbon substrate additions. Thus, results show 'net' treatment effects on decomposition of original thatch organic matter (OM) by indigenous soil microbiological agents.

In Experiment 2, three experimental units were randomly selected from the ME fairway soil cores (photo, right) and surface-treated by a 1 oz. / M application of Daconil in combination with; I-MOL (3 oz. / M), a 2X rate of I-MOL (6 oz. / M), or a positive control (carbonless nutrient analog of I-MOL). Weekly treatment applications were made as described in Exp. 1. Three 5-week experimental runs were conducted using fresh soil cores in Exp. 2. Following incubations, the upper 0.65" or 0.79" layers were systematically removed from Exp. 1 or 2 soil cores, respectively. Each of 2 core sub-samples were dried and ground, then submitted to Dairy-One Forage Quality Lab (Ithaca, NY) for determination of lignin + cellulose (acid-detergent fiber; ADF) and total organic matter (OM) content. No-intercept quadratic regression (PROC REG) was used to model CO_2 evolution by time, while experiment-end ADF and total OM data were analyzed by BLUE-weighted mixed models (SAS Inst., 1998). Flow cells and runs were included as experimental blocking factors. Moreover, inclusion of specific 5– or 6–wk mean cell temperatures as covariate factors proved effective in reducing residual error observed in each experiment model.

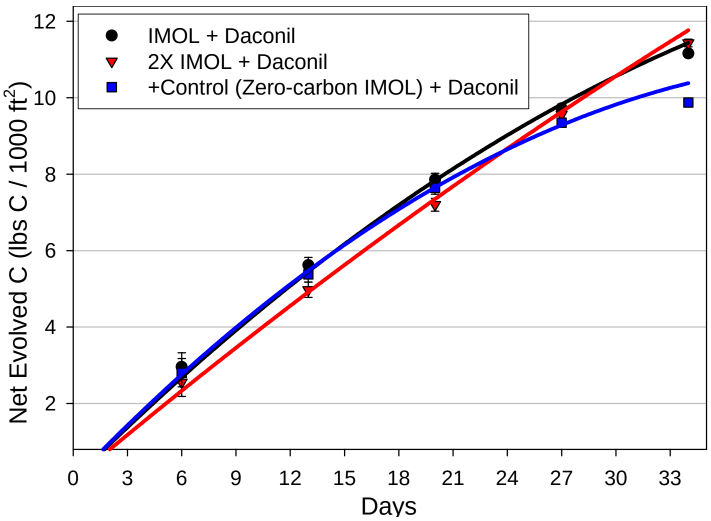
<u>Experiment 1 Results:</u> Microbial carbon evolution from the I-MOL treated-putting green cores (measured as CO_2) significantly exceeded that of the positive control cores by 17.6% (right). This difference amounted to 2 lbs C per 1000 ft^2 (M) over a 6-week period of use (each data point represents the mean value of three independent 6-week experiments). Average daily OM decomposition rate decreased with time elapsed from application (1 to 7 days) as well as over the experimental period (successive weekly applications). These observations likely resulted from a diminished soil OM pool (absence of fresh OM contributions) over the 6-week experimental period, and can be considered unique to the imposed conditions. Considering the observed effect of Daconil on microbial activity in the sand-based putting green cores, soil fungi populations may play more significant roles in lignin and cellulose decomposition than bacteria, as reported in the literature (Holl et al., 2005).



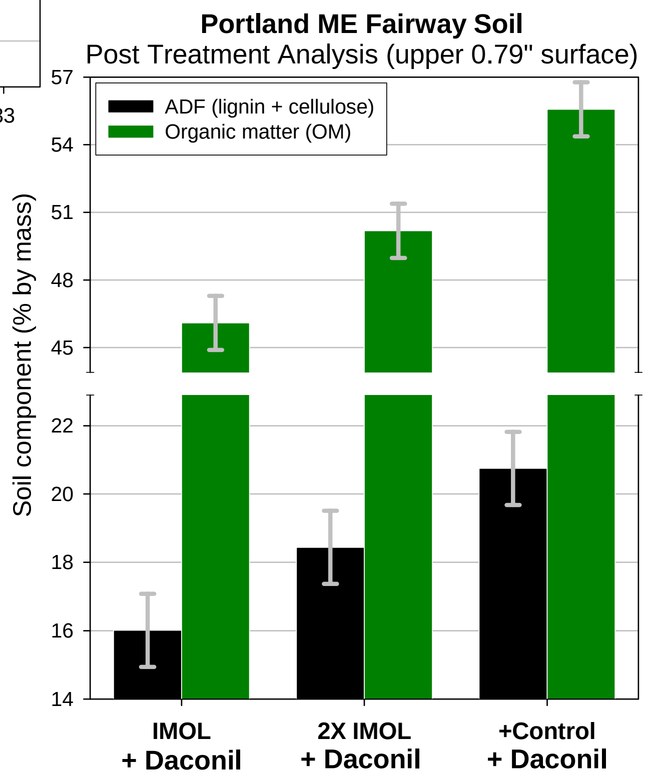


Post-incubation analysis of the sand putting green thatch layer identifies the origin of evolved carbon (left). Resulting OM data show I-MOL treated cores retained 3.85 % OM (by mass), following 6 weekly applications at 3 oz. / M. The combined I-MOL + Daconil treatment shows similar soil OM levels (4.15 %) in the upper 0.65 inches of the putting green surface. The positive control treatment, or carbonless I-MOL analog, resulted in 4.7 % OM by mass in the upper putting green surface. Resulting acid-detergent fiber (ADF; lignin + cellulose content) was significantly reduced by I-MOL compared to the positive control.

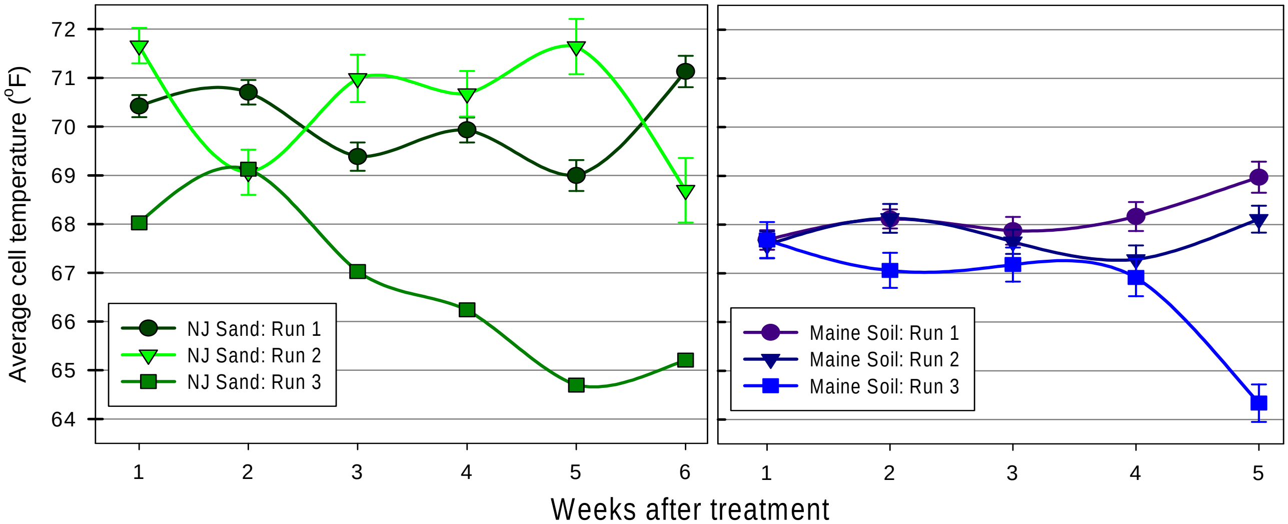
<u>Experiment 2 Results:</u> In Experiment 2, carbon evolution rate was similar among the weekly treatment applications over the 35-day period (top left, page 4). Net evolved carbon accumulated to approximately 11 lbs C / M for all treatments. Initial upper soil surface OM content in the Maine fairway was extremely high, hardly an uncommon trait of mature and acidic turfgrass systems in the northern US. Although the climate of coastal Maine provides 5-6 months of turfgrass growing conditions, the period of elevated soil temperatures needed to support saprophytic decomposition of soil OM is brief. While all Exp. 2 treatments (I-MOL, 2X I-MOL, and the + Control) were made in combination with Daconil fungicide, carbon evolution rates from Experiment 2 plugs were similar to rates observed from non-fungicide treated plugs in Exp. 1. This comparative-tolerance to



fungicide applications may be associated with greater OM content in the Experiment 2 cores. Likewise, the greater age/maturity of the Exp. 2 turfgrass system may correspond to a more robust and diverse microbial population. Holl et al. (2005) reported greater carbon substrate microbial utilization in soil-based turf systems than in newly-established sand-based systems.



Despite similar carbon evolution rates observed among treatments in Exp. 2, notable differences in upper soil surface OM quantity and quality resulted. As in Exp. 1, weekly applications of I-MOL significantly reduced the lignin + cellulose content of OM compared to the positive control (right). Effects of 2X I-MOL applications were intermediate to the positive control and label rate of I-MOL in reducing recalcitrant fiber content of OM. Label rate I-MOL applications significantly reduced total soil OM content compared to 2X or control treatments. These responses to I-MOL in Exp. 2 exceeded those observed in Exp. 1, yet occurred over a shorter incubation period (35- vs. 42-d) in which ambient laboratory temperatures were far cooler (below).



Conclusions

Under the described laboratory conditions and relative to the positive control treatment:

- **Weekly reapplications of I-MOL (3 oz. / M) to thatch/mat enhanced microbial-activity, yet when applied in conjunction with a broad-spectrum fungicide (Daconil), the observed response was substantially reduced in the sand rootzone.**
- **Observed reductions in cellulose + lignin concentrations (acid detergent fiber; ADF) were 23 to 8% over respective 5- to 6-week periods of weekly I-MOL reapplications**
- **Weekly reapplications of I-MOL (3 oz. / M) significantly reduced total OM content by 17% in the upper 0.8" of a heavily-thatched soil turfgrass system, but had no effect on total OM content in the sand rootzone**
- **Arbitrary doubling of I-MOL application rate (3 to 6 oz. / M) did not enhance the described responses**

Discussion: As mentioned, the potential for effectively-preventing thatch accumulation through chemical and/or biological treatment is of inherent interest to turfgrass managers. Numerous 'biochemical' thatch control agents are currently available and advertised as effective alternatives to physical cultivation. Meanwhile, replicated field research results have shown mixed results. These reasons justified conducting the described research under controlled laboratory conditions.

Considering living turfgrass serves as both a sink and source of carbon dioxide, its influence on the collected data was eliminated. The same concern for standardization of influential factors served as justification for implementing a carbonless nutrient analog as the control treatment. Likewise, because thatch is hardly the most readily-decomposed carbon substrate available to microbes within cores of dead turfgrass systems, the concentrations of cellulose + lignin and total organic matter in the treated cores were analytically determined at experiment end. The decision to conduct research in the laboratory, rather than the field, was met with resistance. Ultimately, the research sponsors were convinced the laboratory approach was worthwhile–but not before we agreed upon the following mutually-satisfactory provision: If the laboratory experiments showed the treatment applications resulted in (1) increased CO_2 evolution, (2) decreased residual total organic matter, and (3) significant reduction of residual acid-detergent fiber content; then I was bound to further investigate treatment efficacy through replicated field trials in 2008. This field research is currently underway, and the results will be included in the 2008 PSU Turfgrass Research Reports.

In regard to the results and conclusions shown, it is imperative that I emphasize and each reader recognizes one very specific and important qualification. Under optimal field conditions, where mature leaf/shoot/root tissues regularly undergo senescence and replacement by fresh biomass, total OM and ADF fraction reductions of the magnitude described would be an unlikely–IF NOT IMPOSSIBLE–expectation of I-MOL treatment reapplications. This is because the described results were observed in a system purposely devoid of living vegetation, yet flush with vegetative detritus. The turfgrass vegetative detritus, often less-endearingly referred to as thatch, was generated in recent period by actual turfgrass living on an actual golf course; essentially the same thatch that currently supports dynamic soil microbial populations anywhere. It is important to note the quantities of thatch that serve as the bases for every conclusion made in the described study were indeed static. The obvious follow-up question remains: Were the observations resulting from labile-carbon delivery by I-MOL real differences, or merely insignificant details on a backdrop rightfully obscured by the relentless biomass generation and deposition by intensively-managed modern turfgrass varieties? Field research results may help provide a definitive answer.

In summary, the described results are intriguing. The most common question I encounter from those whom read these associated reports is 'Why does I-MOL facilitate thatch decomposition?' Unfortunately I do not know the unequivocally-acceptable answer, but my best guess is the addition of the labile carbon stimulates microbial birth rate. In turn, the greater number of microbes increases production of extracellular enzymes. These persistent extracellular enzymes, synthesized in mass at the interface of assimilate and heterotrophic activity, may have made the measurable difference. I hope to have specific answers to all these questions before too long, and certainly appreciate your patience and continued interest in the meantime. Stay tuned and have a great summer!

Disclaimer: Trade and/or manufacturer's names mentioned in this report are for information only and do not constitute endorsement, recommendation, or exclusion by the author or Pennsylvania State Univ.

Acknowledgements: The author gratefully acknowledges Mr. Dave Moody, a bright and tireless graduate student and scientist, who conducted this research in fulfillment of his MS degree requirements (Soil Science, 2007). Likewise, a deserving thank you goes out to The Pennsylvania Turfgrass Council, the West Virginia Golf Course Superintendents Assn., and From The Ground Up Inc. for their support of the described research.

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