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Turfgrass Color Evaluation on Green Height 'Penn A-4' Creeping Bentgrass

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

Introduction

This study was conducted on a mature stand of 'Penn A-4' creeping bentgrass (*Agrostis stolonifera*) at the Valentine Turfgrass Research Center, Penn State University, University Park, Pa. The objective of the study was to determine the effect of various products on turfgrass color.

Methods and Materials

This study was a randomized complete block design with three replications. All treatments were applied on July 1 (JULY), and July15 (14DAT) using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi.

The test site was maintained similar to that of a golf course green with respect to irrigation, fertilization and mowing. The test plot size was 21 ft^2.

Results and Discussion

Turfgrass color was rated 14 times during the study (Table 1). All treated turfgrass revealed better color than untreated at some point during the study. The 5 oz/M rate of iron sulfate provided the most green color (10) on several rating dates. On the July 4 rating date, turfgrass treated with iron sulfate at 2 oz/M, Ferromec at 5 oz/M, and Quelent FE at 5 oz/M plus Amino Green at 0.0606 lb N/M were also rated 10 for color. Turfgrass treated with iron sulfate at 2 oz/M was rated 10 for color on July 16 and 17. On the July 17 rating date, Turfgrass treated with Ferromec at 5 oz/M also was rated at 10 for color. In general, turfgrass treated with Quelant FE, Ferromec, and Quelant FE plus Amino Green tended to have a similar pattern of enhanced turfgrass color response.

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Table 1. Color ratings on a scale of 0-10 where 0 = brown, 7= acceptable, and 10 = dark green of creeping bentgrass taken in 2005.

Treatment	Form	Rate	(--------Color--------)					
		oz/M	7-1	7-2	7-4	7-5	7-6	7-8
QUELANT FE	0.24L	0.5	7.3	8.2	7.7	8.2	8.3	8.0
QUELANT FE	0.24L	1	7.7	8.3	8.0	8.5	8.5	8.3
QUELANT FE	0.24L	1.5	7.8	8.5	8.7	9.0	8.7	8.5
QUELANT FE	0.24L	2	7.3	8.3	8.8	9.2	9.0	8.5
QUELANT FE	0.24L	5	7.8	8.8	9.0	8.8	8.7	8.7
IRON SULFATE	WP	0.5	8.3	8.0	9.2	9.0	8.5	8.5
IRON SULFATE	WP	1	8.3	8.5	9.0	8.8	8.7	8.5
IRON SULFATE	WP	1.5	8.8	9.0	9.7	9.2	9.0	8.8
IRON SULFATE	WP	2	9.7	9.3	10.0	9.7	9.3	8.8
IRON SULFATE	WP	5	10.0	10.0	10.0	10.0	10.0	9.3
CHECK			7.3	7.3	7.5	7.7	7.5	7.8
FERROMEC	1.8L	0.5	7.5	8.3	8.2	8.2	8.0	8.3
FERROMEC	1.8L	1	7.7	8.3	8.5	8.3	8.2	8.3
FERROMEC	1.8L	1.5	7.8	8.8	8.7	9.0	9.0	8.7
FERROMEC	1.8L	2	8.0	9.0	9.0	8.8	9.0	8.5
FERROMEC	1.8L	5	8.3	9.7	10.0	9.3	8.8	8.8
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	0.5 0.006 lb N/M	7.3	8.0	9.2	8.8	8.0	8.0
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	1 0.012 lb N/M	7.7	8.7	9.0	8.7	8.3	8.3
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	1.5 0.018 lb N/M	7.8	8.8	9.0	8.3	8.5	8.7
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	2 0.0244 lb N/M	7.3	9.3	9.7	9.3	8.7	8.7
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	5 0.0606 lb N/M	7.8	9.8	10.0	9.5	9.0	8.7

Table 1 (continued). Color ratings on a scale of 0-10 where 0 = brown, 7= acceptable, and 10 = dark green of creeping bentgrass taken in 2005.

Treatment	**Form**	**Rate oz/M**	**(---Color---) 7-16**	**7-17**	**7-18**	**7-19**	**7-21**	**7-22**	**7-23**	**7-24**
QUELANT FE	0.24L	0.5	8.0	8.3	8.5	8.5	8.2	8.0	7.8	7.8
QUELANT FE	0.24L	1	8.3	8.8	8.7	8.5	8.5	8.3	8.2	8.2
QUELANT FE	0.24L	1.5	8.5	8.8	8.8	8.7	8.5	8.5	8.3	8.0
QUELANT FE	0.24L	2	8.7	9.0	9.0	8.8	8.7	8.5	8.2	8.0
QUELANT FE	0.24L	5	8.8	9.0	9.5	9.2	8.7	8.8	8.5	8.0
IRON SULFATE	WP	0.5	9.0	9.2	8.8	9.0	8.2	8.2	8.2	8.0
IRON SULFATE	WP	1	9.3	9.2	8.8	9.0	8.5	8.5	8.0	8.0
IRON SULFATE	WP	1.5	9.7	9.5	9.3	9.3	8.8	8.7	8.2	8.0
IRON SULFATE	WP	2	10.0	10.0	9.5	9.2	8.8	9.0	8.3	8.3
IRON SULFATE	WP	5	10.0	10.0	10.0	10.0	9.2	9.3	8.8	8.5
CHECK			8.2	8.0	8.0	8.2	8.2	7.8	7.8	7.8
FERROMEC	1.8L	0.5	8.7	8.5	8.8	8.7	8.2	8.0	8.2	8.0
FERROMEC	1.8L	1	8.7	8.8	8.8	8.8	8.3	8.2	8.2	8.0
FERROMEC	1.8L	1.5	9.0	9.0	9.0	9.0	8.7	8.5	8.5	8.0
FERROMEC	1.8L	2	9.0	9.3	9.0	9.0	8.7	8.3	8.3	8.0
FERROMEC	1.8L	5	9.8	10.0	9.5	9.5	9.0	8.7	8.5	8.5
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	0.5 0.006 lb N/M	8.3	8.7	8.5	8.5	8.2	8.0	8.2	8.0
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	1 0.012 lb N/M	9.0	9.0	8.8	8.8	8.3	8.3	8.0	8.2
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	1.5 0.018 lb N/M	9.3	9.2	9.0	9.0	8.8	8.3	8.3	8.2
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	2 0.0244 lb N/M	9.3	9.2	9.0	8.8	8.7	8.8	8.2	8.2
QUELANT FE AMINO GREEN (18-3-1)	0.24L 1.8L	5 0.0606 lb N/M	9.8	9.8	9.7	9.2	9.0	9.0	8.7	8.3

Post Emergence Control of Broadleaf Weeds and Phytotoxicity Evaluations

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

Introduction

Broadleaf weed control and phytotoxicity evaluations were conducted on a stand of mature 'Jet Elite' perennial ryegrass (*Lolium perenne* L.) at the Valentine Turfgrass Research Center, Penn State University, University Park, Pa. The objectives of the study were to determine the efficacy of selected broadleaf weed herbicides for the control of dandelion (*Taraxacum officinale*), white clover (*Trifolium repens*), and buckhorn plantain (*Plantago lanceolata*) in perennial ryegrass and the phytotoxicity of these compounds on perennial ryegrass.

Methods and Materials

All plots were rated for the percent dandelion, white clover, and buckhorn plantain prior to the application of any treatment on a plot by plot basis. The test plots were 21 ft^2 and had approximately 80 percent broadleaf weed cover.

The study was a randomized complete block design with three replications. All of the treatments were applied on June 7 and one treatment was reapplied June 20, 2005 (2 WAT) using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi.

The test site was mowed at one and one half inches weekly with a rotary mower with clippings returned to the site. The test site was irrigated to prevent moisture stress.

Results and Discussion

Turfgrass phytotoxicity was rated six times during the study (Table 1). On the June 10th rating date, turfgrass treated with Velocity plus V-10142 had unacceptable phytotoxicity, this continued through the July 6th rating date. On the June 20th rating date, turfgrass treated with Velocity at 30 g ai/A + 2WAT had unacceptable phytotoxicity, this continued through the July 6th rating date. By the final rating date, July 21st, no phytotoxicity was observed.

The change in the broadleaf weed population was rated three times during the study (Table 2). During the study, the change in the dandelion, white clover, and buckhorn plantain populations were somewhat variable. By the final rating date, July 21st, all treated turfgrass had significantly less dandelion and buckhorn plantain populations than untreated. On this date, turfgrass treated with Velocity at 30 g ai/A + 2WAT, V-10142 at 0.5 lb ai/A plus NIS plus Drive at 0.75 lb ai/A, V-10142 at 0.5 lb ai/A plus Turflon at 1 qt/A, Drive at 0.75 lb ai/A plus NIS, and Velocity at 0.25 lb ai/A plus V-10142 at 0.5 lb ai/A had significantly less white clover than untreated.

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Table 1. Evaluations of turfgrass phytotoxicity in 2005 where 0 = worst, 7 = acceptable and 10 = best.

Treatment	**Form**	**Rate**	(----------Phytotoxicity---------)				
		lb ai/A	**6-10**	**6-20**	**6-28**	**7-6**	**7-21**
VELOCITY	80WP	30 g ai/A +2WAT	7.3	5.3	3.0	5.7	10.0
V-10142	75WG	0.5	8.0	9.0	9.0	10.0	10.0
NIS	L	0.25 % v/v					
V-10142	75WG	0.5	8.0	8.0	9.7	10.0	10.0
NIS	L	0.25 % v/v					
DRIVE	75DF	0.75					
V-10142	75WG	0.5	7.0	9.0	9.3	10.0	10.0
TURFLON	4EC	1 qt/A					
DRIVE	75DF	0.75	7.3	9.7	9.3	10.0	10.0
NIS	L	0.25 % v/v					
CHECK			10.0	10.0	10.0	10.0	10.0
TURFLON	4EC	1qt/A	7.0	9.7	9.3	10.0	10.0
V-10147	0.83FL	0.25	8.7	9.7	9.3	10.0	10.0
NIS	L	0.25 % v/v					
V-10147	0.83FL	0.5	8.0	9.3	10.0	10.0	10.0
NIS	L	0.25 % v/v					
V-10147	0.83FL	0.75	7.0	9.0	10.0	10.0	10.0
NIS	L	0.25 % v/v					
VELOCITY	80WP	0.25	6.7	4.3	3.7	6.0	10.0
V-10142	75WG	0.5					

Table 2. Percent change of the dandelion, white clover, and buckhorn plantain populations following applications of selected herbicides.

Treatment	Form	Rate lb ai/A	(--------June 28, 2005 [1,2] Dand	Clover	Plant------------)	(--------------July 6, 2005 Dand	Clover	Plant-----------)
VELOCITY	80WP	30 g ai/A +2WAT	65.28c	62.10bc	50.00d	79.17b	87.98a	100.00a
V-10142 NIS	75WG L	0.5 0.25 % v/v	73.21abc	39.05cd	66.67cd	91.67ab	31.90b	100.00a
V-10142 NIS DRIVE	75WG L 75DF	0.5 0.25 % v/v 0.75	64.76c	91.67ab	94.44ab	95.24a	100.00a	100.00a
V-10142 TURFLON	75WG 4EC	0.5 1 qt/A	98.89a	97.76a	98.33a	100.00a	100.00a	100.00a
DRIVE NIS	75DF L	0.75 0.25 % v/v	75.99abc	87.83ab	94.44ab	100.00a	100.00a	96.67a
CHECK			0.00d	0.00e	0.00e	-6.67c	8.33bc	31.11b
TURFLON	4EC	1 qt/A	93.61ab	84.07ab	93.33abc	98.06a	98.52a	93.33a
V-10147 NIS	0.83FL L	0.25 0.25 % v/v	82.38abc	17.99de	76.67abc	100.00a	0.00c	100.00a
V-10147 NIS	0.83FL L	0.5 0.25 % v/v	93.33ab	0.46e	93.33abc	100.00a	3.70c	96.67a
V-10147 NIS	0.83FL L	0.75 0.25 % v/v	71.90bc	43.52cd	68.89bcd	91.43ab	13.89bc	88.89a
VELOCITY V-10142	80WP 75WG	0.25 0.5	84.92abc	64.29abc	91.11abc	100.00a	82.14a	100.00a

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

2 - Negative numbers represent an increase in population and positive numbers a decrease in population.

Table 2 (continued). Percent change of the dandelion, white clover, and buckhorn plantain populations following applications of selected herbicides.

Treatment	Form	Rate lb ai/A	Dand (------------July 21, 2005[1,2]	Clover	Plant ---------)
VELOCITY	80WP	30 g ai/A +2WAT	100.00a	87.37a	96.67ab
V-10142	75WG	0.5	83.33a	-51.43c	66.67b
NIS	L	0.25 % v/v			
V-10142	75WG	0.5	97.71a	99.17a	86.67ab
NIS	L	0.25 % v/v			
DRIVE	75DF	0.75			
V-10142	75WG	0.5	98.89a	98.50a	100.00a
TURFLON	4EC	1 qt/A			
DRIVE	75DF	0.75	98.06a	100.00a	82.22ab
NIS	L	0.25 % v/v			
CHECK			0.00b	-18.52bc	0.00c
TURFLON	4EC	1 qt/A	93.61a	84.07a	96.67ab
V-10147	0.83FL	0.25	98.89a	-56.61c	93.33ab
NIS	L	0.25 % v/v			
V-10147	0.83FL	0.5	98.89a	-52.78c	83.33ab
NIS	L	0.25 % v/v			
V-10147	0.83FL	0.75	100.00a	0.93b	94.44ab
NIS	L	0.25 % v/v			
VELOCITY	80WP	0.25	100.00a	94.05a	100.00a
V-10142	75WG	0.5			

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

2 - Negative numbers represent an increase in population and positive numbers a decrease in population.

Post Emergence Control of Ground Ivy and Phytotoxicity Evaluations

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

Introduction

Broadleaf weed control and phytotoxicity evaluations were conducted on a stand of mature 'SR 4200' perennial ryegrass (*Lolium perenne* L.) at the Valentine Turfgrass Research Center, Penn State University, University Park, Pa. The objectives of the study were to determine the efficacy of selected broadleaf weed herbicides for the control of ground ivy *(Glechoma hederacea)* in perennial ryegrass and the phytotoxicity of these compounds on perennial ryegrass.

Methods and Materials

All plots were rated for the percent ground ivy prior to the application of any treatment on a plot by plot basis. The test plots were 21 ft^2 and had approximately 70 percent ground ivy cover. The ground ivy population had been plugged into the area using a typical golf course cup cutter for four years prior to the 2005 growing season. During the study, the ground ivy population was no longer increased by way of plugging. Any population increase was a result of the ground ivy population's growth habit during the study.

The study was a randomized complete block design with three replications. All of the treatments were applied on June 20, 2005 using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi.

The test site was mowed at two inches weekly with a rotary mower with clippings returned to the site. The test site was irrigated to prevent moisture stress.

Results and Discussion

Phytotoxicity was evaluated six times during the study (Table 1). There was no phytotoxicity found on the perennial ryegrass on any of the rating dates.

The percent control was evaluated once on August 8, 2005 (Table 2). All treated turfgrass had significantly less ground ivy than untreated. It should be noted that there was an increase in the untreated ground ivy population. Additionally, although not significant, when MacroSorb Foliar was part of the treatment regime there was a trend of increased control of ground ivy with the respective herbicides.

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Table 1. Evaluations of perennial ryegrass phytotoxicity in 2005 where 0 = worst, 7 = acceptable and 10 = no phytotoxicity.

Treatment	Form	Rate lb ai/A	(-----Phytotoxicity-----) 6-28	7-5	7-12	7-19	7-26	8-2
DRIVE	75DF	0.75	10.0	10.0	10.0	10.0	10.0	10.0
2,4,D AMINE	3.87L	1						
MSO	L	1 % V/V						
DRIVE	75DF	0.75	10.0	10.0	10.0	10.0	10.0	10.0
2,4,D AMINE	3.87L	1						
MSO	L	1 % V/V						
MACROSORB FOLIAR	L	2 FL OZ/M						
CHECK			10.0	10.0	10.0	10.0	10.0	10.0
DRIVE	75DF	0.75	10.0	10.0	10.0	10.0	10.0	10.0
2,4,D AMINE	3.87L	1						
MACROSORB FOLIAR	L	2 FL OZ/M						
CONFRONT	3SL	32 FL OZ/A	10.0	10.0	10.0	10.0	10.0	10.0
CONFRONT	3SL	32 FL OZ/A	10.0	10.0	10.0	10.0	10.0	10.0
MACROSORB FOLIAR	L	2 FL OZ/M						

Table 2. Percent control of the ground ivy population following applications of selected herbicides.

Treatment	Form	Rate lb ai/A	(--------% Control [1, 2]--------) August 8, 2005
DRIVE	75DF	0.75	84.27a
2,4,D AMINE	3.87L	1	
MSO	L	1 % V/V	
DRIVE	75DF	0.75	89.66a
2,4,D AMINE	3.87L	1	
MSO	L	1 % V/V	
MACROSORB FOLIAR	L	2 FL OZ/M	
CHECK			-22.72b
DRIVE	75DF	0.75	98.27a
2,4,D AMINE	3.87L	1	
MACROSORB FOLIAR	L	2 FL OZ/M	
CONFRONT	3SL	32 FL OZ/A	84.76a
CONFRONT	3SL	32 FL OZ/A	87.30a
MACROSORB FOLIAR	L	2 FL OZ/M	

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

2 - Negative numbers indicate an increase in ground ivy population and positive numbers a decrease in population.

Postemergence Smooth Crabgrass Control

J. A. Borger, Dr. T. L. Watschke and N. B. Naedel[1]

Introduction

Postemergence 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 herbicides for the postemergence control of smooth crabgrass.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on June 12, 2005 using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi. The site was mowed once weekly with a rotary mower at one and one half inches with clippings returned to the site.

Results and Discussion

The control of smooth crabgrass was rated once during the study (Table 1). Acceptable smooth crabgrass control (85% or greater) was found only for turfgrass treated Drive at 0.75 lb ai/A plus MSO at 1 %v/v.

Table 1. Evaluations of the percent control of smooth crabgrass taken in 2005. Commercially acceptable control was considered to be 85% and above.

Treatment	Form	Rate (lb ai/A)	% Control- 8/8
DRIVE	75DF	0.75	75.0
DRIVE	75DF	0.75	68.3
MACROSORB FOLIAR	L	2 oz/M	
DRIVE	75DF	0.75	85.0
MSO	L	1 % v/v	
CHECK			0.0
DRIVE	75DF	0.75	81.7
MACROSORB FOLIAR	L	2 oz/M	
MSO	L	1 % v/v	
ACCLAIM EXTRA	0.57EW	20 oz/A	63.3
PENDULUM	3.8 C	1.5	

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Postemergence Smooth Crabgrass Control

J. A. Borger, Dr. T. L. Watschke and N. B. Naedel[1]

Introduction

Postemergence 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 herbicides for the postemergence control of smooth crabgrass.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on June 12, 2005 using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi. The site was mowed once weekly with a rotary mower at one and one half inches with clippings returned to the site.

Results and Discussion

The control of smooth crabgrass was rated once during the study (Table 1). Acceptable smooth crabgrass control (85% or greater) was found only for turfgrass treated with Acclaim at 20 oz/A, Acclaim at 15 oz/A plus MacroSorb Foliar at 2 oz/M, and Acclaim at 20 oz/A plus MacroSorb Foliar at 2 oz/M.

Table 1. Evaluations of the percent control of smooth crabgrass taken in 2005. Commercially acceptable control was considered to be 85% and above.

Treatment	Form	Rate (oz/A)	% Control-8/8
ACCLAIM	0.57EW	10	78.3
ACCLAIM	0.57EW	15	80.0
ACCLAIM	0.57EW	20	95.0
CHECK			0.0
ACCLAIM	0.57EW	10	83.4
MACROSORB FOLIAR	L	2 oz/M	
ACCLAIM	0.57EW	15	88.3
MACROSORB FOLIAR	L	2 oz/M	
ACCLAIM	0.57EW	20	92.7
MACROSORB FOLIAR	L	2 oz/M	

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Seedhead Suppression of Annual Bluegrass on a Putting Green

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

Introduction

This study was conducted on a mixed stand of 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 14 (FB), April 19 (BT), May 5 (3 WAT), and May 10, 2005 (3 WAT), respectively, using a three-foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two 11004 flat fan nozzles at 40 psi.

Full bloom of Forysthia (*Fosythia x intermedia)* occurred April 13, 2005. At this time 49 growing degree days had been accumulated when using a base of 50. Boot stage of the annual bluegrass was observed April 18, 2005. Non treated test areas within the test site revealed approximately 100% coverage of annual bluegrass seedheads.

The site was maintained using cultural practices for irrigation, mowing, and fertilization that would be typical for a putting green.

Results and Discussion

Color was rated twice during the study (Table 1). On the April 20th rating date, turfgrass treated with Proxy plus Primo MAXX plus Bayleton, Embark T/O (FB), Proxy plus Cutless (BT), Proxy plus Trimmit (BT), and Trimmit alone had unacceptable color. On the April 28th rating date, turfgrass treated with Proxy plus Primo MAXX plus Bayleton, Embark T/O (FB), Embark T/O (BT), Embark T/O plus Ferromec (FB), Embark T/O plus MacroSorb Foliar at 4 oz/M (BT), and Cutless alone again had unacceptable color.

Phytotoxicity was rated three times during the study (Table 2). On the May 4th rating date, turfgrass treated with Embark T/O (BT), Embark T/O plus Ferromec (FB), Embark T/O plus MacroSorb Foliar at 4 and 8 oz/M (BT), Embark T/O plus CoRon (BT), Embark T/O plus Quelant Amino Green (BT), and Trimmit alone, had unacceptable phytotoxicity.

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On the May 12th rating date, turfgrass treated with Embark T/O (BT), Embark T/O plus Ferromec (FB), Embark T/O plus MacroSorb Foliar at 4 and 8 oz/M (BT), Embark T/O plus MacroSorb Foliar at 4 oz/M plus Ferromec (BT), Embark T/O plus CoRon (BT) Embark T/O plus Quelant Amino Green (BT), and Embark T/O plus Quelant FE plus Quelant Amino Green (BT) had unacceptable phytotoxicity. By the May 20th rating date, no unacceptable phytotoxicity was found.

Turfgrass quality was rated twice during the study (Table 2). Quality, as a function of color, phytotoxicity, and seedhead suppression, varied among treated and non-treated turfgrass on both rating dates.

Seedhead suppression was rated twice during the study (Table 3). On the May 20th rating date, turfgrass treated with Proxy plus Primo MAXX plus Quelant Amino Green, Proxy plus Cutless plus CoRon, Proxy plus Trimmit plus CoRon, and Primo MAXX alone was not significantly different than non-treated turfgrass. Although not significantly different from the remaining treated turfgrass, turfgrass treated with Embark T/O (BT), Embark T/O plus Ferromec (BT), Embark T/O plus MacroSorb Foliar at 4 and 8 oz/M (BT), Embark T/O plus MacroSorb Foliar at 4 oz/M plus Ferromec (BT), Embark T/O plus CoRon (BT), Embark T/O plus Quelant Amino Green (BT), and Embark T/O plus Quelant FE at 2 and 3 oz/M plus Quelant Amino Green (BT) provided more than 80% seedhead suppression.

Table 1. Color ratings of an annual bluegrass/creeping bentgrass putting green on a scale of 0 to 10 where 0 = brown, 7 = acceptable, and 10 = dark green in 2005.

Treatment	Form	Rate oz/M	Timing	(---------------Color--------------) 4/20	4/28
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	7.2	8.8
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	7.8	9.0
BXP1	L	6	FB/3 WAT		
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	6.8	6.7
BAYLETON	50WP	1	FB/3 WAT		
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	8.8	9.7
SIGNATURE	80WG	4	FB/3 WAT		
EMBARK T/O	0.2SL	40 OZ/A	FB	6.8	6.5
EMBARK T/O	0.2SL	40 OZ/A	BT	7.3	6.8
EMBARK T/O	0.2SL	40 OZ/A	FB	7.2	6.3
FERROMEC	L	5	FB		
EMBARK T/O	0.2SL	40 OZ/A	BT	8.7	9.3
FERROMEC	L	5	BT		
EMBARK T/O	0.2SL	40 OZ/A	BT	7.2	6.5
MACROSORB FOLIAR	L	4	BT		
EMBARK T/O	0.2SL	40 OZ/A	BT	7.3	7.0
MACROSORB FOLIAR	L	8	BT		
EMBARK T/O	0.2SL	40 OZ/A	BT	8.7	9.3
MACROSORB FOLIAR	L	4	BT		
FERROMEC	L	5	BT		
EMBARK T/O	0.2SL	40 OZ/A	BT	8.7	8.7
MACROSORB FOLIAR	L	8	BT		
FERROMEC (15-0-0)	L	5	BT		
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	BT/3 WAT	7.3	8.5
MACROSORB FOLIAR	L	4	BT/3 WAT		
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	BT/3 WAT	7.0	8.2
MACROSORB FOLIAR	L	8	BT/3 WAT		
EMBARK T/O	0.2SL	40 OZ/A	BT	7.0	7.3
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT		
EMBARK T/O	0.2L	40 OZ/A	BT	7.7	7.0
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT		
PROXY+PRIMO MAXX	2SL	3/0.125	BT/3 WAT	7.2	8.2
CHECK				7.8	8.5
PROXY+PRIMO MAXX	2SL/1MEC	3/0.125	BT/3 WAT	8.2	9.5
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT/3 WAT		
PROXY+PRIMO MAXX	2SL/1MEC	3/0.125	BT/3 WAT	8.5	9.5
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT/3 WAT		
PROXY	2SL	5	BT	6.7	7.7
CUTLESS	50W	0.25 LB/A	BT		
PROXY	2SL	5	BT	7.0	8.5
CUTLESS	50W	0.25 LB/A	BT		
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT		
PROXY	2SL	5	BT	7.3	8.3
CUTLESS	50W	0.25 LB/A	BT		
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT		
PROXY	2SL	5	BT	6.8	7.7
TRIMMIT	2SC	6 OZ/A	BT		
PROXY	2SL	5	BT	7.3	8.0
TRIMMIT	2SC	6 OZ/A	BT		
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT		
PROXY	2SL	5	BT	7.8	8.0
TRIMMIT	2SC	6 OZ/A	BT		
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT		
TRIMMIT	2SC	6 OZ/A	BT	6.7	7.0
CUTLESS	50W	0.25 LB/A	BT	7.0	6.8
PROXY	2SL	5	BT	7.3	7.7
PRIMO MAXX	1MEC	0.125	BT	7.3	7.7
EMBARK T/O	0.2SL	20 OZ/A	BT	7.2	7.5
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	BT/3 WAT		
EMBARK T/O	0.2SL	40 OZ/A	BT	8.0	8.3
QUELANT FE	L	2	BT		
QUELANT AMINO GREEN (18-3-1)	1.8L	3	BT		
EMBARK T/O	0.2SL	40 OZ/A	BT	8.0	8.3
QUELANT FE	L	3	BT		
MACROSORB FOLIAR	L	2	BT		

Table 2. 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 2005.

Treatment	Form	Rate oz/M	Timing	(--------------Phytotoxicity-----------) 5/4	5/12	5/20
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	10.0	8.3	7.3
PROXY+PRIMO MAXX BXP1	2SL/1MEC L	5/0.125 6	FB/3 WAT FB/3 WAT	10.0	9.3	8.3
PROXY+PRIMO MAXX BAYLETON	2SL/1MEC 50WP	5/0.125 1	FB/3 WAT FB/3 WAT	7.8	7.3	7.7
PROXY+PRIMO MAXX SIGNATURE	2SL/1MEC 80WG	5/0.125 4	FB/3 WAT FB/3 WAT	10.0	9.3	8.3
EMBARK T/O	0.2SL	40 OZ/A	FB	7.3	8.0	8.7
EMBARK T/O	0.2SL	40 OZ/A	BT	6.2	6.0	7.0
EMBARK T/O FERROMEC	0.2SL L	40 OZ/A 5	FB FB	6.5	7.0	8.3
EMBARK T/O FERROMEC	0.2SL L	40 OZ/A 5	BT BT	7.2	6.7	8.3
EMBARK T/O MACROSORB FOLIAR	0.2SL L	40 OZ/A 4	BT BT	6.0	5.7	7.7
EMBARK T/O MACROSORB FOLIAR	0.2SL L	40 OZ/A 8	BT BT	6.3	6.2	8.0
EMBARK T/O MACROSORB FOLIAR FERROMEC	0.2SL L L	40 OZ/A 4 5	BT BT BT	9.0	6.3	7.3
EMBARK T/O MACROSORB FOLIAR FERROMEC (15-0-0)	0.2SL L L	40 OZ/A 8 5	BT BT BT	7.5	7.2	8.0
PROXY+PRIMO MAXX MACROSORB FOLIAR	2SL/1MEC L	5/0.125 4	BT/3 WAT BT/3 WAT	9.7	8.7	8.3
PROXY+PRIMO MAXX MACROSORB FOLIAR	2SL/1MEC L	5/0.125 8	BT/3 WAT BT/3 WAT	9.0	8.5	7.7
EMBARK T/O CORON (28-0-0)	0.2SL 2.9L	40 OZ/A 0.2 LB AI/M	BT BT	6.3	6.0	8.3
EMBARK T/O QUELANT AMINO GREEN (18-3-1)	0.2L 1.8L	40 OZ/A 0.2 LB AI/M	BT BT	6.0	5.7	7.3
PROXY+PRIMO MAXX	2SL	3/0.125	BT/3 WAT	9.7	9.7	9.7
CHECK				10.0	10.0	10.0
PROXY+PRIMO MAXX CORON (28-0-0)	2SL/1MEC 2.9L	3/0.125 0.2 LB AI/M	BT/3 WAT BT/3 WAT	9.7	10.0	10.0
PROXY+PRIMO MAXX QUELANT AMINO GREEN (18-3-1)	2SL/1MEC 1.8L	3/0.125 0.2 LB AI/M	BT/3 WAT BT/3 WAT	9.7	10.0	10.0
PROXY CUTLESS	2SL 50W	5 0.25 LB/A	BT BT	8.0	9.7	9.3
PROXY CUTLESS CORON (28-0-0)	2SL 50W 2.9L	5 0.25 LB/A 0.2 LB AI/M	BT BT BT	7.8	9.7	10.0
PROXY CUTLESS QUELANT AMINO GREEN (18-3-1)	2SL 50W 1.8L	5 0.25 LB/A 0.2 LB AI/M	BT BT BT	9.3	10.0	10.0
PROXY TRIMMIT	2SL 2SC	5 6 OZ/A	BT BT	9.3	9.7	9.3
PROXY TRIMMIT CORON (28-0-0)	2SL 2SC 2.9L	5 6 OZ/A 0.2 LB AI/M	BT BT BT	9.0	9.0	9.0
PROXY TRIMMIT QUELANT AMINO GREEN (18-3-1)	2SL 2SC 1.8L	5 6 OZ/A 0.2 LB AI/M	BT BT BT	9.3	10.0	8.3
TRIMMIT	2SC	6 OZ/A	BT	6.3	8.0	9.0
CUTLESS	50W	0.25 LB/A	BT	7.3	8.3	8.3
PROXY	2SL	5	BT	9.3	10.0	9.7
PRIMO MAXX	1MEC	0.125	BT	8.5	8.7	9.3
EMBARK T/O PROXY+PRIMO MAXX	0.2SL 2SL/1MEC	20 OZ/A 5/0.125	BT BT/3 WAT	7.3	7.3	8.0
EMBARK T/O QUELANT FE QUELANT AMINO GREEN (18-3-1)	0.2SL L 1.8L	40 OZ/A 2 3	BT BT BT	7.2	6.7	8.3
EMBARK T/O QUELANT FE MACROSORB FOLIAR	0.2SL L L	40 OZ/A 3 2	BT BT BT	8.3	7.7	8.7

Table 3. Ratings of the quality and percent seedhead suppression of an annual bluegrass/creeping bentgrass putting green in 2005.

Treatment	Form	Rate	Timing	(--Quality[1]--)		(--%Suppression[2]--)	
		oz/M		5/4	5/20	5/4	5/20
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	7.7	7.7	56.1a-e	67.7a-e
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	7.2	6.7	42.8a-f	51.9a-e
BXP1	L	6	FB/3 WAT				
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	7.8	7.3	79.4a	67.7a-e
BAYLETON	50WP	1	FB/3 WAT				
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	FB/3 WAT	7.2	7.8	40.0a-f	63.0a-e
SIGNATURE	80WG	4	FB/3 WAT				
EMBARK T/O	0.2SL	40 OZ/A	FB	7.5	7.5	70.6abc	64.8a-e
EMBARK T/O	0.2SL	40 OZ/A	BT	6.5	7.7	38.9a-f	82.0abc
EMBARK T/O	0.2SL	40 OZ/A	FB	7.0	7.3	79.4a	78.3a-d
FERROMEC	L	5	FB				
EMBARK T/O	0.2SL	40 OZ/A	BT	6.7	8.5	47.2a-f	90.6a
FERROMEC	L	5	BT				
EMBARK T/O	0.2SL	40 OZ/A	BT	6.3	8.0	53.9a-f	84.4abc
MACROSORB FOLIAR	L	4	BT				
EMBARK T/O	0.2SL	40 OZ/A	BT	7.2	8.2	66.1a-d	84.4abc
MACROSORB FOLIAR	L	8	BT				
EMBARK T/O	0.2SL	40 OZ/A	BT	6.8	7.3	32.8a-f	80.2a-d
MACROSORB FOLIAR	L	4	BT				
FERROMEC	L	5	BT				
EMBARK T/O	0.2SL	40 OZ/A	BT	7.0	8.0	46.7a-f	79.1a-d
MACROSORB FOLIAR	L	8	BT				
FERROMEC (15-0-0)	L	5	BT				
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	BT/3 WAT	7.0	7.7	35.0a-f	55.6a-e
MACROSORB FOLIAR	L	4	BT/3 WAT				
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	BT/3 WAT	6.0	7.0	18.9b-f	55.6a-e
MACROSORB FOLIAR	L	8	BT/3 WAT				
EMBARK T/O	0.2SL	40 OZ/A	BT	6.3	8.2	49.4a-f	83.9abc
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT				
EMBARK T/O	0.2L	40 OZ/A	BT	6.3	8.0	45.6a-f	86.8abc
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT				
PROXY+PRIMO MAXX	2SL	3/0.125	BT/3 WAT	6.7	6.7	28.9a-f	48.1a-e
CHECK				6.0	6.0	0.0f	0.0f
PROXY+PRIMO MAXX	2SL/1MEC	3/0.125	BT/3 WAT	6.7	7.0	22.8b-f	42.1cde
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT/3 WAT				
PROXY+PRIMO MAXX	2SL/1MEC	3/0.125	BT/3 WAT	7.2	6.8	45.0a-f	36.5def
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT/3 WAT				
PROXY	2SL	5	BT	6.8	6.3	47.8a-f	47.9a-e
CUTLESS	50W	0.25 LB/A	BT				
PROXY	2SL	5	BT	7.5	6.3	64.4a-d	32.3ef
CUTLESS	50W	0.25 LB/A	BT				
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT				
PROXY	2SL	5	BT	7.3	7.0	51.7a-f	65.1a-e
CUTLESS	50W	0.25 LB/A	BT				
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT				
PROXY	2SL	5	BT	7.5	6.7	58.9a-d	47.1a-e
TRIMMIT	2SC	6 OZ/A	BT				
PROXY	2SL	5	BT	7.0	6.0	34.4a-f	33.9ef
TRIMMIT	2SC	6 OZ/A	BT				
CORON (28-0-0)	2.9L	0.2 LB AI/M	BT				
PROXY	2SL	5	BT	7.5	7.7	41.7a-f	46.0a-e
TRIMMIT	2SC	6 OZ/A	BT				
QUELANT AMINO GREEN (18-3-1)	1.8L	0.2 LB AI/M	BT				
TRIMMIT	2SC	6 OZ/A	BT	6.8	7.0	73.9ab	46.6a-e
CUTLESS	50W	0.25 LB/A	BT	7.0	7.0	52.2a-f	60.8a-e
PROXY	2SL	5	BT	7.0	7.0	36.1a-f	37.0def
PRIMO MAXX	1MEC	0.125	BT	6.2	6.7	12.2def	44.2b-e
EMBARK T/O	0.2SL	20 OZ/A	BT	6.8	7.8	37.2a-f	78.8a-d
PROXY+PRIMO MAXX	2SL/1MEC	5/0.125	BT/3 WAT				
EMBARK T/O	0.2SL	40 OZ/A	BT	6.3	8.3	2.8ef	88.6ab
QUELANT FE	L	2	BT				
QUELANT AMINO GREEN (18-3-1)	1.8L	3	BT				
EMBARK T/O	0.2SL	40 OZ/A	BT	6.5	8.5	16.7c-f	80.2a-d
QUELANT FE	L	3	BT				
MACROSORB FOLIAR	L	2	BT				

1 – Rating scale: 0 = worst quality, 7 = acceptable, and 10 = best quality.

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

Creeping Bentgrass Phytotoxicity and Control Evaluation of Lawn Height 'Midnight' Kentucky Bluegrass

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

Introduction

Phytotoxicity and control evaluations were conducted on a stand of mature 'Midnight' Kentucky bluegrass (*Poa pratensis*) and creeping bentgrass (*Agrostis stolonifera*) at the Valentine Turfgrass Research Center, Penn State University, University Park, Pa. The objective of the study was to determine the phytotoxicity to creeping bentgrass and Kentucky bluegrass as well as efficacy of these compounds to control creeping bentgrass.

Methods and Materials

The study was a randomized complete block design with three replications. Treatments were applied on August 25 (FALL), September 7 (2 WAT), and September 21 (4 WAT), 2004 using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi.

The test site was mowed at one and one half inches twice weekly with a rotary mower with clippings returned to the site.

Results and Discussion

Turfgrass phytotoxicity was rated two times (Table 1). There was no turfgrass phytotoxicity on these two rating dates (Aug 26 & 31, 2004). Creeping bentgrass phytotoxicity was rated seven times (Table 2). Phytotoxicity was rated below acceptable (7.0) on several dates for all treated creeping bentgrass. Conversely, no phytotoxicity was observed on the Kentucky bluegrass at any time (Table 3).

The change in the creeping bentgrass population was evaluated twice (Table 4). On the final rating date, May 26, 2005, turfgrass treated with mesotrione 4SC at 0.125 and 0.187 lb ai/A plus NIS at 0.25 and MSO at 1.0 %v/v, respectively, applied once in the fall were not significantly different than untreated that had a 50% increase in population. The remaining treated turfgrass had a significant reduction of creeping bentgrass compared to untreated turfgrass. Although, not significant from other treated turfgrass, turfgrass treated with mesotrione 4SC at 0.187 followed two weeks later at 0.135 lb ai/A plus MSO at 1 %v/v and mesotrione 4SC at 0.15, 0.233. and 0.15 lb ai/A plus NIS at 0.25 %v/v (FALL, 2 WAT, and 4 WAT respectively) had a 90% or greater reduction of creeping bentgrass.

It would appear that a reduction of a creeping bentgrass population in a mixed creeping bentgrass/'Midnight' Kentucky bluegrass stand is attainable if multiple applications of mesotrione and MSO are applied in the fall of the year.

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Table 1. Evaluations of turfgrass phytotoxicity where 0 = worst, 7 = acceptable, and 10 = no phytotoxicity in 2004.

Treatment	**Form**	**Rate lb ai/A**	**Timing**	**(----------Phytotoxicity-------) 8/27**	**8/31**
MESOTRIONE	4SC	0.125	FALL	10.0	10.0
MSO	L	0.25%V/V	FALL		
MESOTRIONE	4SC	0.187	FALL	10.0	10.0
MSO	L	0.25%V/V	FALL		
MESOTRIONE	4SC	0.125	FALL/2 WAT	10.0	10.0
MSO	L	0.25%V/V	FALL/2 WAT		
MESOTRIONE	4SC	0.187/0.125	FALL /2 WAT	10.0	10.0
MSO	L	0.25%V/V	FALL/2 WAT		
MESOTRIONE	4SC	0.187	FALL/2 WAT	10.0	10.0
MSO	L	0.25%V/V	FALL/2 WAT		
CHECK				10.0	10.0
MESOTRIONE	4SC	0.15/0.233/0.15	FALL/2 WAT/4 WAT	10.0	10.0
MSO	L	0.25%V/V	FALL /2 WAT/4 WAT		
MESOTRIONE	4SC	0.125	FALL	10.0	10.0
MSO	L	1.0%V/V	FALL		
MESOTRIONE	4SC	0.187	FALL	10.0	10.0
MSO	L	1.0%V/V	FALL		
MESOTRIONE	4SC	0.125	FALL/2 WAT	10.0	10.0
MSO	L	1.0%V/V	FALL /2 WAT		
MESOTRIONE	4SC	0.187/0.125	FALL/2 WAT	10.0	10.0
MSO	L	1.0%V/V	FALL /2WAT		
MESOTRIONE	4SC	0.187	FALL/2 WAT	10.0	10.0
MSO	L	1.0%V/V	FALL/2 WAT		
MESOTRIONE	4SC	0.15	FALL /2 WAT/4 WAT	10.0	10.0
MSO	L	1.0%V/V	FALL /2 WAT/4 WAT		

Table 2. Evaluations of creeping bentgrass phytotoxicity where 0 = worst, 7 = acceptable, and 10 = no phytotoxicity in 2004.

Treatment	Form	Rate lb ai/A	Timing	(------------------Phytotoxicity--------------)							
				9/3	9/8	9/16	9/22	9/29	10/6	10/18	
MESOTRIONE	4SC	0.125	FALL		6.7	5.7	6.0	7.0	8.3	10.0	10.0
NIS	L	0.25%V/V	FALL								
MESOTRIONE	4SC	0.187	FALL		7.0	5.7	6.0	6.7	7.7	8.0	10.0
NIS	L	0.25%V/V	FALL								
MESOTRIONE	4SC	0.125	FALL/2 WAT	6.7	5.3	3.0	5.0	4.3	6.7	8.7	
NIS	L	0.25%V/V	FALL/2 WAT								
MESOTRIONE	4SC	0.187/0.125	FALL /2 WAT		5.7	5.3	2.7	4.7	3.7	4.0	7.0
NIS	L	0.25%V/V	FALL/2 WAT								
MESOTRIONE	4SC	0.187	FALL/2 WAT	6.0	5.3	2.3	3.3	5.3	3.3	6.0	
NIS	L	0.25%V/V	FALL/2 WAT								
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	
MESOTRIONE	4SC	0.15/0.233/0.15	FALL/2 WAT/4 WAT	5.7	5.7	2.7	4.0	3.0	3.0	6.0	
NIS	L	0.25%V/V	FALL /2 WAT/4 WAT								
MESOTRIONE	4SC	0.125	FALL		5.7	4.7	5.0	6.7	5.3	8.3	10.0
MSO	L	1.0%V/V	FALL								
MESOTRIONE	4SC	0.187	FALL		5.7	4.3	5.0	6.3	8.0	9.3	10.0
MSO	L	1.0%V/V	FALL								
MESOTRIONE	4SC	0.125	FALL/2 WAT	7.0	5.3	3.7	5.3	6.0	7.0	9.0	
MSO	L	1.0%V/V	FALL /2 WAT								
MESOTRIONE	4SC	0.187/0.125	FALL/2 WAT	6.0	5.3	3.7	5.0	4.3	6.0	8.7	
MSO	L	1.0%V/V	FALL /2WAT								
MESOTRIONE	4SC	0.187	FALL/2 WAT	5.3	4.3	2.3	3.3	3.3	4.3	6.0	
MSO	L	1.0%V/V	FALL/2 WAT								
MESOTRIONE	4SC	0.15	FALL /2 WAT/4 WAT		6.0	5.0	3.3	4.7	3.0	3.3	4.0
MSO	L	1.0%V/V	FALL /2 WAT/4 WAT								

Table 3. Evaluations of ‘Midnight’ Kentucky bluegrass phytotoxicity where 0 = worst, 7 = acceptable, and 10 = no phytotoxicity in 2004.

Treatment	Form	Rate lb ai/A	Timing	(------Phytotoxicity------) 9/3	9/8	9/16	9/22	9/29	10/6	10/18	
MESOTRIONE	4SC	0.125	FALL		10.0	10.0	10.0	10.0	10.0	10.0	10.0
NIS	L	0.25%V/V	FALL								
MESOTRIONE	4SC	0.187	FALL		10.0	10.0	10.0	10.0	10.0	10.0	10.0
NIS	L	0.25%V/V	FALL								
MESOTRIONE	4SC	0.125	FALL/2 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
NIS	L	0.25%V/V	FALL/2 WAT								
MESOTRIONE	4SC	0.187/0.125	FALL /2 WAT		10.0	10.0	10.0	10.0	10.0	10.0	10.0
NIS	L	0.25%V/V	FALL/2 WAT								
MESOTRIONE	4SC	0.187	FALL/2 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
NIS	L	0.25%V/V	FALL/2 WAT								
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	
MESOTRIONE	4SC	0.15/0.233/0.15	FALL/2 WAT/4 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
NIS	L	0.25%V/V	FALL /2 WAT/4 WAT								
MESOTRIONE	4SC	0.125	FALL		10.0	10.0	10.0	10.0	10.0	10.0	10.0
MSO	L	1.0%V/V	FALL								
MESOTRIONE	4SC	0.187	FALL		10.0	10.0	10.0	10.0	10.0	10.0	10.0
MSO	L	1.0%V/V	FALL								
MESOTRIONE	4SC	0.125	FALL/2 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
MSO	L	1.0%V/V	FALL /2 WAT								
MESOTRIONE	4SC	0.187/0.125	FALL/2 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
MSO	L	1.0 %V/V	FALL /2WAT								
MESOTRIONE	4SC	0.187	FALL/2 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	
MSO	L	1.0%V/V	FALL/2 WAT								
MESOTRIONE	4SC	0.15	FALL /2 WAT/4 WAT		10.0	10.0	10.0	10.0	10.0	10.0	10.0
MSO	L	1.0%V/V	FALL /2 WAT/4 WAT								

Table 4. Percent change of the creeping bentgrass population in 'Midnight' Kentucky bluegrass.

Treatment	**Form**	**Rate lb ai/A**	**Timing**	**(--------%Change--------) 10/4/04**	**5/26/05**
MESOTRIONE	4SC	0.125	FALL	-8.3d[1,2]	28.3ab
NIS	L	0.25%V/V	FALL		
MESOTRIONE	4SC	0.187	FALL	23.6cd	2.2bc
NIS	L	0.25%V/V	FALL		
MESOTRIONE	4SC	0.125	FALL/2 WAT	61.1abc	74.4ab
NIS	L	0.25%V/V	FALL/2 WAT		
MESOTRIONE	4SC	0.187/0.125	FALL /2 WAT	71.4ab	78.6ab
NIS	L	0.25%V/V	FALL/2 WAT		
MESOTRIONE	4SC	0.187	FALL/2 WAT	66.3ab	51.5ab
NIS	L	0.25%V/V	FALL/2 WAT		
CHECK				-8.3d	-50.0 c
MESOTRIONE	4SC	0.15/0.233/0.15	FALL/2 WAT/4 WAT	76.4a	91.9a
NIS	L	0.25%V/V	FALL /2 WAT/4 WAT		
MESOTRIONE	4SC	0.125	FALL	23.3cd	36.1ab
MSO	L	1.0%V/V	FALL		
MESOTRIONE	4SC	0.187	FALL	1.7d	0.0bc
MSO	L	1.0%V/V	FALL		
MESOTRIONE	4SC	0.125	FALL/2 WAT	30.6bcd	47.8ab
MSO	L	1.0 %V/V	FALL /2 WAT		
MESOTRIONE	4SC	0.187/0.125	FALL/2 WAT	68.3ab	90.0a
MSO	L	1.0%V/V	FALL /2WAT		
MESOTRIONE	4SC	0.187	FALL/2 WAT	67.2ab	76.1ab

MSO	L	1.0%V/V	FALL/2 WAT			
MESOTRIONE	4SC	0.15	FALL	/2 WAT/4 WAT	66.7ab	63.3ab
MSO	L	1.0%V/V	FALL	/2 WAT/4 WAT		

1 - Means followed by same letter do not significantly differ (P=0.05, Duncan's New MRT)
2 – Positive numbers represent a percent decrease and negative numbers a percent increase.

Seedhead Suppression of Annual Bluegrass at Fairway Height

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

Introduction

This study was conducted on a mature stand of annual bluegrass (*Poa annua*) at the Valentine Turfgrass Research Center, University Park, PA. The objective of the study was to evaluate selected growth regulators for turfgrass color and the seedhead suppression of annual bluegrass under fairway height conditions.

Methods and Materials

Treatments were applied on Oct 29 (NOV 1), Nov 16 (NOV 15), Nov 29, 2004 (NOV 30), and April 14, 2005 (FB) using a three-foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two 11004 flat fan nozzles at 40 psi.

The study was a randomized complete block design with three replications. The April 14, 2005 application of materials was at forsythia full bloom. The turf was maintained using cultural practices for irrigation, mowing, and fertilization that would be typical for a fairway.

Results and Discussion

Turfgrass color was rated five times (Table 1). Unacceptable color was rated on April 4th for turfgrass treated with the combination of Primo plus Proxy. On the April 26th rating date, turfgrass treated with Proxy plus Primo applied NOV 15 plus FB and NOV 30 plus FB had unacceptable color.

The percent seedhead suppression was rated once on May 24, 2005 (Table 2). All treated turfgrass had significantly more seedhead suppression than non-treated. The greatest amount of seedhead suppression provided was 23.3%.

Although significantly different than non-treated turfgrass, a 23.3% reduction in annual bluegrass seedhead may not be a sufficient reduction for most turfgrass managers.

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Table 1. Color ratings of an annual bluegrass at fairway height on a scale of 0 to 10 where 0 = brown, 7 = acceptable, and 10 = dark green.

Treatment	Form	Rate oz/M	Timing	4/8	4/12	4/20	4/26	5/4
				(-----------Color--------------)				
PROXY	2SL	5	NOV 1	7.8	8.0	7.2	7.5	10.0
PROXY	2SL	5	NOV 15	7.7	8.3	7.3	7.5	10.0
PROXY	2SL	5	NOV 30	7.7	8.7	7.7	8.2	10.0
PROXY	2SL	5	FB	7.0	7.3	6.5	7.2	10.0
PRIMO	1EC	0.25	FB					
CHECK				7.0	7.3	7.0	7.3	10.0
PROXY	2SL	5	NOV 1/FB	7.5	8.3	6.8	7.0	10.0
PRIMO	1EC	0.25	FB					
PROXY	2SL	5	NOV 15/FB	7.7	8.2	6.5	6.7	10.0
PRIMO	1EC	0.25	FB					
PROXY	2SL	5	NOV 30/FB	7.5	8.0	6.8	6.8	10.0
PRIMO	1EC	0.25	FB					

Table 2. Ratings of the percent seedhead suppression of an annual bluegrass at fairway height taken on May 24, 2005.

Treatment	Form	Rate oz/M	Timing	Percent Reduction
PROXY	2SL	5	NOV 1	16.7a[1,2]
PROXY	2SL	5	NOV 15	20.0a
PROXY	2SL	5	NOV 30	16.7a
PROXY	2SL	5	FB	20.0a
PRIMO	1EC	0.25	FB	
CHECK				0.0b
PROXY	2SL	5	NOV 1/FB	20.0a
PRIMO	1EC	0.25	FB	
PROXY	2SL	5	NOV 15/FB	23.3a
PRIMO	1EC	0.25	FB	
PROXY	2SL	5	NOV 30/FB	20.0a
PRIMO	1EC	0.25	FB	

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

2 – Data were transformed using Abbott's (% of untreated).

Evaluation of Primo Formulations and Sprayer Nozzles on Fairway Height Creeping Bentgrass

J. A. Borger, Dr. T. L. Watschke and N. B. Naedel[1]

Introduction

This study was conducted on a mature stand of 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 the efficacy of varying nozzle types (droplet size) to apply Primo MAXX and Primo WSB using color ratings and measurements of plant height and foliar fresh weight yield.

Methods and Materials

This study was a randomized complete block design with three replications. The plot size was 40 ft^2. All treatments were applied on June 8 and June 23, 2005 using a four foot battery powered walk behind boom sprayer calibrated to deliver 1 (all treatments except nozzle TT11006) or 2 gpm using two nozzles of varying types/droplet size at 40 psi. The test site was maintained similar to that of a golf course fairway with respect to irrigation, fertilization and mowing. Turfgrass height was measured using a Turfcheck 1 prism.

Results and Discussion

Turfgrass color was rated seven times during the study (Table 1). Turfgrass color was never rated below acceptable. The lowest turfgrass color rating during the study was 7.8 on the first rating date (June 15, 2005). There were only slight color differences between treated and untreated turfgrass.

Turfgrass height was rated seven times during the study (Table 2). On the first rating date, June 15th, turfgrass treated with Primo MAXX at 0.125 oz/M with an XR Tee Jet XR11003 nozzle had significantly lower height than untreated. On the second rating date, June 22nd, turfgrass treated with Primo MAXX at 0.25 oz/M with a Turf Jet 1/4TT J04 nozzle, Primo MAXX at 0.125 oz/M with an AL Tee Jet AI 11003 nozzle, Primo MAXX at 0.25 oz/M with an AL Tee Jet AI 11003 nozzle, Primo MAXX at 0.125 oz/M with an TUR Tee Jet TT 11003 nozzle, Primo MAXX at 0.25 oz/M with an TUR Tee Jet TT 11003 nozzle, Primo MAXX at 0.125 oz/M with an XR Tee Jet XR 11004 nozzle, Primo MAXX at 0.25 oz/M with an TUR Tee Jet TT 11006 nozzle, Primo WSB at 0.0625 oz/M with an XR Tee Jet XR 11003 nozzle had significantly lower height than untreated. On the July 7th rating date, turfgrass treated with Primo MAXX at 0.25 oz/M with an TUR Tee Jet TT 11006 nozzle, Primo WSB at 0.125 oz/M with an XR Tee Jet XR 11003 nozzle had significantly lower height. Finally, on the July 12th rating date, turfgrass treated with Primo MAXX at 0.25 oz/M with a Turf Jet 1/4TT J04 nozzle, Primo MAXX at 0.25 oz/M with an XR Turf Jet XR 1104 nozzle, Primo MAXX at 0.25 oz/M with a TUR Tee Jet TT 11006 nozzle, Primo WSB at 0.0625 oz/M with an XR Tee Jet XR 11003 nozzle, and Primo WSB at 0.125 oz/M with an XR Tee Jet XR 11003 nozzle had significantly less height than untreated.

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Turfgrass fresh clipping weights were collected five times during the study (Table 3). On the first rating date, June 22nd, all treated turfgrass had significantly less clipping weight than untreated. On the second rating date, June 30th, all treated turfgrass except Primo WSB at 0.0625 oz/M with an XR Tee Jet XR 11003 nozzle had significantly less clipping weight than untreated. On the July 7th rating date, turfgrass treated with Primo MAXX at 0.25 oz/M with a Turf Jet 1/4TT J04 nozzle, Primo MAXX at 0.125 oz/M with a TUR Tee Jet TT 11003 nozzle, Primo MAXX at 0.25 oz/M with an XR Tee Jet XR 11004 nozzle, Primo MAXX at 0.125 oz/M with an XR Tee Jet XR 11003 nozzle, Primo MAXX at 0.25 oz/M with an XR Tee Jet XR 11003 nozzle, Primo MAXX at 0.125 oz/M with a TUR Tee Jet TT 11006 nozzle, and Primo WSB at 0.125 oz/M with an XR Tee Jet XR 11003 nozzle had significantly less clipping weight than untreated. Finally, on the July 12th rating date, turfgrass treated with Primo MAXX at 0.125 oz/M with an XR Tee Jet XR 11003 nozzle had significantly less clipping weight than untreated.

Table 1. Color ratings on a scale of 0-10 where 0 = brown, 7= acceptable, and 10 = dark green of PGR's applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate oz/M	6-15	6-22	6-30	7-7	7-12	7-20	7-28
PRIMO MAXX TURF JET 1/4TT JO4 (2.8) XC[1]	1MEC	0.125	8.0	8.3	8.2	8.3	8.3	8.0	8.3
PRIMO MAXX TURF JET 1/4TT JO4 (2.8) XC	1MEC	0.25	8.0	8.5	8.5	8.5	8.2	8.0	8.7
PRIMO MAXX AL TEEJET AI11003 (2.0) VC	1MEC	0.125	7.8	8.3	8.3	8.7	8.3	8.3	8.8
PRIMO MAXX AL TEEJET AI11003 (2.0) VC	1MEC	0.25	8.0	8.5	8.7	8.5	8.2	8.2	8.8
PRIMO MAXX TUR TEEJET TT11003 (2.0) C	1MEC	0.125	8.0	8.2	8.5	8.8	8.7	8.2	8.7
PRIMO MAXX TUR TEEJET TT11003 (2.0) C	1MEC	0.25	8.3	8.3	8.3	8.7	8.3	8.5	8.7
PRIMO MAXX XR TEEJET XR11004 (2.8) M	1MEC	0.125	8.0	8.7	8.7	8.5	8.7	8.3	8.7
CHECK			8.0	8.8	8.3	8.2	8.2	8.2	8.3
PRIMO MAXX XR TEEJET XR11004 (2.8) M	1MEC	0.25	8.0	8.3	8.7	8.5	8.0	8.2	8.5
PRIMO MAXX XR TEEJET XR11003 (2.0) F	1MEC	0.125	8.0	8.3	8.2	8.7	8.8	8.5	9.0
PRIMO MAXX XR TEEJET XR11003 (2.0) F	1MEC	0.25	8.0	8.8	8.8	9.0	8.8	8.2	8.5
PRIMO MAXX TUR TEEJET TT11006 (2.0) XC	1MEC	0.25	8.0	9.0	8.8	8.5	8.3	8.2	8.8
PRIMO MAXX TUR TEEJET TT11006 (2.0) XC	1MEC	0.125	8.0	8.8	8.5	8.5	8.3	8.2	8.5
PRIMO WSB XR TEEJET XR11003 (2.0) C	WS	0.0625	8.2	8.7	8.5	8.5	8.3	8.3	8.5
PRIMO WSB XR TEEJET XR11003 (2.0) C	WS	0.125	8.0	8.7	8.7	8.7	8.7	8.2	8.7

1 – Nozzle type (ground speed mph) droplet size where XC = extra coarse, VC = very coarse, C = coarse, M = medium, and F = fine.

Table 2. Height ratings (in inches) of PGR's applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate oz/M	6-15	6-22	6-30	7-7	7-12	7-20	7-28
PRIMO MAXX TURF JET 1/4TT JO4 (2.8) XC[1]	1MEC	0.125	0.41ab[2]	0.39ab	0.39ab	0.39ab	0.39abc	0.54a	0.51ab
PRIMO MAXX TURF JET 1/4TT JO4 (2.8) XC	1MEC	0.25	0.39ab	0.38b	0.39ab	0.38abc	0.37bc	0.51ab	0.51ab
PRIMO MAXX AL TEEJET AI11003 (2.0) VC	1MEC	0.125	0.38ab	0.36b	0.38ab	0.38abc	0.38abc	0.51ab	0.51ab
PRIMO MAXX AL TEEJET AI11003 (2.0) VC	1MEC	0.25	0.38ab	0.38b	0.37ab	0.39abc	0.39abc	0.52ab	0.53ab
PRIMO MAXX TUR TEEJET TT11003 (2.0) C	1MEC	0.125	0.38ab	0.38b	0.35b	0.38abc	0.39abc	0.52ab	0.54a
PRIMO MAXX TUR TEEJET TT11003 (2.0) C	1MEC	0.25	0.39ab	0.37b	0.39ab	0.4a	0.4ab	0.51ab	0.51ab
PRIMO MAXX XR TEEJET XR11004 (2.8) M	1MEC	0.125	0.38ab	0.37b	0.37ab	0.39abc	0.38abc	0.52ab	0.51ab
CHECK			0.42a	0.42a	0.39ab	0.4a	0.41a	0.51ab	0.51ab
PRIMO MAXX XR TEEJET XR11004 (2.8) M	1MEC	0.25	0.38ab	0.38ab	0.38ab	0.37abc	0.37bc	0.52ab	0.53ab
PRIMO MAXX XR TEEJET XR11003 (2.0) F	1MEC	0.125	0.37b	0.38ab	0.39ab	0.38abc	0.39abc	0.55a	0.53ab
PRIMO MAXX XR TEEJET XR11003 (2.0) F	1MEC	0.25	0.39ab	0.39ab	0.39ab	0.38abc	0.38abc	0.53ab	0.51ab
PRIMO MAXX TUR TEEJET TT11006 (2.0) XC	1MEC	0.25	0.38ab	0.38b	0.38ab	0.37bc	0.37bc	0.53ab	0.52ab
PRIMO MAXX TUR TEEJET TT11006 (2.0) XC	1MEC	0.125	0.39ab	0.39ab	0.38ab	0.4a	0.41a	0.52ab	0.51ab
PRIMO WSB XR TEEJET XR11003 (2.0) C	WS	0.0625	0.39ab	0.38b	0.41a	0.38abc	0.37bc	0.47b	0.49ab
PRIMO WSB XR TEEJET XR11003 (2.0) C	WS	0.125	0.38ab	0.39ab	0.39ab	0.36c	0.36c	0.51ab	0.49b

1 – Nozzle type (ground speed mph) droplet size where XC = extra coarse, VC = very coarse, C = coarse, M = medium, and F = fine.

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

Table 3. Fresh clipping weight (grams) of creeping bentgrass taken in 2005.

Treatment	Form	Rate oz/M	6-22	6-30	7-7	7-12	7-20
PRIMO MAXX TURF JET 1/4TT JO4 (2.8) XC[1]	1MEC	0.125	5.4bc[2]	7.5bc	3.6ab	6.3ab	29.6a
PRIMO MAXX TURF JET 1/4TT JO4 (2.8) XC	1MEC	0.25	4.7bc	5.7c	2.9b	4.7ab	33.3a
PRIMO MAXX AL TEEJET AI11003 (2.0) VC	1MEC	0.125	3.9c	7.2bc	3.9ab	5.2ab	27.3a
PRIMO MAXX AL TEEJET AI11003 (2.0) VC	1MEC	0.25	5.2bc	6.1c	3.2ab	5.9ab	37.2a
PRIMO MAXX TUR TEEJET TT11003 (2.0) C	1MEC	0.125	3.6c	5.7c	2.9b	6.0ab	33.9a
PRIMO MAXX TUR TEEJET TT11003 (2.0) C	1MEC	0.25	6.1bc	8.3bc	4.1ab	6.1ab	39.4a
PRIMO MAXX XR TEEJET XR11004 (2.8) M	1MEC	0.125	7.3bc	9.3bc	4.1ab	6.3ab	42.2a
CHECK			14.3a	15.7a	5.7a	7.8a	37.6a
PRIMO MAXX XR TEEJET XR11004 (2.8) M	1MEC	0.25	4.2c	6.0c	2.8b	5.8ab	33.1a
PRIMO MAXX XR TEEJET XR11003 (2.0) F	1MEC	0.125	3.7c	5.4c	2.4b	4.1b	29.9a
PRIMO MAXX XR TEEJET XR11003 (2.0) F	1MEC	0.25	4.8bc	6.2c	2.8b	5.3ab	36.6a
PRIMO MAXX TUR TEEJET TT11006 (2.0) XC	1MEC	0.25	8.1b	8.3bc	3.7ab	6.3ab	40.1a
PRIMO MAXX TUR TEEJET TT11006 (2.0) XC	1MEC	0.125	7.0bc	7.5c	2.7b	4.9ab	34.4a
PRIMO WSB XR TEEJET XR11003 (2.0) C	WS	0.0625	8.3b	11.8ab	3.6ab	4.7ab	28.9a
PRIMO WSB XR TEEJET XR11003 (2.0) C	WS	0.125	5.6bc	6.5bc	2.6b	5.2ab	31.0a

1 – Nozzle type (ground speed mph) droplet size where XC = extra coarse, VC = very coarse, C = coarse, M = medium, and F = fine.

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

Evaluation of Plant Growth Regulators and Other Materials Applied to Fairway Height Creeping Bentgrass

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

Introduction

This study was conducted on a mature stand of 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 the efficacy of a fungicide, herbicide, and plant growth regulators alone or in combination with a liquid fertilizer using color ratings, measurements of plant height, and fresh weight foliar yield.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on June 7 (SUMMER), June 23 (2 WAT) and July 12, 2005 (4 WAT) using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi. The test site was maintained similar to that of a golf course fairway with respect to irrigation, fertilization and mowing. Turfgrass height was measured using a Turfcheck 1 prism.

Results and Discussion

Turfgrass color was rated nine times during the study (Table 1). Only on the first rating date, June 15th, was unacceptable turfgrass color found following the application of Velocity at 45 g ai/A or greater.

Turfgrass height was rated ten times during the study (Table 2). On the June 15th rating date, turfgrass treated with Trimmit plus Rubigan at 1.5 oz/M, Trimmit plus 18-3-1 (fertilizer), and Velocity at 60 g ai/A had significantly lower height than untreated. On the June 22nd rating date, turfgrass treated with Trimmit plus Rubigan at 0.75 oz/M with or without 18-3-1, Trimmit plus Rubigan at 1.5 oz/M plus 18-3-1, Trimmit plus 18-3-1, and Trimmit plus Banner MAXX had significantly lower height than untreated. On the June 30th rating date, turfgrass treated with Trimmit in any combination had significantly lower height than untreated. On the July 7th rating date, turfgrass treated with Trimmit plus Rubigan at 1.5 oz/M and Trimmit plus Banner MAXX had significantly lower height than untreated. On the July 12th rating date, turfgrass treated with Trimmit plus banner MAXX had significantly lower height than untreated.

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On the July 28th rating date, turfgrass treated with Trimmit in any combination and Cutless at 12 oz/A alone had significantly lower height than untreated. On the August 4th rating date, turfgrass treated with Trimmit plus Rubigan at 0.75 oz/M had significantly lower height than untreated. On the August 9th rating date, turfgrass treated with Trimmit plus Rubigan at 0.75 oz/M, Trimmit plus Rubigan at 1.5 oz/M with and without 18-3-1, and Trimmit plus 18-3-1 had significantly lower height than untreated. Finally, on the August 17th rating date, turfgrass treated with Trimmit plus 18-3-1 had significantly higher height than untreated.

Turfgrass fresh clipping weight was taken eight times during the study (Table 3). On the June 22nd rating date, turfgrass treated with Trimmit in any combination had significantly less fresh clipping weight than untreated. On the June 30th rating date, turfgrass treated with Trimmit plus Banner MAXX had significantly less fresh clipping weight than untreated. On the July 12th rating date, turfgrass treated with Trimmit plus Rubigan at 1.5 oz/M plus 18-3-1 had significantly more fresh clipping weight than untreated. On the July 20th and August 9th rating dates, turfgrass treated with Velocity at the 30 and 45 g ai/A rate had significantly more fresh clipping weight than untreated. Finally, on the August 17th rating date, turfgrass treated with Trimmit plus Rubigan at 0.75 oz/M plus 18-3-1 had significantly more fresh clipping weight than untreated.

Table 1. Color ratings on a scale of 0-10 where 0 = brown, 7= acceptable, and 10 = dark green of materials applied to creeping bentgrass taken in 2005.

Treatment	**Form**	**Rate lb ai/A**	**Timing**	**6-15**	**6-22**	**6-30**	**7-7**	**7-12**	**7-20**	**7-28**	**8-4**	**8-17**
TRIMMIT	2SC	0.4	JUNE/4 WAT	7.5	8.5	8.2	8.2	8.0	8.7	9.2	8.7	8.0
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT									
TRIMMIT	2SC	0.4	JUNE/4 WAT	8.0	8.7	8.7	8.5	8.5	8.8	9.3	9.0	8.0
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT									
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT									
TRIMMIT	2SC	0.4	JUNE/4 WAT	7.7	8.7	8.5	8.3	8.3	8.3	9.5	8.7	8.0
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT									
TRIMMIT	2SC	0.4	JUNE/4 WAT	7.8	8.8	8.7	8.7	8.7	8.7	9.3	6.0	8.0
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT									
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT									
TRIMMIT	2SC	0.4	JUNE/4 WAT	7.7	8.8	8.7	8.5	8.7	8.5	9.2	8.8	8.0
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT									
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT	7.7	8.8	8.8	8.7	8.5	8.8	8.8	8.5	8.0
CHECK				7.5	8.3	8.5	8.2	8.0	8.2	8.3	8.2	8.0
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT	7.7	8.3	8.3	8.5	8.5	8.8	8.7	8.3	8.0
VELOCITY	80WP	30 G A/A	JUNE/2 WAT	7.0	8.8	8.5	8.3	8.0	8.3	8.8	8.5	8.0
VELOCITY	80WP	45 G A/A	JUNE/2 WAT	6.0	8.2	8.3	8.5	8.2	8.5	8.5	8.2	8.0
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	6.0	8.0	8.0	8.3	8.2	8.0	8.7	8.3	8.0
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	7.8	8.5	8.3	8.2	8.2	8.5	8.5	8.8	8.0
CUTLESS	50W	12 OZ /A	JUNE/4 WAT	7.8	8.0	7.8	8.0	8.3	8.2	8.8	8.8	8.0
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT									
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	7.7	8.3	8.5	8.5	8.5	8.2	8.8	8.7	8.0
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT									
TRIMMIT	2SC	0.4	JUNE/4 WAT	7.7	8.3	8.3	8.2	8.2	9.0	9.3	9.0	8.0
BANNER MAXX	1.3L	44 FL OZ/A	JUNE/4 WAT									

Table 2. Height ratings (in inches) of materials applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate lb ai/A	Timing	(------Height------) 6-15	6-22	6-30	7-7	7-12
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.40c-f	0.36de	0.37bc	0.39ab	0.39a-d
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.40c-f	0.35e	0.37bc	0.40ab	0.40abc
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT					
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.38ef	0.37b-e	0.37bc	0.38bc	0.40abc
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.40c-f	0.36cde	0.37bc	0.41ab	0.42ab
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT					
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.39def	0.36cde	0.37bc	0.40ab	0.39a-d
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT					
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT	0.44abc	0.41ab	0.43a	0.42a	0.40abc
CHECK				0.46a	0.41ab	0.41ab	0.42a	0.43a
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT	0.44abc	0.39a-e	0.41ab	0.41ab	0.40abc
VELOCITY	80WP	30 G A/A	JUNE/2 WAT	0.41c-f	0.41ab	0.39ab	0.39abc	0.39a-d
VELOCITY	80WP	45 G A/A	JUNE/2 WAT	0.39def	0.42a	0.38abc	0.40ab	0.38bcd
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	0.37f	0.38a-e	0.39abc	0.39abc	0.37cd
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	0.43a-d	0.38a-e	0.41ab	0.41ab	0.42ab
CUTLESS	50W	12 OZ /A	JUNE/4 WAT	0.45ab	0.39a-d	0.41ab	0.41ab	0.40abc
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT					
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	0.41b-f	0.40abc	0.41ab	0.40ab	0.39a-d
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.42a-e	0.36cde	0.34c	0.36c	0.36d
BANNER MAXX	1.3L	44 FL OZ/A	JUNE/4 WAT					

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

Table 2 (continued). Height ratings (in inches) of materials applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate lb ai/A	Timing	Height 7-20	Height 7-28	Height 8-4	Height 8-9	Height 8-17
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.43b	0.41efg	0.42c	0.41d	0.64abc
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.43b	0.43c-f	0.44abc	0.43bcd	0.66ab
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT					
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.44b	0.37g	0.45abc	0.40d	0.63a-d
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.43b	0.39efg	0.44abc	0.41d	0.67ab
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT					
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.43b	0.39efg	0.46abc	0.41d	0.69a
18-3-1	1.8L	0.2 LB N/M	JUNE/4 WAT					
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT	0.52a	0.52a	0.49ab	0.51a	0.62bcd
CHECK				0.48ab	0.49ab	0.49ab	0.48abc	0.60bcd
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT	0.46b	0.48abc	0.46abc	0.48abc	0.57d
VELOCITY	80WP	30 G A/A	JUNE/2 WAT	0.48ab	0.49ab	0.47abc	0.49ab	0.59bcd
VELOCITY	80WP	45 G A/A	JUNE/2 WAT	0.48ab	0.49ab	0.48abc	0.48abc	0.58cd
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	0.49ab	0.49ab	0.51a	0.47abc	0.61bcd
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	0.46ab	0.42d-g	0.48abc	0.43bcd	0.59bcd
CUTLESS	50W	12 OZ /A	JUNE/4 WAT	0.48ab	0.47a-d	0.47abc	0.48abc	0.63a-d
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT					
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	0.47ab	0.44b-e	0.46abc	0.46a-d	0.63a-d
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT					
TRIMMIT	2SC	0.4	JUNE/4 WAT	0.44b	0.38fg	0.44bc	0.42cd	0.59bcd
BANNER MAXX	1.3L	44 FL OZ/A	JUNE/4 WAT					

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

Table 3. Fresh clipping weight (grams) of materials applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate lb ai/A	Timing	Fresh Clipping Weight[1] 6-22	6-30	7-7	7-12	7-20
TRIMMIT RUBIGAN	2SC 1AS	0.4 0.75 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	3.93d	5.07cde	3.9ab	6.9ab	7.4e
TRIMMIT RUBIGAN 18-3-1	2SC 1AS 1.8L	0.4 0.75 FL OZ/M 0.2 LB N/M	JUNE/4 WAT JUNE/4 WAT JUNE/4 WAT	4.20d	5.90cde	4.6ab	8.1ab	7.2e
TRIMMIT RUBIGAN	2SC 1AS	0.4 1.5 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	4.67cd	4.47de	4.2ab	5.6ab	7.3e
TRIMMIT RUBIGAN 18-3-1	2SC 1AS 1.8L	0.4 1.5 FL OZ/M 0.2 LB N/M	JUNE/4 WAT JUNE/4 WAT JUNE/4 WAT	4.33d	6.43cde	6.3ab	9.5a	9.9de
TRIMMIT 18-3-1	2SC 1.8L	0.4 0.2 LB N/M	JUNE/4 WAT JUNE/4 WAT	3.90d	6.10cde	5.5ab	8.6ab	8.4e
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT	10.90a	13.43a	7.2a	5.2ab	20.9ab
CHECK				8.47ab	9.10a-d	4.8ab	3.8b	14.7b-e
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT	8.77ab	9.47abc	5.2ab	4.3b	20.1abc
VELOCITY	80WP	30 G A/A	JUNE/2 WAT	9.40ab	8.57bcd	5.4ab	5.1ab	24.0a
VELOCITY	80WP	45 G A/A	JUNE/2 WAT	9.00ab	8.77bcd	5.5ab	4.4b	24.8a
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	5.80bcd	6.60b-e	4.0ab	3.8b	18.5a-d
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	8.13abc	9.33abc	5.3ab	3.7b	11.6cde
CUTLESS RUBIGAN	50W 1AS	12 OZ /A 0.75 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	6.33bcd	9.37abc	4.6ab	3.8b	10.9de
CUTLESS RUBIGAN	50W 1AS	12 OZ/A 1.5 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	8.53ab	11.20ab	6.1ab	5.9ab	13.3b-e
TRIMMIT BANNER MAXX	2SC 1.3L	0.4 44 FL OZ/A	JUNE/4 WAT JUNE/4 WAT	3.50d	3.87e	2.8b	4.9ab	8.2e

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

Table 3 (continued). Fresh clipping weight (grams) of materials applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate lb ai/A	Timing	(------------Fresh Clipping Weight [1]------------) 8-4	8-9	8-17
TRIMMIT RUBIGAN	2SC 1AS	0.4 0.75 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	3.6bc	5.5e	22.2abc
TRIMMIT RUBIGAN 18-3-1	2SC 1AS 1.8L	0.4 0.75 FL OZ/M 0.2 LB N/M	JUNE/4 WAT JUNE/4 WAT JUNE/4 WAT	3.7bc	5.5e	35.6a
TRIMMIT RUBIGAN	2SC 1AS	0.4 1.5 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	2.4c	4.8e	22.2abc
TRIMMIT RUBIGAN 18-3-1	2SC 1AS 1.8L	0.4 1.5 FL OZ/M 0.2 LB N/M	JUNE/4 WAT JUNE/4 WAT JUNE/4 WAT	3.4bc	6.7de	27.6abc
TRIMMIT 18-3-1	2SC 1.8L	0.4 0.2 LB N/M	JUNE/4 WAT JUNE/4 WAT	5.6abc	7.0de	32.9ab
RUBIGAN	1AS	1.5 FL OZ/M	JUNE/4 WAT	7.9a	14.4ab	26.9abc
CHECK				4.8abc	9.8b-e	17.9bc
RUBIGAN	1AS	0.75 FL OZ/M	JUNE/4 WAT	6.6ab	13.4abc	20.7abc
VELOCITY	80WP	30 G A/A	JUNE/2 WAT	6.6ab	15.3a	20.8abc
VELOCITY	80WP	45 G A/A	JUNE/2 WAT	6.6ab	15.7a	18.7bc
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	4.7abc	11.6a-d	17.2bc
CUTLESS	50W	12 OZ/A	JUNE/4 WAT	4.4bc	8.0cde	16.4c
CUTLESS RUBIGAN	50W 1AS	12 OZ /A 0.75 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	4.6bc	7.8de	17.6bc
CUTLESS RUBIGAN	50W 1AS	12 OZ/A 1.5 FL OZ/M	JUNE/4 WAT JUNE/4 WAT	6.3ab	9.8b-e	22.2abc
TRIMMIT BANNER MAXX	2SC 1.3L	0.4 44 FL OZ/A	JUNE/4 WAT JUNE/4 WAT	3.0c	5.6e	22.7abc

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

Annual Bluegrass Control and Dollar Spot Suppression in Fairway Height Creeping Bentgrass

J.A Borger, T. L. Watschke, M. D. Soika, 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 applications of selected materials could reduce dollar spot (*Sclerotinia homoeocarpa*) and the annual bluegrass population under fairway conditions.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on June 2 (JUNE), June 9 (7 DAT), June 14 (14 DAT), June 21 (21 DAT), June 30 (28 DAT), July 7 (35 DAT), July 15 (42 DAT), Sept 7 (SEPT), Oct 5 (OCT), and Nov 11, 2004 (NOV) using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles 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 test site consisted of approximately 70 percent creeping bentgrass and 30 percent annual bluegrass at the initiation of the study. The annual bluegrass population was visually evaluated on May 23, 2004, on a plot by plot basis, to determine the baseline population in each plot. The change in the annual bluegrass population was compared to these baseline ratings.

On July 21, 2004, the test area was put on a maintenance fungicide program to control disease.

Results and Discussion

Turfgrass discoloration was rated four times (Table 1). All turfgrass treated with Velocity at any rate or formulation was rated below acceptable (7.0) at least once over this time period. By the July 28th rating date no unacceptable discoloration was found. On July 13, 2004 turfgrass treated with Trimmit was rated below acceptable (6.0).

Dollar spot was rated 15 times (Table 2). There was no significant differences found on the June 7th and 14th rating dates between treated or non-treated turfgrass. Turfgrass treated with Velocity had less dollar spot, when compared to non-treated turfgrass on the June 23rd, 30th, and July 13th rating dates with the exception of Velocity plus Aquathol K, Velocity 80WP at 45 g ai/A plus MacroSorb Foliar at 2 oz/M applied once (JUNE), and Velocity 80WP at 60 g ai/A plus GBJ2 at 2 oz/M applied once (JUNE). Generally, turfgrass treated with multiple applications of

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Velocity tended to have less dollar spot when compared to non-treated. On the June 23rd rating date turfgrass treated with Trimmit was not significantly different than non-treated. On the July 13th, 21st, 28th, and August 3rd rating dates turfgrass treated with Trimmit had significantly less dollar spot than non-treated turfgrass. On the August 18th rating date, only turfgrass treated with Trimmit at 0.66 lb ai/A applied JUNE, SEPT, and OCT was not significantly different than non-treated turfgrass, all other turfgrass treated with Trimmit had significantly less dollar spot. On the August 25th rating date, all turfgrass treated with Trimmit had significantly less dollar spot. The next rating date, August 31st, only turfgrass treated with Trimmit combined with Rubigan or 18-3-4 had significantly less dollar spot than non-treated, all other turfgrass treated with Trimmit was not significantly different than non-treated. Generally, turfgrass treated with Trimmit tended to provide dollar spot suppression until ratings stopped on September 29th. Turfgrass treated with Rubigan tended to have less dollar spot than non-treated. Ratings of percent dollar spot stopped before treatments of Prograss or combinations of Prograss were applied.

On May 12, 2005 turfgrass was rated for the percent reduction of annual bluegrass (Table 3). Only turfgrass treated with Velocity 80WP at 45 g ai/A plus MacroSorb Foliar at 2 oz/M applied once (JUNE) and Rubigan alone did not significantly reduce the annual bluegrass in the sward compared to non-treated. When Trimmit was combined with Prograss, annual bluegrass was reduced significantly more that Prograss applied alone. Although not significantly different from other treated turfgrass, turfgrass treated with Trimmit alone or in combination with 18-3-4, Rubigan, or Prograss at the 0.75 lb ai/A rate and Velocity 80WP at 60 g ai/A plus 18-3-4 applied in JUNE and 28 DAT reduced the annual bluegrass by 80% or more.

It appears that applications of these materials will provide good to excellent control of dollar spot and significantly reduce the annual bluegrass populations in the mixed species sward.

Table 1. Discoloration of a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass in 2004.

Treatment	Form	Rate (lb ai/A)	Timing	(-----Discoloration-------) 6/7	6/9	7/13	7/28
VELOCITY	80WP	45 G AI/A	JUNE	6.0[1]	5.7	10.0	10.0
VELOCITY	80WP	30 G AI/A	JUNE/14DAT	6.7	6.0	10.0	10.0
VELOCITY	80WP	45 G AI/A	JUNE/14DAT	5.8	5.5	10.0	10.0
VELOCITY	80WP	30 G AI/A	JUNE/14/28DAT	5.8	6.8	10.0	10.0
VELOCITY	17.6WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	6.5	6.7	7.3	10.0
VELOCITY	80WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	7.8	6.5	8.3	10.0
VELOCITY	80WP	20 G AI/A	JUNE/14/28/42DAT	6.7	6.5	9.3	10.0
VELOCITY	80WP	60 G AI/A	JUNE	5.8	5.3	9.5	10.0
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	5.8	5.0	8.7	10.0
VELOCITY AQUATHOL K	80WP 4.23L	10 G AI/A 0.25	JUNE JUNE	4.7	4.8	10.0	10.0
VELOCITY 18-3-4	80WP 1.75L	45 G AI/A 0.2 LB AI/M	JUNE JUNE	5.7	5.3	10.0	10.0
VELOCITY MACROSORB FOLIAR	80WP L	45 G AI/A 2 OZ/M	JUNE JUNE	6.2	6.0	9.7	10.0
VELOCITY 18-3-4	80WP 1.75L	60 G AI/A 0.2 LB AI/M	JUNE JUNE	6.5	5.0	10.0	10.0
VELOCITY MACROSORB FOLIAR	80WP L	60 G AI/A 2 OZ/M	JUNE JUNE	5.8	5.0	10.0	10.0
VELOCITY 18-3-4	80WP 1.75L	60 G AI/A 0.2 LB AI/M	JUNE/28DAT JUNE/28DAT	5.8	5.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0
VELOCITY MACROSORB FOLIAR	80WP L	60 G AI/A 2 OZ/M	JUNE/28DAT JUNE/28DAT	5.8	5.3	9.3	10.0
VELOCITY GBJ2	80WP L	60 G AI/A 2 OZ/M	JUNE JUNE	6.0	4.3	10.0	10.0
VELOCITY GBJ2	80WP L	45 G AI/A 2 OZ/M	JUNE JUNE	6.2	5.8	10.0	10.0
TRIMMIT 18-3-4	2SC 1.75L	0.66 0.2 LB AI/M	JUNE/SEPT/OCT JUNE/SEPT/OCT	8.7	10.0	10.0	10.0
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	7.5	8.5	10.0	10.0
TRIMMIT RUBIGAN	2SC 1AS	0.66 0.75 OZ/M	JUNE/SEPT/OCT JUNE/28/42/SEPT/OCT	8.0	9.3	10.0	10.0
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT	7.7	9.0	10.0	10.0
TRIMMIT RUBIGAN	2SC 1AS	0.4 0.75 OZ/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	8.2	8.7	10.0	7.0
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	8.3	7.8	6.0	7.3
TRIMMIT 18-3-4	2SC 1.75L	0.4 0.2 LB AI/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	9.0	9.3	8.3	8.3
PROGRASS	1.5EC	0.75	OCT/NOV	10.0	10.0	10.0	10.0
TRIMMIT RUBIGAN 18-3-4	2SC 1AS 1.75L	0.4 0.75 OZ/M 0.2LB AI/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	9.3	9.3	8.3	7.3
PROGRASS TRIMMIT	1.5EC 2SC	0.75 0.75	OCT/NOV OCT/NOV	10.0	10.0	10.0	10.0
PROGRASS TRIMMIT	1.5EC 2SC	0.375 0.375	OCT/NOV OCT/NOV	10.0	10.0	10.0	10.0

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

Table 2. Percent dollar spot in a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass in 2004.

Treatment	Form	Rate (lb ai/A)	Timing	6/7	6/14	6/23	6/30	7/13
				(-----Percent Dollar Spot---------)				
VELOCITY	80WP	45 G AI/A	JUNE	0.0a[1]	0.0b	0.2b	2.3efg	10.0d-h
VELOCITY	80WP	30 G AI/A	JUNE/14DAT	0.0a	0.0b	0.2b	2.3efg	5.3e-h
VELOCITY	80WP	45 G AI/A	JUNE/14DAT	0.0a	0.0b	0.2b	0.3g	2.3fgh
VELOCITY	80WP	30 G AI/A	JUNE/14/28DAT	0.0a	0.0b	0.3b	1.0fg	2.3fgh
VELOCITY	17.6WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	0.0a	0.0b	0.3b	1.0fg	3.7fgh
VELOCITY	80WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	0.0a	0.0b	0.2b	2.0efg	1.0gh
VELOCITY	80WP	20 G AI/A	JUNE/14/28/42DAT	0.0a	0.3ab	0.3b	1.0fg	3.7fgh
VELOCITY	80WP	60 G AI/A	JUNE	0.0a	0.3ab	0.2b	4.0d-g	11.7c-f
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	0.0a	0.3ab	0.2b	5.7c-g	5.0e-h
VELOCITY AQUATHOL K	80WP 4.23L	10 G AI/A 0.25	JUNE JUNE	0.0a	0.3ab	0.3b	6.7b-f	13.3b-e
VELOCITY 18-3-4	80WP 1.75L	45 G AI/A 0.2 LB AI/M	JUNE JUNE	0.0a	0.3ab	0.3b	8.7a-d	6.7d-h
VELOCITY MACROSORB FOLIAR	80WP L	45 G AI/A 2 OZ/M	JUNE JUNE	0.0a	0.7ab	0.2b	7.0b-e	15.0bcd
VELOCITY 18-3-4	80WP 1.75L	60 G AI/A 0.2 LB AI/M	JUNE JUNE	0.0a	0.0b	0.2b	4.0d-g	10.3d-g
VELOCITY MACROSORB FOLIAR	80WP L	60 G AI/A 2 OZ/M	JUNE JUNE	0.0a	0.0b	0.0b	2.3efg	10.3d-g
VELOCITY 18-3-4	80WP 1.75L	60 G AI/A 0.2 LB AI/M	JUNE/28DAT JUNE/28DAT	0.0a	0.0b	0.2b	1.0fg	1.0gh
CHECK				0.0a	0.3ab	0.7b	13.3a	21.7ab
VELOCITY MACROSORB FOLIAR	80WP L	60 G AI/A 2 OZ/M	JUNE/28DAT JUNE/28DAT	0.0a	0.0b	0.2b	3.7d-g	6.7d-h
VELOCITY GBJ2	80WP L	60 G AI/A 2 OZ/M	JUNE JUNE	0.0a	0.0b	0.2b	2.3efg	15.0bcd
VELOCITY GBJ2	80WP L	45 G AI/A 2 OZ/M	JUNE JUNE	0.0a	0.3ab	0.2b	1.0fg	11.7c-f
TRIMMIT 18-3-4	2SC 1.75L	0.66 0.2 LB AI/M	JUNE/SEPT/OCT JUNE/SEPT/OCT	0.0a	0.3ab	0.0b	2.0efg	6.7d-h
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	0.0a	0.0b	0.0b	2.3efg	5.3e-h
TRIMMIT RUBIGAN	2SC 1AS	0.66 0.75 OZ/M	JUNE/SEPT/OCT JUNE/28/42/SEPT/OCT	0.0a	0.0b	0.0b	2.0efg	0.7h
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT	0.0a	0.0b	0.2b	4.0d-g	2.3fgh
TRIMMIT RUBIGAN	2SC 1AS	0.4 0.75 OZ/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	0.0a	0.0b	0.0b	2.0efg	2.3fgh
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	0.0a	0.3ab	0.0b	2.3efg	2.3fgh
TRIMMIT 18-3-4	2SC 1.75L	0.4 0.2 LB AI/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	0.0a	0.0b	0.2b	3.7d-g	7.0d-h
PROGRASS	1.5EC	0.75	OCT/NOV	0.0a	1.7ab	3.8a	11.7ab	25.0a
TRIMMIT RUBIGAN 18-3-4	2SC 1AS 1.75L	0.4 0.75 OZ/M 0.2LB AI/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	0.0a	0.3ab	0.0b	2.0efg	2.0gh
PROGRASS TRIMMIT	1.5EC 2SC	0.75 0.75	OCT/NOV OCT/NOV	0.0a	1.7ab	1.5b	10.0abc	15.0bcd
PROGRASS TRIMMIT	1.5EC 2SC	0.375 0.375	OCT/NOV OCT/NOV	0.0a	2.0a	2.0b	13.3a	20.0abc

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

Table 2 (cont.). Percent dollar spot in a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass in 2004.

Treatment	Form	Rate (lb ai/A)	Timing	(-----Percent Dollar Spot----------) 7/21	7/28	8/3
VELOCITY	80WP	45 G AI/A	JUNE	16.7c-g[1]	18.3b-f	18.3c-f
VELOCITY	80WP	30 G AI/A	JUNE/14DAT	13.3e-i	13.7d-i	20.0c-f
VELOCITY	80WP	45 G AI/A	JUNE/14DAT	10.0g-k	10.0e-i	16.7def
VELOCITY	80WP	30 G AI/A	JUNE/14/28DAT	8.3h-l	7.0f-i	11.7efg
VELOCITY	17.6WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	10.0g-k	5.0f-i	11.7efg
VELOCITY	80WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	6.7i-l	3.3ghi 1	1.7efg
VELOCITY	80WP	20 G AI/A	JUNE/14/28/42DAT	8.3h-l	3.7ghi	11.7efg
VELOCITY	80WP	60 G AI/A	JUNE	20.0b-e	23.3a-e	23.3b-e
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	11.7f-j	7.0f-i	16.7def
VELOCITY	80WP	10 G AI/A	JUNE	18.3b-f	25.0a-d	25.0a-e
AQUATHOL K	4.23L	0.25	JUNE			
VELOCITY	80WP	45 G AI/A	JUNE	16.7c-g	13.7d-i	18.3c-f
18-3-4	1.75L	0.2 LB AI/M	JUNE			
VELOCITY	80WP	45 G AI/A	JUNE	23.3abc	28.3abc	26.7a-d
MACROSORB FOLIAR	L	2 OZ/M	JUNE			
VELOCITY	80WP	60 G AI/A	JUNE	16.7c-g	17.0b-g	25.0a-e
18-3-4	1.75L	0.2 LB AI/M	JUNE			
VELOCITY	80WP	60 G AI/A	JUNE	16.7c-g	15.3c-h	21.7b-f
MACROSORB FOLIAR	L	2 OZ/M	JUNE			
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	5.3jkl	1.0hi	8.3fg
18-3-4	1.75L	0.2 LB AI/M	JUNE/28DAT			
CHECK				25.0ab	30.0ab	35.0ab
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	10.0g-k	5.0f-i	15.0d-g
MACROSORB FOLIAR	L	2 OZ/M	JUNE/28DAT			
VELOCITY	80WP	60 G AI/A	JUNE	18.3b-f	25.0a-d	26.7a-d
GBJ2	L	2 OZ/M	JUNE			
VELOCITY	80WP	45 G AI/A	JUNE	16.7c-g	18.7b-f	23.3b-e
GBJ2	L	2 OZ/M	JUNE			
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	11.7f-j	13.3d-i	20.0c-f
18-3-4	1.75L	0.2 LB AI/M	JUNE/SEPT/OCT			
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	15.0d-h	15.0c-i	16.7def
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	2.3kl	0.7i	8.3fg
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT			
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT	7.0i-l	5.3f-i	15.0d-g
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	2.3kl	0.7i	2.3g
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT			
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	5.7i-l	8.3f-i	12.0efg
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	5.7i-l	5.3f-i	7.3fg
18-3-4	1.75L	0.2 LB AI/M	JUNE/28/42/SEPT/OCT			
PROGRASS	1.5EC	0.75	OCT/NOV	28.3a	33.3a	35.0ab
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	1.0l	2.0hi	2.3g
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT			
18-3-4	1.75L	0.2LB AI/M	JUNE/28/42/SEPT/OCT			
PROGRASS	1.5EC	0.75	OCT/NOV	21.7a-d	30.0ab	31.7abc
TRIMMIT	2SC	0.75	OCT/NOV			
PROGRASS	1.5EC	0.375	OCT/NOV	28.3a	33.3a	38.3a
TRIMMIT	2SC	0.375	OCT/NOV			

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

Table 2 (cont.). Percent dollar spot in a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass in 2004.

Treatment	Form	Rate (lb ai/A)	Timing	(-----Percent Dollar Spot----------) 8/18	8/25	8/31
VELOCITY	80WP	45 G AI/A	JUNE	5.3def[1]	20.0a-f	15.0c-g
VELOCITY	80WP	30 G AI/A	JUNE/14DAT	5.0def	15.3b-f	12.0d-g
VELOCITY	80WP	45 G AI/A	JUNE/14DAT	2.3ef	13.3c-f	13.3d-g
VELOCITY	80WP	30 G AI/A	JUNE/14/28DAT	2.3ef	16.7b-f	16.7c-g
VELOCITY	17.6WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	2.3ef	18.3a-f	18.3b-g
VELOCITY	80WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	1.0f	13.3c-f	10.0efg
VELOCITY	80WP	20 G AI/A	JUNE/14/28/42DAT	1.0f	10.0c-f	10.0efg
VELOCITY	80WP	60 G AI/A	JUNE	15.0a-d	25.0a-d	25.0a-d
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	5.7def	12.0c-f	13.7d-g
VELOCITY	80WP	10 G AI/A	JUNE	11.7b-f	23.3a-e	23.3a-e
AQUATHOL K	4.23L	0.25	JUNE			
VELOCITY	80WP	45 G AI/A	JUNE	5.0def	11.7c-f	8.7fg
18-3-4	1.75L	0.2 LB AI/M	JUNE			
VELOCITY	80WP	45 G AI/A	JUNE	13.7b-e	30.0ab	23.3a-e
MACROSORB FOLIAR	L	2 OZ/M	JUNE			
VELOCITY	80WP	60 G AI/A	JUNE	15.0a-d	26.7abc	25.0a-d
18-3-4	1.75L	0.2 LB AI/M	JUNE			
VELOCITY	80WP	60 G AI/A	JUNE	12.0b-f	23.3a-e	20.0a-g
MACROSORB FOLIAR	L	2 OZ/M	JUNE			
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	0.7f	10.3c-f	8.7fg
18-3-4	1.75L	0.2 LB AI/M	JUNE/28DAT			
CHECK				15.0a-d	33.3a	25.0a-d
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	2.3ef	3.3f	8.3fg
MACROSORB FOLIAR	L	2 OZ/M	JUNE/28DAT			
VELOCITY	80WP	60 G AI/A	JUNE	10.0c-f	16.7b-f	18.3b-g
GBJ2	L	2 OZ/M	JUNE			
VELOCITY	80WP	45 G AI/A	JUNE	11.7b-f	20.0a-f	18.3b-g
GBJ2	L	2 OZ/M	JUNE			
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	7.0def	18.3a-f	21.7a-f
18-3-4	1.75L	0.2 LB AI/M	JUNE/SEPT/OCT			
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	5.3def	16.7b-f	16.7c-g
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	0.0f	5.0f	8.3fg
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT			
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT	0.3f	13.3c-f	11.7d-g
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	0.3f	7.0ef	8.3fg
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT			
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	2.0ef	8.3def	11.7d-g
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	1.7ef	5.7f	8.7fg
18-3-4	1.75L	0.2 LB AI/M	JUNE/28/42/SEPT/OCT			
PROGRASS	1.5EC	0.75	OCT/NOV	26.7a	30.0ab	31.7ab
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	0.3f	6.7ef	7.0g
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT			
18-3-4	1.75L	0.2LB AI/M	JUNE/28/42/SEPT/OCT			
PROGRASS	1.5EC	0.75	OCT/NOV	20.0abc	31.7ab	28.3abc
TRIMMIT	2SC	0.75	OCT/NOV			
PROGRASS	1.5EC	0.375	OCT/NOV	23.3ab	31.7ab	33.3a
TRIMMIT	2SC	0.375	OCT/NOV			

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

Table 2 (cont.). Percent dollar spot in a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass in 2004.

Treatment	Form	Rate (lb ai/A)	Timing	(-------------Percent Dollar Spot----------) 9/8	9/16	9/22	9/29
VELOCITY	80WP	45 G AI/A	JUNE	13.3b-e[1]	20.0d-i	7.0a-e	0.7c
VELOCITY	80WP	30 G AI/A	JUNE/14DAT	10.0cde	23.3b-g	3.3cde	0.3c
VELOCITY	80WP	45 G AI/A	JUNE/14DAT	5.3de	25.0a-g	5.3b-e	0.0c
VELOCITY	80WP	30 G AI/A	JUNE/14/28DAT	13.3b-e	21.7c-h	8.3a-e	0.0c
VELOCITY	17.6WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	13.3b-e	23.3b-g	13.3ab	0.3c
VELOCITY	80WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	8.3de	15.0e-i	5.3b-e	0.3c
VELOCITY	80WP	20 G AI/A	JUNE/14/28/42DAT	8.3de	18.3e-i	8.3a-e	3.3bc
VELOCITY	80WP	60 G AI/A	JUNE	21.7abc	28.3a-e	11.7abc	5.3abc
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	10.3cde	18.3e-i	8.3a-e	3.3bc
VELOCITY	80WP	10 G AI/A	JUNE	18.3a-d	35.0ab	8.7a-e	1.7c
AQUATHOL K	4.23L	0.25	JUNE				
VELOCITY	80WP	45 G AI/A	JUNE	7.0de	18.3e-i	5.0b-e	3.3bc
18-3-4	1.75L	0.2 LB AI/M	JUNE				
VELOCITY	80WP	45 G AI/A	JUNE	13.3b-e	25.0a-g	11.7abc	3.3bc
MACROSORB FOLIAR	L	2 OZ/M	JUNE				
VELOCITY	80WP	60 G AI/A	JUNE	18.3a-d	28.3a-e	11.7abc	0.0c
18-3-4	1.75L	0.2 LB AI/M	JUNE				
VELOCITY	80WP	60 G AI/A	JUNE	15.0a-e	25.0a-g	7.0a-e	1.7c
MACROSORB FOLIAR	L	2 OZ/M	JUNE				
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	8.3de	13.3f-i	5.0b-e	1.7c
18-3-4	1.75L	0.2 LB AI/M	JUNE/28DAT				
CHECK				25.0ab	36.7a	15.0a	3.7bc
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	3.3e	15.0e-i	0.7e	0.0c
MACROSORB FOLIAR	L	2 OZ/M	JUNE/28DAT				
VELOCITY	80WP	60 G AI/A	JUNE	15.0a-e	25.0a-g	6.7a-e	3.3bc
GBJ2	L	2 OZ/M	JUNE				
VELOCITY	80WP	45 G AI/A	JUNE	18.3a-d	26.7a-f	8.7a-e	0.0c
GBJ2	L	2 OZ/M	JUNE				
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	10.0cde	16.7e-i	10.3a-d	0.3c
18-3-4	1.75L	0.2 LB AI/M	JUNE/SEPT/OCT				
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	11.7cde	20.0d-i	10.0a-d	0.3c
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	5.3de	11.7ghi	2.3de	0.3c
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT				
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT	10.0cde	18.3e-i	2.3de	0.3c
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	5.3de	8.3i	0.7e	0.3c
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT				
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	7.0de	15.0e-i	3.7cde	0.3c
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	4.0e	10.0hi	0.3e	0.0c
18-3-4	1.75L	0.2 LB AI/M	JUNE/28/42/SEPT/OCT				
PROGRASS	1.5EC	0.75	OCT/NOV	26.7a	33.3abc	10.0a-d	8.3ab
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	6.7de	8.7hi	0.0e	0.0c
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT				
18-3-4	1.75L	0.2LB AI/M	JUNE/28/42/SEPT/OCT				
PROGRASS	1.5EC	0.75	OCT/NOV	18.3a-d	31.7a-d	13.3ab	10.0a
TRIMMIT	2SC	0.75	OCT/NOV				
PROGRASS	1.5EC	0.375	OCT/NOV	21.7abc	35.0ab	11.7abc	3.7bc
TRIMMIT	2SC	0.375	OCT/NOV				

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

Table 3. Percent annual bluegrass reduction in a mixed fairway height sward of 'Penneagle' creeping bentgrass and annual bluegrass. Ratings taken on May 12, 2005.

Treatment	Form	Rate (lb ai/A)	Timing	Percent Reduction
VELOCITY	80WP	45 G AI/A	JUNE	51.9c-h[1]
VELOCITY	80WP	30 G AI/A	JUNE/14DAT	48.3d-i
VELOCITY	80WP	45 G AI/A	JUNE/14DAT	53.8b-h
VELOCITY	80WP	30 G AI/A	JUNE/14/28DAT	68.3a-g
VELOCITY	17.6WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	58.3b-h
VELOCITY	80WP	10 G AI/A	JUNE/7/14DAT 21/28/35DAT	74.2a-f
VELOCITY	80WP	20 G AI/A	JUNE/14/28/42DAT	65.6a-g
VELOCITY	80WP	60 G AI/A	JUNE	65.0a-g
VELOCITY	80WP	60 G AI/A	JUNE/28DAT	77.8a-e
VELOCITY AQUATHOL K	80WP 4.23L	10 G AI/A 0.25	JUNE JUNE	33.6ghi
VELOCITY 18-3-4	80WP 1.75L	45 G AI/A 0.2 LB AI/M	JUNE JUNE	38.3f-i
VELOCITY MACROSORB FOLIAR	80WP L	45 G AI/A 2 OZ/M	JUNE JUNE	26.7hij
VELOCITY 18-3-4	80WP 1.75L	60 G AI/A 0.2 LB AI/M	JUNE JUNE	51.1c-i
VELOCITY MACROSORB FOLIAR	80WP L	60 G AI/A 2 OZ/M	JUNE JUNE	52.8b-h
VELOCITY 18-3-4	80WP 1.75L	60 G AI/A 0.2 LB AI/M	JUNE/28DAT JUNE/28DAT	84.4a-d
CHECK				0.0j
VELOCITY MACROSORB FOLIAR	80WP L	60 G AI/A 2 OZ/M	JUNE/28DAT JUNE/28DAT	61.7a-h
VELOCITY GBJ2	80WP L	60 G AI/A 2 OZ/M	JUNE JUNE	50.0c-i
VELOCITY GBJ2	80WP L	45 G AI/A 2 OZ/M	JUNE JUNE	45.0e-i
TRIMMIT 18-3-4	2SC 1.75L	0.66 0.2 LB AI/M	JUNE/SEPT/OCT JUNE/SEPT/OCT	98.0a
TRIMMIT	2SC	0.66	JUNE/SEPT/OCT	98.1a
TRIMMIT RUBIGAN	2SC 1AS	0.66 0.75 OZ/M	JUNE/SEPT/OCT JUNE/28/42/SEPT/OCT	97.4a
RUBIGAN	1AS	0.75 OZ/M	JUNE/28/42/SEPT/OCT	15.8ij
TRIMMIT RUBIGAN	2SC 1AS	0.4 0.75 OZ/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	84.4a-d
TRIMMIT	2SC	0.4	JUNE/28/42/SEPT/OCT	95.3a
TRIMMIT 18-3-4	2SC 1.75L	0.4 0.2 LB AI/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	89.3ab
PROGRASS	1.5EC	0.75	OCT/NOV	52.3c-h
TRIMMIT RUBIGAN 18-3-4	2SC 1AS 1.75L	0.4 0.75 OZ/M 0.2LB AI/M	JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT JUNE/28/42/SEPT/OCT	86.1abc
PROGRASS TRIMMIT	1.5EC 2SC	0.75 0.75	OCT/NOV OCT/NOV	97.7a
PROGRASS TRIMMIT	1.5EC 2SC	0.375 0.375	OCT/NOV OCT/NOV	76.4a-e

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

Preemergence Control of Smooth Crabgrass

J. A. Borger, Dr. T. L. Watschke and N. 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. All treatments were applied on April 19, 2005 (A) and some treatments were re-applied on May 17, (B), May 31 (C), and June 14, 2005 (D) using a three foot CO_2 powered boom sprayer calibrated to deliver 80 gpa using two, flat fan, 11004 nozzles at 40 psi. and a shaker jar. After each application the entire test site received approximately 0.5 inch of water. On April 21, 2005, 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 the test site where materials had been applied that did not contain any fertilizer. The site was mowed once per week with a rotary mower at one and one half inches with clippings returned to the site.

The test site was overseeded with a native source of smooth crabgrass seed in the fall of each growing season. The test site had approximately 90% cover smooth crabgrass in no treated areas.

Smooth crabgrass germination was first noted in the test site on April 25, 2005.

Results and Discussion

Turfgrass phytotoxicity was rated four times during the study (Table 1). Turfgrass treated with MON 44951 had below acceptable phytotoxicity on the May 9th (A application) and June 10th (C application only) rating dates.

Several materials provided commercially acceptable smooth crabgrass control (Table 2). Turfgrass treated with Dimension FG at 240 lb/A, Pendulum applied at the A plus C timings, Barricade 4FL at 18 plus 6 oz/A, Barricade 65WG at 13.8 plus 4.6 oz/A, Betasan at 7.4 oz/M plus Dimension at 0.187 lb ai/A, Betasan at 5.9 oz/M plus Dimension at 0.187 lb ai/A, Betasan at 4.5 oz/M plus Dimension at 0.187 lb ai/A, Dimension at 0.5 lb ai/A, Dimension at 0.25 lb ai/A (A/C), Betasan at 7.4 oz/M (A) plus Dimension at 0.187 lb ai/A (C), Betasan at 5.9 oz/M (A) plus Dimension at 0.187 lb ai/A (C), Betasan at 4.5 oz/M (A) plus Dimension at 0.187 lb ai/A (C), and Dimension at 0.187 lb ai/A (A/C) provided 85% or more smooth crabgrass control.

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Table 1. Evaluations of phytotoxicity where 0 = worst, 7 = acceptable, and 10 = no phytotoxicity taken in 2005.

Treatment	Form	Rate (lbs ai/A)	Timing	5/9	5/23	6/10	6/20
DIMENSION FG	0.21G	180 lb/A	A	10.0	10.0	10.0	10.0
DIMENSION FG	0.21G	240 lb/A	A	10.0	10.0	10.0	10.0
STONEWALL	0.2G	250 lb/A	A	10.0	10.0	10.0	10.0
MON 44951 MON 0810	75WG AL	1.5 oz/A 0.25 % v/v	A A	6.0	9.0	10.0	10.0
MON 44951 MON 0810	75WG AL	2 oz/A 0.25 % v/v	A A	6.0	9.0	10.0	10.0
MON 44951 MON 0810	75WG AL	2.5 oz/A 0.25 % v/v	A A	6.0	9.0	10.0	10.0
MON 44951 MON 0810	75WG AL	1 oz/A 0.25 % v/v	A/C A/C	6.0	9.0	6.0	10.0
MON 44951 MON 0810	75WG AL	1.5 oz/A 0.25 % v/v	A/C A/C	6.0	9.0	6.0	10.0
MON 44951 MON 0810	75WG AL	2 oz/A 0.25 % v/v	A/C A/C	6.0	9.0	6.0	10.0
PENDULUM	3.3EC	2/1.5	A/C	10.0	10.0	10.0	10.0
PENDULUM	3.3EC	1.5	A/C	10.0	10.0	10.0	10.0
PENDULUM	3.8CS	2/1.5	A/C	10.0	10.0	10.0	10.0
PENDULUM	3.8CS	1.5	A/C	10.0	10.0	10.0	10.0
BARRICADE	4L	18/6 oz/A	A/C	10.0	10.0	10.0	10.0
BARRICADE	65WG	13.8/4.6 oz/A	A/C	10.0	10.0	10.0	10.0
V-10142	75WG	0.375	A	10.0	10.0	10.0	10.0
V-10142	75WG	0.5	A	10.0	10.0	10.0	10.0
V-10142	75WG	0.75	A	10.0	10.0	10.0	10.0
V-10142	0.5G	0.75	A	10.0	10.0	10.0	10.0
PENDULUM	60WG	1.5	A	10.0	10.0	10.0	10.0
V-10142 PENDULUM	75WG 60WG	0.375/ 1.5	A A	10.0	10.0	10.0	10.0
V-10142 PENDULUM	75WG 60WG	0.5 1.5	A A	10.0	10.0	10.0	10.0
BETASAN	4E	7.4 oz/M	A	10.0	10.0	10.0	10.0
BETASAN	4E	2.5 oz/M	A/B/D	10.0	10.0	10.0	10.0
BETASAN TUPERSAN	4E 50WP	7.4 oz/M 2.2 oz/M	A C	10.0	10.0	10.0	10.0
BETASAN DIMENSION	4E 40WP	7.4 oz/M 0.1875	A A	10.0	10.0	10.0	10.0
BETASAN DIMENSION	4E 40WP	5.9 oz/M 0.1875	A A	10.0	10.0	10.0	10.0
BETASAN DIMENSION	4E 40WP	4.5 oz/M 0.1875	A A	10.0	10.0	10.0	10.0
DIMENSION	40WP	0.1875	A	10.0	10.0	10.0	10.0
DIMENSION	40WP	0.5	A	10.0	10.0	10.0	10.0
DIMENSION	40WP	0.25	A/C	10.0	10.0	10.0	10.0
BETASAN DIMENSION	4E 40WP	7.4 oz/M 0.1875	A C	10.0	10.0	10.0	10.0
BETASAN DIMENSION	4E 40WP	5.9 oz/M 0.1875	A C	10.0	10.0	10.0	10.0
BETASAN DIMENSION	4E 40WP	4.5 oz/M 0.1875	A C	10.0	10.0	10.0	10.0
DIMENSION	40WP	0.1875	A/C	10.0	10.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0

Table 2. Evaluations of the percent control of smooth crabgrass taken on Aug 8, 2005. Commercially acceptable control was considered to be 85% and above.

Treatment	Form	Rate (lbs ai/A)	Timing	% Control
DIMENSION FG	0.21G	180 lb/A	A	80.0
DIMENSION FG	0.21G	240 lb/A	A	85.0
STONEWALL	0.2G	250 lb/A	A	55.0
MON 44951	75WG	1.5 oz/A	A	1.7
MON 0810	AL	0.25 % v/v	A	
MON 44951	75WG	2 oz/A	A	15.0
MON 0810	AL	0.25 % v/v	A	
MON 44951	75WG	2.5 oz/A	A	8.3
MON 0810	AL	0.25 % v/v	A	
MON 44951	75WG	1 oz/A	A/C	5.0
MON 0810	AL	0.25 % v/v	A/C	
MON 44951	75WG	1.5 oz/A	A/C	6.7
MON 0810	AL	0.25 % v/v	A/C	
MON 44951	75WG	2 oz/A	A/C	8.3
MON 0810	AL	0.25 % v/v	A/C	
PENDULUM	3.3EC	2/1.5	A/C	95.0
PENDULUM	3.3EC	1.5	A/C	89.7
PENDULUM	3.8CS	2/1.5	A/C	97.7
PENDULUM	3.8CS	1.5	A/C	94.3
BARRICADE	4L	18/6 oz/A	A/C	99.0
BARRICADE	65WG	13.8/4.6 oz/A	A/C	99.0
V-10142	75WG	0.375	A	18.3
V-10142	75WG	0.5	A	28.3
V-10142	75WG	0.75	A	63.3
V-10142	0.5G	0.75	A	60.0
PENDULUM	60WG	1.5	A	50.0
V-10142	75WG	0.375/	A	43.3
PENDULUM	60WG	1.5	A	
V-10142	75WG	0.5	A	43.3
PENDULUM	60WG	1.5	A	
BETASAN	4E	7.4 oz/M	A	68.3
BETASAN	4E	2.5 oz/M	A/B/D	76.7
BETASAN	4E	7.4 oz/M	A	63.3
TUPERSAN	50WP	2.2 oz/M	C	
BETASAN	4E	7.4 oz/M	A	97.7
DIMENSION	40WP	0.1875	A	
BETASAN	4E	5.9 oz/M	A	94.7
DIMENSION	40WP	0.1875	A	
BETASAN	4E	4.5 oz/M	A	93.0
DIMENSION	40WP	0.1875	A	
DIMENSION	40WP	0.1875	A	63.3
DIMENSION	40WP	0.5	A	97.7
DIMENSION	40WP	0.25	A/C	97.7
BETASAN	4E	7.4 oz/M	A	96.3
DIMENSION	40WP	0.1875	C	
BETASAN	4E	5.9 oz/M	A	96.3
DIMENSION	40WP	0.1875	C	
BETASAN	4E	4.5 oz/M	A	96.3
DIMENSION	40WP	0.1875	C	
DIMENSION	40WP	0.1875	A/C	96.0
CHECK				0.0

Phytotoxicity and Tolerance Evaluation of Selected Materials on Creeping Bentgrass, Rough Bluegrass, Tall Fescue, Perennial Ryegrass, and Kentucky Bluegrass

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

Introduction

Phytotoxicity and tolerance evaluations were conducted on a stand of mature fairway height 'Penneagle' creeping bentgrass (*Agrostis stolonifera*), fairway height 'Winter Play' rough bluegrass (*Poa trivialis*), lawn height 'Plantation' tall fescue (*Festuca arundinacea S.*), lawn height 'Jet-Elite' perennial ryegrass (*Lolium perenne L.*), and lawn height 'Park' Kentucky bluegrass (*Poa pratensis*) at the Valentine Turfgrass Research Center, Penn State University, University Park, Pa. The objective of the study was to determine the phytotoxicity and tolerance of selected materials on creeping bentgrass, rough bluegrass, tall fescue, perennial ryegrass, and Kentucky bluegrass.

Methods and Materials

The study was a randomized complete block design with three replications. Treatments were applied on June 23 (JUNE), July 12 (2 WAT/3 WAT), July 21 (4 WAT), August 4 (6 WAT), and September 2, 2005 (9 WAT) using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi.

The creeping bentgrass and rough bluegrass were mowed with a reel mower at one half inch with clippings removed and the tall fescue, perennial ryegrass, and Kentucky bluegrass were mowed at one and one half inches with clippings returned to the site.

Results and Discussion

Turfgrass phytotoxicity was evaluated eight times during the study (Table 1). Creeping bentgrass treated with mesotrione twice, had unacceptable phytotoxicity until the August 14, 2005 rating date. Creeping bentgrass treated three times with mesotrione had unacceptable phytotoxicity on all eight rating dates. Rough bluegrass treated with MON 44951 or Velocity at any rate or time or application schedule had unacceptable phytotoxicity. Rough bluegrass treated with mesotrione had unacceptable phytotoxicity on three rating dates (June 28, July 6, and Aug 14). Tall fescue treated with MON 44951 had unacceptable phytotoxicity on all but the first rating date except for the 0.25, 0.3, and 0.5 oz/A rate applied four times (July 6 rating date). Tall fescue treated with Velocity 80WP had unacceptable phytotoxicity on July 6 and July 21 rating dates. Following applications of Velocity 17.6WG phytotoxicity was unacceptable on the July 21 rating date. Tall fescue treated with mesotrione three times had unacceptable phytotoxicity on the

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August 1 rating date. Perennial ryegrass treated with MON 44951 or Velocity at any rate or application schedule had unacceptable phytotoxicity on the July 21 rating date. Additionally, perennial ryegrass treated with MON 44951 at the 0.25 oz/A rate and applied four times had unacceptable phytotoxicity on the August 1 rating date. Only Kentucky bluegrass treated with any formulation of Velocity had unacceptable phytotoxicity on all rating dates except June 28.

The percent green vegetation was rated once during the study on October 6, 2005 (Table 2). Creeping bentgrass treated with mesotrione had significantly less green vegetation than untreated. Only rough bluegrass treated with MON 44951 at 0.25 oz/A applied twice or any rate of mesotrione had green vegetation that was not significantly different than untreated. Only tall fescue treated with any formulation of Velocity or any rate of mesotrione had green vegetation that was not significantly different than untreated. Perennial ryegrass treated with MON 44951 at 0.5 oz/A applied three or four times and MON 44951 at 0.3 oz/A applied four times had significantly less green vegetation than untreated. Only Kentucky bluegrass treated with any formulation of Velocity had significantly less green vegetation than untreated.

Although further evaluations need to be conducted, it appears that selective post emergence suppression of creeping bentgrass, rough bluegrass, and tall fescue could be accomplished in certain turfgrass swards.

Table 1. Evaluations of fairway height creeping bentgrass phytotoxicity where 0 = worst, 7 = acceptable and 10 = best in 2005.

Creeping Bentgrass Treatment	Form	Rate (oz/A)	Timing	(---Phytotoxicity--- 6/28	7/6	7/14	7/21	8/1	8/14	8/26	9/9)
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3/6 WAT	8.8	10.0	10.0	7.7	10.0	7.0	10.0	10.0
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3/6 WAT	9.0	10.0	10.0	7.0	10.0	7.0	10.0	10.0
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3 WAT	9.0	10.0	10.0	7.7	10.0	9.0	10.0	10.0
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3 WAT	9.0	10.0	10.0	7.3	10.0	9.0	10.0	10.0
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3/6/9 WAT	9.0	10.0	10.0	8.0	10.0	7.0	10.0	10.0
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3/6/9 WAT	9.0	10.0	10.0	7.3	10.0	7.0	10.0	10.0
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	9.0	10.0	10.0	7.0	10.0	10.0	10.0	10.0
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	8.8	10.0	10.0	7.0	10.0	10.0	10.0	10.0
MON 44951 MON 0818	WG L	0.3 0.25 % V/V	JUNE/3/6/9 WAT	9.0	10.0	10.0	7.0	10.0	7.0	10.0	10.0
MESOTRIONE X 77	4SC L	0.187 LB A/A 0.25 % V/V	JUNE/2 WAT	3.0	5.3	6.5	2.0	5.7	7.0	10.0	10.0
MESOTRIONE X 77	4SC L	0.187 LB A/A 0.25 % V/V	JUNE/2/4 WAT	3.0	5.3	6.5	2.0	2.0	4.0	6.0	5.0

Table 1 (continued). Evaluations of fairway height rough bluegrass phytotoxicity where 0 = worst, 7 = acceptable and 10 = best in 2005.

Rough Bluegrass Treatment	Form	Rate (oz/A)	Timing	Phytotoxicity 6/28	7/6	7/14	7/21	8/1	8/14	8/26	9/9
MON 44951	WG	0.25	JUNE/3/6 WAT	6.0	6.7	6.0	4.3	4.3	4.0	4.0	2.3
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3/6 WAT	6.0	6.0	6.0	4.3	4.3	4.0	3.0	2.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3 WAT	6.0	6.0	6.0	4.0	4.3	5.0	5.0	4.3
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3 WAT	6.0	6.0	5.0	3.0	2.0	1.0	2.0	1.7
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3/6/9 WAT	6.0	6.0	6.0	3.7	3.3	1.0	1.0	1.0
MON 0818	L	0.25 % V/V									
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 44951	WG	0.5	JUNE/3/6/9 WAT	6.0	6.3	6.0	4.0	3.0	0.0	0.0	0.3
MON 0818	L	0.25 % V/V									
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	6.0	4.3	4.0	2.3	0.3	0.0	1.0	1.3
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	6.0	4.7	4.0	2.7	0.0	0.0	1.0	1.0
MON 44951	WG	0.3	JUNE/3/6/9 WAT	6.0	6.0	4.0	4.0	2.7	2.0	2.0	1.0
MON 0818	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2 WAT	6.0	6.7	7.0	10.0	9.3	6.0	9.0	10.0
X 77	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2/4 WAT	6.0	6.7	7.0	10.0	8.3	6.0	8.0	10.0
X 77	L	0.25 % V/V									

Table 1 (continued). Evaluations of fairway height tall fescue phytotoxicity where 0 = worst, 7 = acceptable and 10 = best in 2005.

Tall Fescue Treatment	Form	Rate (oz/A)	Timing	(------Phytotoxicity------) 6/28	7/6	7/14	7/21	8/1	8/14	8/26	9/9
MON 44951	WG	0.25	JUNE/3/6 WAT	8.0	6.0	5.0	3.0	1.3	1.0	1.0	3.3
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3/6 WAT	8.0	6.0	5.3	3.3	1.3	0.0	0.0	0.3
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3 WAT	8.0	6.7	5.0	3.0	1.3	2.0	2.0	2.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3 WAT	8.0	6.3	5.0	3.0	1.0	2.0	2.0	1.7
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3/6/9 WAT	8.0	7.0	6.0	3.3	2.0	3.0	2.0	1.0
MON 0818	L	0.25 % V/V									
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 44951	WG	0.5	JUNE/3/6/9 WAT	8.0	7.3	4.7	3.3	1.0	2.0	1.0	0.7
MON 0818	L	0.25 % V/V									
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	8.0	6.3	9.0	6.3	10.0	10.0	10.0	10.0
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	8.0	8.3	9.3	6.7	9.3	10.0	10.0	10.0
MON 44951	WG	0.3	JUNE/3/6/9 WAT	8.0	7.0	5.0	3.3	1.3	3.0	1.0	3.7
MON 0818	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2 WAT	8.0	10.0	10.0	9.3	8.3	10.0	10.0	10.0
X 77	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2/4 WAT	8.0	10.0	10.0	9.0	4.0	10.0	10.0	10.0
X 77	L	0.25 % V/V									

Table 1 (continued). Evaluations of lawn height perennial ryegrass phytotoxicity where 0 = worst, 7 = acceptable and 10 = best in 2005.

Perennial Ryegrass Treatment	Form	Rate (oz/A)	Timing	(----Phytotoxicity----) 6/28	7/6	7/14	7/21	8/1	8/14	8/26	9/9
MON 44951	WG	0.25	JUNE/3/6 WAT	9.0	9.7	8.3	6.3	8.7	9.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3/6 WAT	9.0	8.7	8.7	6.2	8.0	9.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3 WAT	9.0	9.7	9.2	6.3	8.7	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3 WAT	9.0	8.7	7.0	6.2	8.0	9.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3/6/9 WAT	9.0	8.0	7.0	6.2	6.7	9.0	10.0	10.0
MON 0818	L	0.25 % V/V									
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 44951	WG	0.5	JUNE/3/6/9 WAT	9.0	8.7	7.0	6.3	8.0	9.0	10.0	10.0
MON 0818	L	0.25 % V/V									
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	9.0	8.7	7.3	6.2	8.3	10.0	10.0	10.0
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	9.0	9.0	7.0	6.5	8.3	10.0	10.0	10.0
MON 44951	WG	0.3	JUNE/3/6/9 WAT	9.0	9.0	7.0	6.5	8.3	9.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2 WAT	9.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
X 77	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2/4 WAT	9.0	10.0	10.0	10.0	9.0	10.0	10.0	10.0
X 77	L	0.25 % V/V									

Table 1 (continued). Evaluations of lawn height Kentucky bluegrass phytotoxicity where 0 = worst, 7 = acceptable and 10 = best in 2005.

Kentucky Bluegrass Treatment	Form	Rate (oz/A)	Timing	(-----Phytotoxicity							-----)
				6/28	7/6	7/14	7/21	8/1	8/14	8/26	9/9
MON 44951	WG	0.25	JUNE/3/6 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3/6 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3 WAT	9.7	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.5	JUNE/3 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MON 44951	WG	0.25	JUNE/3/6/9 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
CHECK				10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 44951	WG	0.5	JUNE/3/6/9 WAT	9.3	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	7.0	5.0	4.7	2.7	1.3	1.0	1.0	0.7
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	7.0	5.0	5.0	5.3	2.0	1.0	1.0	1.7
MON 44951	WG	0.3	JUNE/3/6/9 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
MON 0818	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
X 77	L	0.25 % V/V									
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2/4 WAT	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
X 77	L	0.25 % V/V									

Table 2. Evaluations of percent green vegetation of fairway height creeping bentgrass.

Creeping Bentgrass

Treatment	**Form**	**Rate (oz/A)**	**Timing**	**(% Green Veg[1]) 10/6/2005**
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3/6 WAT	100.0a
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3/6 WAT	100.0a
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3 WAT	100.0a
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3 WAT	100.0a
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3/6/9 WAT	100.0a
CHECK				100.0a
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3/6/9 WAT	100.0a
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	100.0a
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	100.0a
MON 44951 MON 0818	WG L	0.3 0.25 % V/V	JUNE/3/6/9 WAT	100.0a
MESOTRIONE X 77	4SC L	0.187 LB A/A 0.25 % V/V	JUNE/2 WAT	86.7b
MESOTRIONE X 77	4SC L	0.187 LB A/A 0.25 % V/V	JUNE/2/4 WAT	20.0c

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

Table 2(continued). Evaluations of percent green vegetation of fairway height rough bluegrass.

Rough Bluegrass

Treatment	**Form**	**Rate (oz/A)**	**Timing**	**(% Green Veg[1]) 10/6/2005**
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3/6 WAT	1.0c
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3/6 WAT	1.0c
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3 WAT	91.7a
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3 WAT	50.0b
MON 44951 MON 0818	WG L	0.25 0.25 % V/V	JUNE/3/6/9 WAT	1.0c
CHECK				100.0a
MON 44951 MON 0818	WG L	0.5 0.25 % V/V	JUNE/3/6/9 WAT	1.0c
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	2.3c
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	2.3c
MON 44951 MON 0818	WG L	0.3 0.25 % V/V	JUNE/3/6/9 WAT	1.0c
MESOTRIONE X 77	4SC L	0.187 LB A/A 0.25 % V/V	JUNE/2 WAT	100.0a
MESOTRIONE X 77	4SC L	0.187 LB A/A 0.25 % V/V	JUNE/2/4 WAT	98.3a

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

Table 2(continued). Evaluations of percent green vegetation of lawn height tall fescue.

Tall Fescue Treatment	Form	Rate (oz/A)	Timing	(% Green Veg[1]) 10/6/2005
MON 44951	WG	0.25	JUNE/3/6 WAT	2.3d
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.5	JUNE/3/6 WAT	1.0d
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.25	JUNE/3 WAT	38.3b
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.5	JUNE/3 WAT	25.0c
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.25	JUNE/3/6/9 WAT	2.3d
MON 0818	L	0.25 % V/V		
CHECK				100.0a
MON 44951	WG	0.5	JUNE/3/6/9 WAT	1.0d
MON 0818	L	0.25 % V/V		
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	100.0a
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	100.0a
MON 44951	WG	0.3	JUNE/3/6/9 WAT	2.3d
MON 0818	L	0.25 % V/V		
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2 WAT	100.0a
X 77	L	0.25 % V/V		
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2/4 WAT	100.0a
X 77	L	0.25 % V/V		

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

Table 2(continued). Evaluations of percent green vegetation of lawn height perennial ryegrass.

Perennial Ryegrass Treatment	Form	Rate (oz/A)	Timing	(% Green Veg[1]) 10/6/2005
MON 44951	WG	0.25	JUNE/3/6 WAT	96.0ab
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.5	JUNE/3/6 WAT	81.7c
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.25	JUNE/3 WAT	98.7a
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.5	JUNE/3 WAT	98.7a
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.25	JUNE/3/6/9 WAT	95.0ab
MON 0818	L	0.25 % V/V		
CHECK				100.0a
MON 44951	WG	0.5	JUNE/3/6/9 WAT	70.0d
MON 0818	L	0.25 % V/V		
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	99.3a
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	100.0a
MON 44951	WG	0.3	JUNE/3/6/9 WAT	88.3bc
MON 0818	L	0.25 % V/V		
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2 WAT	100.0a
X 77	L	0.25 % V/V		
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2/4 WAT	100.0a
X 77	L	0.25 % V/V		

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

Table 2(continued). Evaluations of percent green vegetation of lawn height Kentucky bluegrass.

Kentucky Bluegrass Treatment	Form	Rate (oz/A)	Timing	(% Green Veg[1]) 10/6/2005
MON 44951	WG	0.25	JUNE/3/6 WAT	100.0a
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.5	JUNE/3/6 WAT	100.0a
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.25	JUNE/3 WAT	100.0a
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.5	JUNE/3 WAT	100.0a
MON 0818	L	0.25 % V/V		
MON 44951	WG	0.25	JUNE/3/6/9 WAT	100.0a
MON 0818	L	0.25 % V/V		
CHECK				100.0a
MON 44951	WG	0.5	JUNE/3/6/9 WAT	100.0a
MON 0818	L	0.25 % V/V		
VELOCITY	80WP	60 G A/A	JUNE/2 WAT	13.7c
VELOCITY	17.6WG	60 G A/A	JUNE/2 WAT	63.3b
MON 44951	WG	0.3	JUNE/3/6/9 WAT	100.0a
MON 0818	L	0.25 % V/V		
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2 WAT	100.0a
X 77	L	0.25 % V/V		
MESOTRIONE	4SC	0.187 LB A/A	JUNE/2/4 WAT	100.0a
X 77	L	0.25 % V/V		

1 - Means followed by same letter do not significantly differ (P=.05, Duncan's New MRT)

Annual Bluegrass Prevention on a Newly Established Putting Green

Dr. T. L. Watschke, 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 (14DAT), October 1, 2003 (28DAT) as well as August 25 (FALL), September 7 (14 DAT), and September 21, 2004 (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 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.

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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 2. Percent annual bluegrass ratings of a simulated 'Penncross' creeping bentgrass/annual bluegrass putting green.

Treatment	Form	Rate oz/M	Timing	9/4/03	4/21/04	5/2/05
BETASAN	4EC	9.2	FALL	1.0a[1]	1.3a	15.0ab
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT	1.0a	1.7a	13.3ab
CHECK				1.0a	2.7a	18.3a
BETASAN RUBIGAN	4EC AS	9.2 2	FALL 14DAT/28DAT	1.0a	1.7a	8.3b
BETASAN RUBIGAN	4EC AS	9.2 2/4	FALL 14DAT/28DAT	1.0a	1.0a	13.3ab
RUBIGAN	AS	2	FALL /14DAT/28DAT	1.0a	1.0a	8.3b

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

Evaluation of Plant Growth Regulators on Fairway Height Creeping Bentgrass

M.B. Naedel, J.A. Borger, M.D. Soika, and T.L Watschke

Introduction

This study was conducted on a mature stand of 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 the efficacy of a fungicide, plant growth regulators alone or in combination with a liquid fertilizer using color ratings, dollar spot (*Sclerotinia homoeocarpa*) incidence, measurements of plant height, and fresh weight foliar yield.

Methods and Materials

This study was a randomized complete block design with three replications. Treatments were applied on June 8 (SUMMER), and July 12, 2005 (28 DAT) using a three foot CO_2 powered boom sprayer calibrated to deliver 40 gpa using two, flat fan, 11004 nozzles at 40 psi. The test site was maintained similar to that of a golf course fairway with respect to irrigation, fertilization and mowing. Turfgrass height was measured using a Turfcheck 1 prism.

Results and Discussion

Turfgrass color was rated nine times during the study (Table 1). None of the treated or untreated turfgrass was rated below acceptable (7.0) during the study.

Turfgrass height was evaluated ten times during the study (Table 2). On the June 22nd rating date turfgrass treated with Trimmit alone or in combination and Primo Maxx alone had significantly lower height than untreated turfgrass. On the June 29th rating date turfgrass treated with Trimmit alone, Primo MAXX at the 11 oz/A rate, and Trimmit at 32 oz/A plus ECO-N (24-0-0) had significantly lower height than untreated turfgrass. On the July 20th rating date turfgrass treated with Trimmit combined with Primo Maxx alone or with ECO-N (24-0-0) had significantly lower height than untreated turfgrass. On the July 28th rating date turfgrass treated with Trimmit at 32 oz/A alone or combined with ECO-N (24-0-0) and Trimmit at 16 oz/A plus Primo MAXX plus ECO-N (24-0-0) had significantly lower height than untreated turfgrass. On the August 4th rating date turfgrass treated with Trimmit alone, Primo MAXX alone, Trimmit at 16 oz/A plus ECO-N (24-0-0), and Primo MAXX at 11 oz/A plus ECO-N (24-0-0) had significantly lower height than untreated turfgrass. On this date turfgrass treated with Banner MAXX had significantly higher height than untreated turfgrass. Finally, on the August 17th rating date turfgrass treated with Trimmit at 16 oz/A plus Primo MAXX plus ECO-N (24-0-0) had significantly higher height than untreated turfgrass.

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Turfgrass fresh clipping weights were collected six times during the study (Table 3). On the June 22nd rating date only turfgrass treated with ECO – N (24-0-0) had significantly more fresh clipping weight than untreated turfgrass. On the June 29th rating date turfgrass treated with Trimmit at 32 oz/A and Trimmit at 16 oz/A plus Primo MAXX plus ECO-N (24-0-0) had significantly less fresh clipping weight than untreated turfgrass. On the July 12th rating date turfgrass treated with Trimmit at 32 oz/A plus ECO – N and Trimmit plus Primo MAXX had significantly more fresh clipping weight than untreated turfgrass. Finally, on the August 17th rating date turfgrass rebound was apparent on some of the treated turfgrass.

The percent dollar spot was rated five times during the study (Table 4). On three rating dates; July 14th, 20th, and August 4th turfgrass treated with Banner MAXX had significantly less dollar spot than untreated turfgrass. On the July 14th and August 4th rating dates turfgrass treated with Trimmit at 16 oz/A plus Primo MAXX plus ECO-N (24-0-0) had significantly less dollar spot than untreated turfgrass. Finally on the August 4th rating date turfgrass treated with ECON – N (24-0-0) had significantly more dollar spot than untreated turfgrass.

Table 1. Color ratings on a scale of 0-10 where 0 = brown, 7= acceptable, and 10 = dark green of PGR's applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate OZ/A	Timing	6-15	6-22	6-29	7-7	7-12	7-20	7-28	8-4	8-17
TRIMMIT	2SC	32	SUMMER/28 DAT	8.0	8.2	8.2	8.2	8.0	8.2	9.0	8.3	8.0
TRIMMIT	2SC	16	SUMMER/28 DAT	8.2	8.7	8.7	8.5	8.3	8.5	8.8	8.7	8.0
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	8.3	8.3	8.8	8.7	8.3	8.5	9.2	8.8	8.0
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	8.0	8.3	8.7	8.5	8.5	8.5	9.0	8.7	8.0
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT	9.0	9.0	8.7	8.3	8.2	8.5	9.0	8.5	8.0
TRIMMIT	2SC	32	SUMMER/28 DAT	9.0	8.7	8.7	8.8	8.8	9.0	9.2	9.0	8.0
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT									
CHECK				8.0	8.8	8.2	8.0	8.2	8.2	8.8	8.0	8.0
TRIMMIT	2SC	16	SUMMER/28 DAT	8.3	8.5	8.5	8.2	8.3	8.7	8.8	8.7	8.0
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT									
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	8.5	8.5	8.7	8.3	8.2	8.8	9.0	8.5	8.0
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT									
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	8.5	8.7	8.7	8.7	8.7	8.8	8.8	8.7	8.0
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT									
BANNER MAXX	1.3L	88	SUMMER/28 DAT	8.0	8.8	8.5	8.2	8.3	8.8	9.2	8.7	8.0
TRIMMIT	2SC	16	SUMMER/28 DAT	8.2	8.0	8.3	8.8	8.7	8.7	9.3	9.0	8.0
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT									
TRIMMIT	2SC	16	SUMMER/28 DAT	8.5	8.3	8.5	8.5	8.3	9.0	8.8	9.0	8.0
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT									
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT									

Table 2. Height ratings (in inches) of PGR's applied to creeping bentgrass taken in 2005.

Treatment	Form	Rate OZ/A	Timing	6-15 [1]	6-22	6-29	7-7	7-12	7-20	7-28	8-4	8-9	8-17
TRIMMIT	2SC	32	SUMMER/28 DAT	0.36b	0.33d	0.35d	0.38a	0.38a	0.43de	0.42d	0.38e	0.43c	0.62ab
TRIMMIT	2SC	16	SUMMER/28 DAT	0.38ab	0.32d	0.38cd	0.39a	0.39a	0.45b-e	0.44bcd	0.42d	0.44c	0.63ab
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	0.39ab	0.33d	0.38cd	0.37a	0.37a	0.45b-e	0.45bcd	0.42d	0.44c	0.61ab
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	0.39ab	0.35cd	0.41bc	0.38a	0.38a	0.44cde	0.45bcd	0.42d	0.44c	0.63ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT	0.41ab	0.45a	0.44ab	0.38a	0.39a	0.50a	0.51ab	0.43cd	0.52a	0.61ab
TRIMMIT	2SC	32	SUMMER/28 DAT	0.39ab	0.34cd	0.38cd	0.38a	0.37a	0.42ef	0.41d	0.42d	0.42c	0.64ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT										
CHECK				0.40ab	0.41ab	0.43ab	0.39a	0.39a	0.47a-d	0.50abc	0.46bc	0.48abc	0.58b
TRIMMIT	2SC	16	SUMMER/28 DAT	0.39ab	0.35cd	0.41bc	0.40a	0.41a	0.48abc	0.44cd	0.41d	0.45bc	0.61ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT										
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	0.37ab	0.35cd	0.41abc	0.39a	0.39a	0.44cde	0.46bcd	0.42d	0.44c	0.59b
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT										
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	0.39ab	0.38bc	0.42abc	0.38a	0.38a	0.47a-d	0.53a	0.48ab	0.51ab	0.62ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT										
BANNER MAXX	1.3L	88	SUMMER/28 DAT	0.42a	0.41b	0.46a	0.41a	0.40a	0.49ab	0.53a	0.49a	0.51ab	0.64ab
TRIMMIT	2SC	16	SUMMER/28 DAT	0.36b	0.34cd	0.38cd	0.37a	0.38a	0.41ef	0.46bcd	0.46bc	0.42c	0.66ab
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT										
TRIMMIT	2SC	16	SUMMER/28 DAT	0.38ab	0.32d	0.38cd	0.40a	0.39a	0.38f	0.40d	0.48ab	0.41c	0.68a
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT										
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT										

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

Table 3. Fresh clipping weight (grams) of creeping bentgrass taken in 2005.

Treatment	Form	Rate OZ/A	Timing	6-22 [1]	6-29	7-7	7-12	8-9	8-17
				(Weight)					
TRIMMIT	2SC	32	SUMMER/28 DAT	3.3c-f	5.1c	4.3a	10.0abc	7.2a	33.7cd
TRIMMIT	2SC	16	SUMMER/28 DAT	3.8c-f	7.1abc	5.8a	11.6abc	8.7a	41.7bcd
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	2.7ef	6.8abc	5.4a	7.3bc	6.4a	33.9cd
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	5.1bcd	11.5ab	6.7a	7.4bc	7.1a	29.3cd
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT	9.3a	12.6a	6.6a	10.1abc	8.4a	35.4cd
TRIMMIT	2SC	32	SUMMER/28 DAT	3.0def	6.7abc	6.3a	15.0ab	10.6a	63.3a
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT						
CHECK				9.4a	11.4ab	5.5a	6.8c	6.1a	24.4d
TRIMMIT	2SC	16	SUMMER/28 DAT	5.0b-e	8.7abc	6.9a	13.5abc	10.2a	42.8bc
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT						
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	3.0def	8.2abc	6.7a	10.0abc	8.3a	37.0cd
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT						
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	5.5bc	11.6ab	7.4a	11.5abc	9.4a	39.6bcd
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT						
BANNER MAXX	1.3L	88	SUMMER/28 DAT	7.1b	8.1abc	6.6a	9.3abc	8.0a	32.7cd
TRIMMIT	2SC	16	SUMMER/28 DAT	2.2f	5.9bc	7.2a	16.5a	11.8a	55.3ab
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT						
TRIMMIT	2SC	16	SUMMER/28 DAT	2.3f	4.0c	5.0a	11.7abc	8.3a	45.6bc
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT						
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT						

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

Table 4. Percent dollar spot incidence on creeping bentgrass taken in 2005.

Treatment	Form	Rate OZ/A	Timing	7-7 [1]	7-14	7-20	8-4	8-17
				(% Dollar Spot)				
TRIMMIT	2SC	32	SUMMER/28 DAT	10.0a	13.3a-d	20.0ab	26.7abc	53.3ab
TRIMMIT	2SC	16	SUMMER/28 DAT	2.0ab	8.3cde	13.3abc	18.3cd	46.7b
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	5.3ab	15.0abc	18.3ab	30.0abc	55.0ab
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	10.0a	21.7a	28.3a	38.3ab	71.7a
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT	10.0a	20.0ab	26.7a	41.7a	50.0ab
TRIMMIT	2SC	32	SUMMER/28 DAT	7.0ab	10.0b-e	20.0ab	18.3cd	50.0ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT					
CHECK				6.7ab	11.7a-d	21.7ab	25.0bcd	53.3ab
TRIMMIT	2SC	16	SUMMER/28 DAT	7.0ab	13.3a-d	18.3ab	20.0cd	50.0ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT					
PRIMO MAXX	1MEC	11	SUMMER/28 DAT	8.3ab	15.0abc	23.3ab	26.7abc	48.3ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT					
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT	5.3ab	11.7a-d	15.0abc	21.7cd	51.7ab
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT					
BANNER MAXX	1.3L	88	SUMMER/28 DAT	0.3b	0.3e	0.3c	2.0e	13.3d
TRIMMIT	2SC	16	SUMMER/28 DAT	5.3ab	10.0b-e	15.3abc	15.3cde	25.0cd
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT					
TRIMMIT	2SC	16	SUMMER/28 DAT	3.7ab	3.7de	8.3bc	8.3de	38.3bc
PRIMO MAXX	1MEC	6.5	SUMMER/28 DAT					
ECO-N (24-0-0)	2.2L	0.25 LB N/M	SUMMER/28 DAT					

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

Management of Basal-rot Anthracnose on a Putting Green with Fungicides, 2005

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Introduction

Basal-rot Anthracnose *(Colletotrichum graminicola)* frequently causes major injury to putting greens; particularly those comprised of high populations of annual bluegrass *(Poa annua)*. The use of fungicides is a significant component of a turf manager's approach in the management of basal-rot Anthracnose. The objective of this study was to evaluate the effects of various products, rates, rotations, and application timings for controlling Anthracnose infection on *Poa annua*.

Materials and Methods

The study was conducted at the Valentine Turfgrass Research Center, University Park, PA, on a mixed stand of annual bluegrass and creeping bentgrass. The site was maintained as a golf course green, mowed six times per week at 0.125-inch cutting height. The soil was a modified sandy clay loam with a pH of 7.0. The experiment was fertilized on 19 Apr with 1.0 lb nitrogen (18-9-18). Treatment plots, 3 ft x 6 ft, were arranged in a randomized complete block design with three replications. Treatments were applied with a CO_2-powered sprayer, using a TeeJet 11008E nozzle at 40 psi, in water equivalent to 2 gal per 1000 sq ft. Treatment applications were made on 5 and 18 May, and 2, 15, and 29 Jun, unless otherwise noted in the table. Disease severity was evaluated on 24 May, 2, 9, and 22 Jun, and 14 Jul. Only the annual bluegrass was evaluated, as the bentgrass was not symptomatic. Data were subjected to analysis of variance and multiple comparisons of the mean values were made using the Waller-Duncan k-ratio test. Data from 24 May, and 2 and 9 Jun are presented.

Results and Discussion

Anthracnose basal rot severity was moderate in the experiment; and declined after 9 Jun. The 9 Jun evaluation revealed six of the treatments were significantly different from the untreated check: Ecoguard (7-and 14-day intervals), Insignia + Cascade, Heritage 50WG, Spectro + Alude, and the Ecoguard-Endorse alternation. Only the two Ecoguard (applied alone) treatments and the Insignia + Cascade combination were significantly different from the untreated check on each of the three rating dates. Phytotoxicity was observed after the first application of the Insignia-Cascade mixture in which the Cascade had been applied at 16.0 fl oz. The Cascade rate was changed to 8.0 fl oz, after which no phytotoxicity was observed in the study.

Table. Management of basal-rot anthracnose on a putting green with fungicides, 2005.

Treatment, formulation, and rate per 1000 sq ft	Anthracnose severity[z] 24 May		2 Jun		9 Jun	
Untreated Check	4.3	a[y]	4.0	a-d[y]	4.0	b-f[y]
Lynx 45WP 0.6 oz	4.0	ab	5.0	ab	4.7	a-d
Lynx 45WP 0.3 oz	3.7	abc	5.0	ab	4.3	a-e
Lynx 45WP 1.2 oz[x]	3.3	abc	4.0	a-d	5.0	abc
BASF Northern Greens Program[w]	3.3	abc	4.0	a-d	3.3	b-h
1. Insignia 20WG 0.5 oz + Emerald 70WG 0.13 oz						
2. Manicure 82.5WG 3.2 oz + Propiconazole Pro ME 1.0 fl oz						
3. Insignia 20WG 0.5 oz + Emerald 70WG 0.13 oz						
4. Manicure 82.5WG 3.2 oz + Propiconazole Pro ME 1.0 fl oz						
5. Manicure 82.5WG 3.2 oz + Iprodione Pro 2SC 2.0 fl oz						
Endorse 2.5WP 4.0 oz	3.0	abc	4.0	a-d	4.3	a-e
Lynx Flo 2SC 0.5 fl oz	3.0	abc	3.3	b-f	4.3	a-e
Insignia 20WG 0.9 oz + Revolution L 6.0 fl oz	3.0	abc	2.0	e-h	2.3	e-i
Tartan SC 1.28 fl oz	2.7	abc	4.3	abc	2.7	d-i
Medallion 50WP 0.25 oz	2.7	abc	5.3	a	4.0	b-f
3336 Plus F 6.0 fl oz + Alude L 5.5 fl oz	2.3	abc	1.0	h	3.0	c-i
Spectro 90WDG 4.0 oz	2.3	abc	3.7	a-e	3.0	c-i
Signature 80WG 4.0 oz + Daconil Ultrex 82.5WG 2.4 oz	2.3	abc	3.0	c-g	3.0	c-i
Tartan SC 0.6 fl oz	2.3	abc	3.0	c-g	3.7	b-g
Lynx Flo 2SC 1.0 fl oz	2.3	abc	5.3	a	6.3	a
Lynx Flo 2SC 2.0 fl oz[x]	2.3	abc	3.3	b-f	5.3	ab
Insignia 20WG 0.9 oz + Propiconazole Pro 1.3ME 1.0 fl oz	2.3	abc	5.3	a	3.0	c-i
Insignia 20WG 0.9 oz + Primer L 6.0 fl oz	2.3	abc	1.7	fgh	2.0	f-i
Daconil Ultrex 82.5WG 3.25 oz	2.3	abc	2.3	d-h	2.0	f-i
Ecoguard L 20.0 fl oz alternate Endorse 2.5WP 4.0 oz[v]	2.3	abc	2.3	d-h	1.3	hi
Spectro 90WDG 4.0 oz + Alude L 5.0 fl oz	2.0	abc	1.7	fgh	1.7	ghi
Heritage TL 0.8ME 1.0 fl oz	2.0	abc	3.0	c-g	3.0	c-i
Insignia 20WG 0.9 oz + Manicure 82.5WG 3.2 oz	2.0	abc	4.3	abc	2.3	e-i
3336 4F 6.0 fl oz	1.7	abc	1.7	fgh	3.7	b-g
3336 Plus F 6.0 fl oz	1.7	abc	1.3	gh	3.0	c-i
Heritage 50WG 0.2 oz	1.7	abc	1.7	fgh	1.3	hi
Insignia 20WG 0.9 oz	1.7	abc	2.3	d-h	2.0	f-i
Signature 80WG 4.0 oz + 26GT 2SC 3.0 fl oz	1.3	bc	1.7	fgh	3.0	c-i
Insignia 20WG 0.9 oz + Cascade L 8.0 fl oz	1.3	bc	1.3	gh	1.3	hi
Ecoguard L 20.0 fl oz alt. Daconil Ultrex 82.5WG 3.25 oz[u]	1.3	bc	2.0	e-h	3.0	c-i
Ecoguard L 20.0 fl oz[t]	1.3	bc	0.7	h	1.0	i
Ecoguard L 20.0 fl oz	1.0	c	2.0	e-h	1.3	hi

[z]Disease severity index 0-10; 0=asymptomatic, and 10=>90% annual bluegrass symptomatic, mean of three replications.

[y]Means within column followed by different letters are significantly different ($P \leq 0.05$) according to the

Waller-Duncan k-ratio test.
[x]Treatment applied as a curative treatment 2, 15, and 29 Jun.
[w]Treatments were applied on 14-day intervals in the order indicated in the table beginning 5 May.
[v]Products were applied alternately on a 14-day interval (Ecoguard 5 May, 2 and 29 Jun; Endorse 18 May and 15 Jun).
[u]Products were applied alternately on a 14-day interval (Ecoguard 5 May, 2 and 29 Jun; Daconil Ultrex 18 May and 15 Jun).
[t]Treatment applied on a 7-day interval from 5 May through 6 Jul.

Control of Brown Patch on a Fairway Turf with Fungicides, 2005

W. Uddin, M. D. Soika, and E. L. Soika
Department of Plant Pathology

Introduction

Brown Patch (*Rhizoctonia solani*) can be a serious disease on golf courses during prolonged warm and humid periods of summer. This study was conducted at the Valentine Turfgrass Research Center, University Park, PA, on colonial bentgrass (*Agrostis capillaris,* 'Bardot') maintained under golf course fairway management conditions. The objective of the study was to evaluate various fungicides, rates, and tank-mixtures for effectiveness in controlling brown patch.

Materials and Methods

The experiment was conducted at the Valentine Turfgrass Research Center, University Park, PA, on colonial bentgrass maintained under golf course fairway management conditions, mowed three times per week at 0.5-inch cutting height. The soil was Hagerstown silt loam with pH 6.7. The test area was fertilized on 9 May (29-5-10) and 10 May (31-0-0) respectively with 1.0 lb nitrogen per 1000 sq ft, and 6 and 15 Jun with 0.5 lb nitrogen (15-0-29) and 1.0 lb nitrogen (19-9-18) respectively per 1000 sq ft. Besumec 4F was applied at the rate of 2.0 gal per acre on 12 May for pre-emergent control of crabgrass. Mach 2 (1.5 fl oz per 1000 sq ft) was applied on 7 Jul for control of cutworms. Treatment plots, 3 ft x 6 ft, were arranged in a randomized complete block design with three replications. Applications were made with a CO_2-powered sprayer, using a TeeJet 11008E nozzle, at 40 psi, in water equivalent to 2 gal per 1000 sq ft. Treatments were applied on 13 and 27 Jun, and 11 and 26 Jul, unless otherwise noted in the table. Disease severity was assessed weekly from 4 Jul to 26 Jul, and on 17 Aug. Data were subjected to analysis of variance and multiple comparisons of the mean values were made using the Waller-Duncan k-ratio test ($P \leq 0.05$).

Results and Discussion

Brown patch severity was light in the study. Prolonged periods of hot and dry weather were not conducive for disease development. The untreated check in the 17 Aug evaluation had less than 15% of the turf being symptomatic. Seven treatments gave excellent control of brown patch throughout the experiment. ProStar, Insignia (0.5 oz, 14-day interval), and both rates of Heritage TL provided total suppression throughout the trial. No phytotoxicity was observed during the study.

Table. Control of brown patch on a fairway turf with fungicides, 2005.

Treatment, formulation, and rate per 1000 sq ft	Brown patch severity[z] 4 Jul		11 Jul		18 Jul		26 Jul		17 Aug	
Propensity 1.3ME 2.0 fl oz	0.0	b[y]	0.7	bcd[y]	0.8	b[y]	1.2	ab[y]	1.8	a[y]
Iprodione Pro 2SC 4.0 fl oz	0.0	b	0.5	cd	0.2	c	0.5	bc	1.8	a
Echo Ultimate 82.5WG 3.25 oz	0.0	b	0.8	a-d	0.0	c	1.0	ab	1.7	ab
Echo 720 6F 3.6 fl oz	0.0	b	1.2	abc	0.2	c	0.7	bc	1.5	ab
Daconil Weatherstik 6F 3.6 fl oz	0.2	b	1.2	abc	0.2	c	0.8	ab	1.3	ab
Untreated Check	1.7	a	1.5	ab	1.7	a	1.5	a	1.2	ab
Bayleton 50DF 0.5 oz	0.3	b	0.5	cd	0.8	b	0.8	ab	1.2	ab
Daconil Ultrex 82.5WG 3.25 oz	0.0	b	1.7	a	0.0	c	0.5	bc	0.8	bc
Insignia 20WG 0.9 oz[x]	0.0	b	0.0	d	0.0	c	0.0	c	0.2	c
Heritage 50WG 0.2 oz	0.0	b	0.0	d	0.0	c	0.0	c	0.0	c
Heritage TL 0.5 fl oz + Banner MAXX 1.0 fl oz	0.2	b	0.0	d	0.0	c	0.0	c	0.0	c
Heritage TL 0.8ME 1.0 fl oz	0.0	b	0.0	d	0.0	c	0.0	c	0.0	c
Heritage TL 0.8ME 0.5 fl oz	0.0	b	0.0	d	0.0	c	0.0	c	0.0	c
Insignia 20WG 0.5 oz	0.0	b	0.0	d	0.0	c	0.0	c	0.0	c
ProStar 70WP 1.5 oz	0.0	b	0.0	d	0.0	c	0.0	c	0.0	c

[z]Disease severity index 0-10; 0=asymptomatic, and 10=>90% turf area symptomatic, mean of three replications.

[y]Means within each column followed by different letters are significantly different ($P \leq 0.05$) according to the Waller-Duncan k-ratio test.

[x]Treatment applied on a 28-day interval (13 Jun and 11 Jul).

TITLE: INFLUENCE OF TURFGRASS MANAGEMENT PRACTICES ON DEVELOPMENT OF ANTHRACNOSE BASAL ROT IN MIXED BENT-POA GREENS

INVESTIGATOR/COOPERATOR:

Dr. Wakar Uddin
Department of Plant Pathology
The Pennsylvania State University
University Park, PA 16802

PURPOSE:

To determine the effects of source and rate of nitrogen application on severity of anthracnose basal rot in mixed Bent-Poa greens

LOCATION OF PROJECT:

Valentine Turfgrass Research Center, The Pennsylvania State University

INTRODUCTION

Anthracnose basal rot is a serious disease of annual bluegrass (*Poa annua* var. *annua*) and creeping bentgrass (*Agrostis palustris*), particularly in annual bluegrass-bent mix greens in different geographic regions of the United States. Historically, the disease has occurred in annual bluegrass during periods of moderate temperature and high moisture in summer particularly, when the plants are under nutritional and/or environmental stress. Currently, the problem has become more evident in creeping bentgrass in annual bluegrass-bent mix greens. The disease problem had also been observed in pure bentgrass stands in certain regions of U.S. Additionally, the disease has been diagnosed on turf during cold and wet periods in certain locations in the northeastern U.S. In January of 2001, anthracnose basal rot disease was diagnosed in annual bluegrass-bent mix greens under the snow cover in Pennsylvania, and profuse production of spores was observed in the newly infected plants. Application of fungicide does not always provide satisfactory control of the disease. Therefore, cultural management of turf plays an important role in development of the disease. While many superintendents usually maintain a fertility program with moderate to low nitrogen application usually with quick release type nitrogen sources, such management practices appears to favor the anthracnose basal rot disease. Additionally, it is unclear whether modification of fertility program will have serious impact on anthracnose basal rot development. For example, application low amount of nitrogen for reduce turfgrass growth in mixed bent-Poa green are potentially serious predisposing factors to anthracnose basal rot development. Additionally, quick release nitrogen may also favor the disease. Therefore, the objectives of this study are developed to evaluate the application rates and sources of nitrogen as factors that could influence anthracnose basal rot severity. Finding from this study will aid in development of a sound turfgrass cultural management program.

MATERIALS AND METHODS

Field Plot Maintenance

The experiment was conducted in 2005 at the Joseph Valentine Turfgrass Research Center, University Park, PA, on a mixed sward of creeping bentgrass (*Agrostis palustris* Huds.) cv. Penncross and annual bluegrass (*Poa annua* L.) cv. Annua. The turf was maintained as a golf course green mowed at a 0.125-inch height six times per week. The soil was Hagerstown silt-loam with pH 6.9. The experimental area was not fertilized at any point during the growing season prior to initiation of the study. No herbicides, fungicides, or insecticides were applied prior to or during the test period. Irrigation was applied as needed to prevent drought stress.

Application of Field Treatments

Three sources of nitrogen with varying release characteristics: urea 46-0-0), methylene urea (26-0-0), and IBDU (30-0-0), were utilized in the experiment. Each nitrogen source was applied at 0.1, 0.3, and 0.5 lb actual nitrogen per 1000 sq ft on a 14-day schedule from 27 Apr through 6 Jul. All treatments were applied six times during that period. An untreated control was included for comparison.

Treatment plots 3 feet by 6 feet were arranged in a randomized complete block design with three replications. Treatments were applied with a CO2-powered sprayer equipped with a TeeJet 11008E nozzle at 40 psi in water equivalent to 2 gal per 1000 ft^2.

Plots were evaluated for symptoms of anthracnose-basal rot. Assessments were made on 24, 27, and 30 May; 2, 5, and 8 Jun; and 14 Jul. Foliar tissue samples were collected from each plot on 8, 16, and 22 Aug for analysis of nitrogen levels. Soil samples, 0.75-in. diameter by 2-in. depth, were collected on 8, 16, and 22 Aug for analysis of soil nitrogen levels. Four sub-samples were collected from each plot in all replications. Results of foliar tissue analysis and overall assessment of the disease severity (i.e. AUDPC, rate r, Y_{max}) will be presented in a later date in the next report.

Statistical Analysis

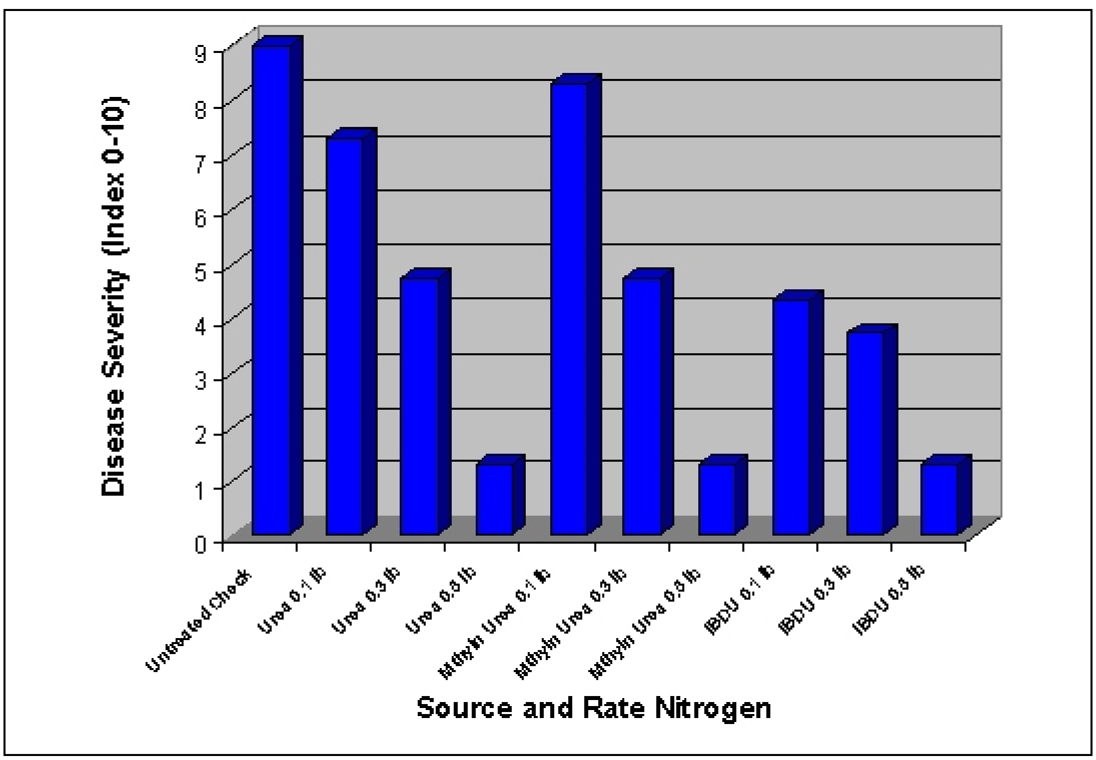
Severity of anthracnose basal rot (Index 0-10; 0=turf asymptomatic; 10=>90% turf area symptomatic) was assessed every four days. Disease severity data were subject to analysis of variance using the General Linear Model procedure, and multiple comparison of means were made using Student-Newman-Keul's test. Statistical procedures was performed using Statistical Analysis System software (SAS version 8.02, Cary, NC).

RESULTS AND CONCLUSION

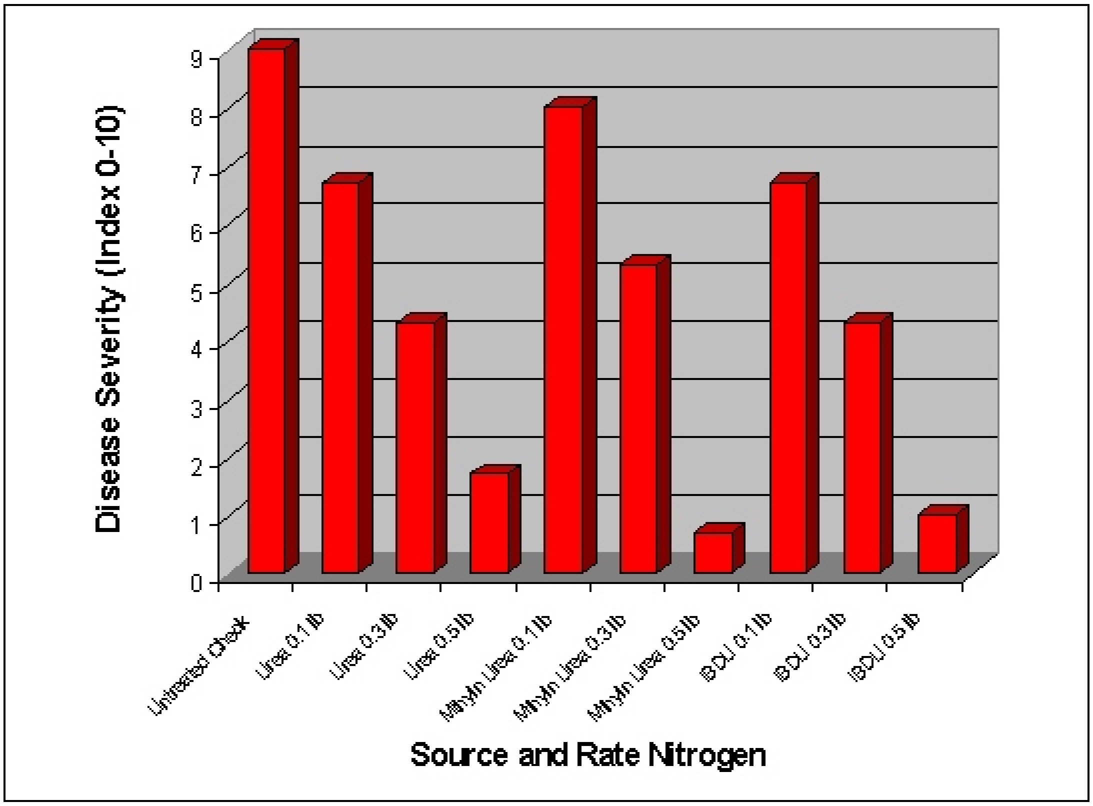
The results of our study indicates that source of nitrogen and application rate are important factors influencing anthracnose basal rot development. In first disease assessment, the effect of nitrogen source and application rate on disease severity were significant ($P \leq 0.05$). Application of low rate (0.1 lb) of urea and methylene urea did not significantly reduced anthracnose basal rot. However, application of low rate (0.1 lb) of IBDU significantly reduced the disease. Disease severity in plots treated with low rate (0.1 lb) of IBDU was significantly not different from that of the plots which received middle rate (0.3 lb) of urea and methylene urea. Application of high rate (0.5 lb) of nitrogen, regardless of the source, provided the most effective control of anthracnose basal rot. Disease severity on those plots were 13% compared to 90% in untreated control. Although disease severity in plots that received low rate of IBDU was significantly lower than that of the plots received low rate of urea and methylene urea, such differences were not observed when application rates were increased to middle rate or high rate. Effects of source of nitrogen and application rate on development of anthracnose basal rot disease in the second disease assessment followed a similar pattern.

It has been reported in the literature that several turfgrass pathogen effectively infects plant hosts that were grown under stressed conditions such as drought, wounding, and fertility. *C. graminicola* is a stress-pathogen that appeared to have effectively infected the host plants under low nitrogen condition and quick release type as the source of nitrogen. Although it has become apparent in recent years that the fungus can also effectively infect plants that are growing under non-stressed conditions, the nitrogen fertility factor appears to remain critical during the infection process. Our study revealed the significance of nitrogen fertility as part of the cultural management practices in anthracnose basal rot development. These results will be instrumental in providing disease management recommendations to golf course superintendents.

Disease Assessment 1



Disease Assessment 2



Effects of Fungicides for Dollar Spot Control on a Bentgrass Fairway, 2005

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Department of Plant Pathology

Introduction

The use of fungicides for managing dollar spot (*Sclerotinia homoeocarpa*) on golf courses is a fundamental practice to maintain high quality playing surfaces. This study was conducted at the Joseph Valentine Turfgrass Research Center, University Park, PA, on a stand of creeping bentgrass (*Agrostis Palustris*, 'Penneagle'). The study included various fungicides, rates, mixtures, and/or application intervals to investigate control strategies and fungicide efficacy.

Materials and Methods

The experiment was conducted at the Valentine Turfgrass Research Center, University Park, PA, on a sward of creeping bentgrass maintained under golf course fairway management conditions. The turfgrass was mowed three times per week at 0.5-inch cutting height. The soil was a Hagerstown silt loam with pH 6.8. The experiment was fertilized 19 Apr with 1.0 lb nitrogen (18-9-18) per 1000 sq ft, and on 1 Jun with 0.25 lb nitrogen (46-0-0) per 1000 sq ft. Bensumec 4F was applied on 12 May at a rate of 2 gal/A for pre-emergent control of crabgrass. Trimec Bentgrass Formula was applied on 17 May (0.7 fl oz per 1000 sq ft) for control of broadleaf weeds. Mach 2 2SC (1.5 fl oz per 1000 sq ft) was applied 7 Jul for control of black cutworms. Treatment plots, 3 ft x 6 ft, were arranged in a randomized complete block design with three replications. Treatments were applied with a CO_2-powered sprayer, using a TeeJet 11008E nozzle at 40 psi, in water equivalent to 2 gal per 1000 sq ft. Applications were made on 7 and 21 Jun, and 5 and 19 Jul, unless otherwise noted in the table. Disease incidence was evaluated weekly and data were subjected to analysis of variance and multiple comparisons of the mean values were made using the Waller-Duncan k-ratio test. Data from 26 Jul, and 3 and 10 Aug are presented.

Results and Discussion

Dollar spot incidence was moderate in June and became increasingly severe during July and early August. On 10 Aug 15 treatments were providing excellent control of dollar spot, while 3336 Plus treatments applied at 3.0 or 4.0 fl oz were not significantly different from the untreated check. Complete suppression of dollar spot was achieved throughout the study with the Emerald + Curalan tank mixture, the Emerald + urea mixture, and the two 0.13 oz (14-day interval) Emerald treatments. No phytotoxicity was observed in the experiment.

Table. Effects of fungicides for dollar spot control on a bentgrass fairway, 2005.

Treatment, formulation, and rate per 1000 sq ft	Infection centers per sq ft[z] 26 Jul		3 Aug		10 Aug	
Untreated Check	10.9	a[y]	13.4	a[y]	19.1	a[y]
3336 Plus F 3.0 fl oz[x]	5.4	b	12.9	a	16.3	ab
3336 Plus F 4.0 fl oz[x]	5.6	b	7.1	b	14.3	abc
Daconil Ultrex 82.5WG 1.8 oz	0.9	d	4.9	bc	11.7	bcd
Daconil Ultrex 82.5WG 3.25 oz	0.0	d	1.3	ef	11.1	bcd
Fairway Seaquential L 3.0 fl oz + Daconil Ultrex 82.5WG 1.8 oz	0.9	d	3.8	cd	10.3	cde
Heritage TL 0.8ME 1.0 fl oz	1.1	d	1.8	def	10.0	cde
3336 Plus F 2.0 fl oz[x]	4.1	c	2.3	def	9.9	c-f
Echo Ultimate 82.5WG 3.25 oz	0.6	d	2.7	cde	9.2	c-f
Echo 720 6F 3.6 fl oz	0.4	d	2.0	def	6.2	d-g
Banner MAXX 1.3ME 2.0 fl oz[w]	0.3	d	1.4	def	5.6	efg
Insignia 20WG 0.9 oz	0.4	d	1.7	def	5.1	e-h
Curalan 50EG 1.0 oz	0.0	d	1.0	ef	5.0	e-h
26GT 2SC 3.0 fl oz[x]	0.0	d	0.0	f	4.4	fgh
Heritage 50WG 0.2 oz + Banner MAXX 1.3ME 0.5 fl oz	0.2	d	0.9	ef	3.7	gh
Heritage TL 0.8ME 0.5 fl oz+ Banner MAXX 1.3ME 0.5 fl oz	0.0	d	0.2	f	3.6	gh
Lynx 45WP 0.6 oz[x]	0.3	d	0.8	ef	3.2	gh
Heritage TL 0.8ME 1.0 fl oz + Banner MAXX 1.3ME 0.5 fl oz	0.0	d	0.0	f	1.7	gh
2636 F 4.0 fl oz[x]	0.0	d	0.0	f	1.4	gh
Emerald 70WG 0.18 oz[v]	0.1	d	0.0	f	1.4	gh
Lynx 45WP 1.0 oz[x]	0.0	d	0.0	f	1.2	gh
Emerald 70WG 0.18 oz[u]	0.0	d	0.0	f	0.0	h
Emerald 70WG 0.13 oz[t]	0.0	d	0.0	f	0.0	h
Emerald 70WG 0.13 oz	0.0	d	0.0	f	0.0	h
Emerald 70WG 0.13 oz + urea (0.125 lb N)46GR 0.27 lb	0.0	d	0.0	f	0.0	h
Emerald 70WG 0.18 oz + Curalan 50EG 1.0 oz[x]	0.0	d	0.0	f	0.0	h

[z]Number of infection centers per plot, three sub-samples per plot, mean of three replications.
[y]Means within column followed by different letters are significantly different ($P \leq 0.05$) according to the Waller-Duncan k-ratio test.
[x]Treatment applied on a 21-day interval (7 and 28 Jun, and 19 Jul).
[w]Treatment applied on a 28-day interval (7 Jun and 5 Jul).
[v]Treatment was initiated 24 May and applied on a 21-day interval (24 May, 14 Jun, and 5 Jul).
[u]Treatment was initiated 24 May and applied on a 28-day interval (24 May, 21 Jun, and 19 Jul).
[t]Treatment was initiated 24 May and applied on a 14-day interval (24 May, 7 and 21 Jun, 5 and 19 Jul).

Evaluation of Fungicides for Control of Gray Leaf Spot on Perennial Ryegrass, 2005

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Introduction

Gray leaf spot (*Pyricularia grisea*) is an important disease on perennial ryegrass (*Lolium perenne*) golf course fairways and roughs in the Mid-Atlantic, Mid-West, and New England regions of the United States. This study was located at the Pennsylvania State University on perennial ryegrass. The objective of the study was to evaluate various fungicides, rates, and fungicide combinations for their effectiveness in suppressing gray leaf spot.

Materials and Methods

The study was conducted on perennial ryegrass at the Valentine Turfgrass Research Center, University Park, PA. The site was maintained under golf course fairway management conditions; mowed three times per week at 1.0-inch cutting height. The soil was Hagerstown silt loam, pH 6.8. The experimental area was fertilized with 1.0 lb nitrogen respectively on 9 May (29-5-10) and 10 May (31-0-0), 0.5 lb nitrogen (9-18-17) per 1000 sq ft on 6 Jun, and 1.0 lb nitrogen (18-9-18) per 1000 sq ft on 10 Aug. Chaser Ultra 4.68L was applied 18 May at the rate of 1.0 fl oz per 1000 sq ft for control of broadleaf weeds. Treatment plots, 3 ft x 6 ft, were arranged in a randomized complete block design with three replications. Treatments were applied with a CO_2-powered sprayer using a TeeJet 11008E nozzle at 40 psi, in water equivalent to 2 gal per 1000 sq ft. Treatments were applied on 6 and 20 Jul, and 11 Aug, unless otherwise noted in the table. The experimental turf area was inoculated with *M. grisea* 28 Jul. After inoculation, the turf was maintained at a 2.0-inch cutting height; mowed once per week. Disease severity was evaluated on 15 and 22 Aug. Data were subjected to analysis of variance and multiple comparisons of the mean values were made using the Waller-Duncan k-ratio test.

Results and Discussion

Disease severity was high in the experiment. In the 22 Aug evaluation nearly 80% of the untreated check plots was symptomatic. Twenty-three treatments were significantly different from the untreated check. Excellent control of gray leaf spot was accomplished with Daconil Ultrex, both rates of rates of Headway, both rates Heritage 50WG, the high rate of Heritage TL, both rates of Tartan, Insignia, the high rate mixture of Heritage TL + Banner MAXX, and Compass. Complete control of gray leaf spot was attained with the Insignia + Manicure tank mixture, and the combination of Heritage TL + Daconil Ultrex + Banner MAXX. No phytotoxicity was observed in the experiment.

Table. Evaluation of fungicides for control of gray leaf spot on perennial ryegrass, 2005.

Treatment, formulation, and rate per 1000 sq ft	Gray leaf spot severity[z] 15 Aug		22 Aug	
Banner MAXX 1.3ME 1.0 fl oz	3.0	ab[y]	8.0	a[y]
Ecoguard L 20.0 fl oz alternate 3336 4F 4.0 fl oz[x]	3.7	ab	7.7	a
Untreated Check	3.7	ab	7.7	a
Ecoguard L 20.0 fl oz	4.3	a	7.3	ab
Propensity 1.3ME 2.0 fl oz	2.7	abc	6.7	abc
Lynx 45WP 0.6 oz	3.3	ab	5.7	bcd
Lynx Flo 2SC 1.0 fl oz	2.3	bcd	5.0	cd
Instrata 3.61SC 2.75 fl oz	1.0	c-f	4.7	de
Instrata 3.61SC 4.15 fl oz[w]	0.7	def	4.7	de
Ecoguard L 20.0 fl oz + 3336 4F 4.0 fl oz	3.3	ab	4.7	de
Cyazofamid 3.34SC 0.9 fl oz	2.0	b-e	4.3	de
3336 4F 4.0 fl oz	2.3	bcd	3.0	ef
Heritage TL 0.8ME 1.0 fl oz	0.7	def	2.3	fg
Ecoguard L 20.0 fl oz alternate Daconil Ultrex 82.5WG 3.2 oz[v]	0.3	ef	2.3	fg
Heritage TL 0.8ME 1.0 fl oz + Banner MAXX 1.3ME 1.0 fl oz	0.7	def	2.0	fgh
Headway 1.4ME 1.5 fl oz	2.0	b-e	1.7	f-i
Tartan 2.4SC 1.0 fl oz	0.3	ef	1.7	f-i
Heritage 50WG 0.2 oz	0.3	ef	1.3	f-i
Heritage TL 0.8ME 2.0 fl oz[u]	1.0	c-f	1.3	f-i
Compass 50WG 0.2 oz	0.3	ef	1.3	f-i
Heritage TL 0.8ME 2.0 fl oz + Banner MAXX 1.3ME 2.0 fl oz[u]	0.0	f	0.7	ghi
Insignia 20WG 0.9 oz[u]	0.0	f	0.7	ghi
Tartan 2.4SC 2.0 fl oz	0.3	ef	0.7	ghi
Heritage 50WG 0.4 oz[u]	0.0	f	0.3	hi
Headway 1.4ME 3.0 fl oz[u]	0.0	f	0.3	hi
Daconil Ultrex 82.5WG 3.2 oz	0.3	ef	0.3	hi
Heritage TL 1.0 fl oz + Daconil Ultrex 3.2 oz + Banner MAXX 1.0 fl oz	0.0	f	0.0	i
Insignia 20WG 0.9 oz + Manicure 82.5WG 3.2 oz[u]	0.0	f	0.0	i

[z]Disease severity index 0-10; 0=asymptomatic, and 10=>90% turf area symptomatic, mean of three replications.
[y]Within column, means followed by different letters are significantly different ($P \leq 0.05$) according to the Waller-Duncan k-ratio test.
[x]Treatment applications were alternated (Ecoguard 6 Jul and 11 Aug; 3336 20 Jul).
[w]Treatment applied 29 Jun, 20 Jul, and 11 Aug.
[v]Treatment applications were alternated (Ecoguard 6 Jul and 11 Aug, Daconil Ultrex 20 Jul).
[u]Treatment applied 22 Jun, 20 Jul, and 11 Aug.

Control of Spring Leaf Spot/Melting-out on Kentucky Bluegrass, 2005

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Introduction

Leaf spot diseases caused by species of *Drechslera* and *Bipolaris* are common problems on turfgrasses. The use of fungicides can be an important means of managing spring leaf spot/melting-out. This study was conducted at the Valentine Research Center, University Park, PA, on Kentucky bluegrass (*Poa pratensis*, 'Park'). The objective of the study was to evaluate various treatments and application intervals to assess control of *Drechslera poae.*

Materials and Methods

The experiment was conducted at the Valentine Turfgrass Research Center, University Park, PA, on Kentucky bluegrass mowed three times per week at a cutting height of 1.5 inch. The soil was Hagerstown silt loam with a soil pH of 6.8. The test area was fertilized with 1.0 lb nitrogen per 1000 sq ft (29-5-10) on 29 Mar and 7 Apr. Treatment plots, 3 ft x 6 ft, were arranged in a randomized complete block design with three replications. Fungicides were applied with a CO_2-powered sprayer, using a TeeJet 11008E nozzle at 40 psi, in water equivalent to 2 gal per 1000 sq ft. Applications were made on 13 and 28 Apr, and 11 and 26 May, unless otherwise noted in the table. Disease was assessed on 3, 10, 19, and 24 May. Data were subjected to analysis of variance, and the mean values were separated using the Waller-Duncan k-ratio Test.

Results and Discussion

Severity of leaf spot/melting-out was high during the experiment. Medallion, Insignia (14-day interval), and 26GT provided good suppression of spring leaf spot/melting-out throughout the study. With the exception of the 19 May evaluation, Insignia (28-day interval) also provided good disease suppression. No treatment provided complete control at any point during the experiment; nor was any phytotoxicity observed.

Table. Control of spring leaf spot/melting-out on Kentucky bluegrass, 2005.

Treatment, formulation, and rate per 1000 sq ft	Spring leaf spot/melting-out severity[z] 3 May		10 May		19 May		24 May	
Banner MAXX 1.3ME 2.0 fl oz[y]	4.8	a[x]	6.0	a[x]	4.0	a[x]	8.7	a[x]
Armada 50WP 0.6 oz[y]	3.0	b-e	3.2	c	2.2	abc	5.7	ab
Daconil Ultrex 82.5WG 3.25 oz[w]	2.8	b-e	3.5	bc	3.2	ab	5.7	ab
Untreated Check	4.3	ab	4.7	ab	4.2	a	5.7	ab
Curalan 50EG 1.0 oz	3.3	a-e	4.2	bc	3.5	ab	5.3	abc
Armada 50WP 1.2 oz[y]	3.7	abc	3.7	bc	3.3	ab	5.0	bc
Compass 50WG 0.25 oz[y]	3.5	a-d	3.5	bc	2.8	ab	4.0	bcd
Heritage 50WG 0.3 oz[y]	3.2	b-e	3.2	c	2.8	ab	3.3	bcd
Heritage TL 0.8ME 1.5 fl oz[y]	2.3	c-f	3.0	c	2.3	abc	2.7	bcd
Insignia 20WG 0.9 oz[y]	2.0	def	2.8	c	2.3	abc	2.0	cd
26GT 2SC 4.0 fl oz[y]	1.0	f	0.8	d	1.5	bc	2.0	cd
Insignia 20WG 0.9 oz	1.8	ef	2.8	c	1.5	bc	1.3	d
Medallion 50WP 0.5 oz[w]	1.2	f	1.3	d	0.7	c	0.7	d

[z]Disease severity index 0-10; 0=asymptomatic, and 10=>90% turf area symptomatic, mean of three replications.

[y]Treatment applied on a 28-day interval (13 Apr and 11 May).

[x]Means within column followed by different letters are significantly different ($P \leq 0.05$) according to the Waller-Duncan k-ratio test.

[w]Treatment applied on a 21-day interval (13 Apr and 5 May).

Control of Pythium Foliar Blight on Perennial Ryegrass, 2005

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Introduction

Pythium foliar blight is a potentially devastating disease on fine turf. The use of fungicides plays a crucial role in controlling Pythium foliar blight on golf courses. The study was conducted at the Valentine Turfgrass Research Center, University Park, PA, on perennial ryegrass (*Lolium perenne*, 'Legacy II'). The objective of the study was to evaluate various fungicides, rates, and mixtures to determine their effectiveness in suppressing the disease.

Materials and Methods

The study was conducted at the Valentine Turfgrass Research Center, University Park, PA, on perennial ryegrass maintained under golf course fairway management conditions, and mowed three times per week at 1.0-in. cutting height. The soil was Hagerstown silt loam with pH 6.8. The experimental area was fertilized 9 and 10 May with 1.0 lb nitrogen (29-5-10 and 31-0-0 respectively) per 1000 sq ft, and 6 and 15 Jun with 0.5 lb nitrogen (9-18-17 and 18-9-18 respectively) per 1000 sq ft. Treatment plots, 3 ft x 3.5 ft, were arranged in a randomized complete block design with three replications. Treatments were applied 23 Jun and 5 Jul with a CO_2-powered sprayer using a TeeJet 11008E nozzle. Applications were made at 40 psi, in water equivalent to 2 gal per 1000 sq ft. On 6 Jul the experiment was enclosed in a 30 ft x 48 ft polyethylene greenhouse to reduce radiational cooling. The experiment was inoculated 7 Jul with a mycelial suspension of a five-isolate pool of *Pythium aphanidermatum.* An internal intermittent misting system provided high relative humidity and leaf surface wetness during the course of the study. The greenhouse was vented during daylight hours to maintain a temperature range of 85° to 95°F. Vents were closed during the evenings and nights. Test plots were not mowed between the time of treatment applications on 5 Jul and disease assessments. Disease severity was assessed 14 and 15 Jul. Data were subjected to analysis of variance and multiple comparisons of the mean values were made using the Waller-Duncan k-ratio test

Results and Discussion

Pythium blight severity was very high in the experiment. On 15 Jul 14 treatments provided disease control that was significantly different from the untreated check. Excellent control of Pythium foliar blight was achieved from the two Heritage + Subdue MAXX mixtures, the Cyazofamid combinations with Alude or Insignia, the two formulations of Subdue applied alone, the low and high rates of Cyazofamid, and the Insignia + Signature mixture. No phytotoxicity was observed in the experiment.

Table. Control of Pythium foliar blight on perennial ryegrass, 2005.

Treatment, formulation, and rate per 1000 sq ft	Pythium blight severity*			
	14 Jul		15 Jul	
Untreated Check	9.7	a**	10.0	a**
Banol 6SL 2.0 fl oz	5.3	b	8.0	ab
Signature 80WG 4.0 oz	6.0	b	8.0	ab
Insignia 20WG 0.9 oz	4.3	bc	7.0	bc
Heritage TL 0.8ME 2.0 fl oz	4.7	bc	6.7	bc
Alude L 5.5 fl oz	2.7	cd	6.7	bc
Heritage 50WG 0.4 oz	4.0	bc	6.3	bc
Signature 80WG 6.0 oz	2.7	cd	4.7	cd
Cyazofamid 3.34SC 0.45 fl oz	1.0	de	2.0	de
Insignia 20WG 0.9 oz + Signature 80WG 4.0 oz	0.7	de	1.7	e
Subdue WSP 45WP 0.56 oz	0.7	de	1.3	e
Cyazofamid 3.34SC 0.45 fl oz + Insignia 20WG 0.9 oz	0.7	de	1.3	e
Cyazofamid 3.34SC 0.9 fl oz	0.7	de	1.1	e
Subdue MAXX 2ME 1.0 fl oz	0.3	e	0.7	e
Heritage 50WG 0.2 oz + Subdue MAXX 2ME 0.5 fl oz	0.3	e	0.3	e
Cyazofamid 3.34SC 0.45 fl oz + Alude L 10.0 fl oz	0.0	e	0.3	e
Heritage 50WG 0.2 oz + Subdue MAXX 2ME 1.0 fl oz	0.0	e	0.3	e

*Disease severity index 0-10; 0=asymptomatic, and 10=>90% turf area symptomatic, mean of three replications.

**Within column, means followed by different letters are significantly different ($P \leq 0.05$) according to the Waller-Duncan k-ratio test.

Evaluation of Phosphonate Fungicides for Control of Anthracnose Basal Rot and Putting Green Quality

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Introduction

Phosphonate fungicides are used by golf course managers to control Pythium diseases, suppress anthracnose basal rot, alleviate summer stress, and improve turf quality. In many areas of the northeast, phosphonate products are applied at regular intervals throughout the summer as part of a putting green management program. Over a dozen phosphonate fungicides and fertilizers are currently available for use on golf courses. Although these products have similar active ingredients, they differ in trade name, formulation, label terminology, uses, and price. Understanding the different phosphonate products and how they perform in the field should help golf course managers choose the appropriate product for their particular need.

The objective of this study was to determine if active ingredient (potassium phosphite or fosetyl Al) and formulation of various phosphonate fungicides (Alude, Aliette, and Chipco Signature) provide similar control of anthracnose basal rot and influence the quality of a mixed annual bluegrass (*Poa annua* L.)/creeping bentgrass (*Agrostis stolonifera* L.) putting green when applied at equivalent rates of phosphorous acid (the active compound for controlling diseases).

Materials and Methods

This study was conducted on a research putting green at the Joseph Valentine Turfgrass Research Center, University Park, PA during 2004 and 2005. The putting green soil is a uniform sandy loam with a pH of 7.2, 138 lb Mehlich-3 P/A (69 ppm Mehlich-3 P), 0.07 meq K/100 g soil (28 ppm K), and a CEC of 6.2 meq/100 g soil. The turfgrass is an eight-yr-old mixed stand of ‘Providence’ creeping bentgrass (~70%) and annual bluegrass (~30%). The turf was mowed at 1/8 inch with a triplex greens mower six times per week during the growing season. Clippings were collected in baskets and removed from the site. The test area was fertilized with 2 lb N/1000 ft^2 as IBDU in Oct, 2003 and 2004, and 0.5 lb N/1000 ft^2 as IBDU in June, 2005. Curalan 50EG (vinclozolin, BASF Corp., Research Triangle Park, NC) was applied at 1.0 oz/1000 ft^2 to the test area to control dollar spot in Sep, 2004 (after the 2004 test was terminated) and Turfcide 10% Granular (pentachloronitrobenzene, Crompton Crop Protection, Middlebury, CT) was applied in Nov, 2004 at 10 lb/1000 ft^2 to prevent snow mold diseases. No fungicides were applied to the test area during spring and summer of 2004 and 2005, other than those used as treatments in the test.

2004 treatments: Two sets of treatments were included in the 2004 test. One set included commercial formulations of three phosphonate fungicides; Alude (Cleary Chemical Corp., Dayton, NJ), Aliette (Bayer Environmental Science, Montvale, NJ), and Chipco Signature (Bayer Environmental Science, Montvale, NJ); a 1.0 M solution of reagent-grade phosphorous acid (H_3PO_3) adjusted to a pH of 6.2 with 10.0 M potassium hydroxide (KOH); a solution of reagent-grade phosphoric acid (H_3PO_4) adjusted to a pH of 6.2 with 10.0 M potassium hydroxide; and an untreated control. The second set of treatments included each of the treatments in the first set combined with Curalan 50EG and a Curalan 50EG control. Curalan 50EG (1.0 oz/1000 ft^2) was added to each phosphonate treatment in the second set of treatments to control dollar spot disease (phosphonate fungicides do not control dollar spot) because this disease will severely damage unprotected plots. Also, Curalan 50 EG has very little effect on anthracnose basal rot, and presumably would not greatly influence results of the test (B. Clarke, personal communication).

Dollar spot disease became problematic during late June in the treatments that did not contain Curalan 50EG; thus Curalan 50EG (1.0 oz/1000 ft^2) was added to these treatments beginning with the 30 June, 2004 application and throughout the remainder of the test. Although this change did not affect anthracnose basal rot ratings (all disease severity data was collected before the 30 June application), it could have influenced quality data after 30 June.

2005 treatments: All treatments applied in the 2004 test were also applied in the 2005 test. In addition to these treatments, 3336F (thiophanate methyl, Cleary Chemical Corp, Dayton, NJ) was applied alone and in combination with Alude, Chipco Signature, and reagent-grade phosphorous acid/potassium hydroxide. Another set of treatments included all of the 3336F treatments combined with Curalan 50EG (Table 1).

Treatment rates: All phosphonate treatments (fungicides and the reagent-grade phosphorous acid/ potassium hydroxide treatment) in 2004 and 2005 were applied at equivalent amounts of phosphorous acid, based on phosphorous acid equivalents listed on the Alude label and according to the chemical formula and amount of fosetyl Al listed on the Aliette and Chipco Signature labels. The rate of phosphorous acid used in this study was based on the phosphorous acid equivalent of an intermediate product rate (5.7 oz/1000 ft^2) listed on the Chipco Signature label for anthracnose diseases, and for summer stress complex on the Alude label. The rates of product and phosphorous acid for all phosphonate treatments, the reagent-grade phosphoric acid/potassium hydroxide, Curalan 50EG, and 3336F treatments are provided in Table 1.

The experimental design was a randomized complete block design with four replications. Plot size was 10 ft by 3 ft. In 2004, all treatments were applied every 14 d beginning on 21 May and ending 13 Aug for a total of seven applications. In 2005, all treatments were applied every 14 d beginning on 4 May and ending 29 July for a total of seven applications. Treatments were applied with a CO_2-powered backpack sprayer equipped with a single boom fitted with an 11008E nozzle. Applications were made at 40 psi with a dilution rate equivalent to 2 gal H_2O/1000 ft^2.

Anthracnose basal rot disease severity and turf quality ratings were made every 14 d, just prior to treatment applications. Disease severity was visually assessed on a scale of 0 to 10, with 10 indicating severe disease symptoms and 0 indicating no visible symptoms. Quality was assessed visually using a scale of 0 to 10, with 10 indicating excellent turf quality and 0 indicating extremely poor quality turf. Disease severity and quality data were subjected to analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test at the 0.05 level of significance.

Results

Anthracnose basal rot control:

2004 results: Anthracnose basal rot symptoms were apparent in mid to late June, but symptoms did not become severe at any time during the summer. The only treatments that showed a noticeable reduction in disease symptoms compared to the untreated and Curalan 50 EG controls on both rating dates were Chipco Signature and Chipco Signature + Curalan 50EG (Table 1). The Alude + Curalan 50EG treatment showed less severe symptom development compared to the untreated control, Curalan 50EG control, and Alude treatment on 22 June, but not on 30 June, 2004.

2005 results: A severe infestation of anthracnose basal rot occurred in early July, 2005, and the trial was rated on 5 July. Of the phosphonate treatments with no Curalan 50EG or 3336F added, only Chipco Signature and the reagent-grade phosphorous acid/potassium hydroxide treatments showed a reduction in anthracnose basal rot severity relative to the untreated control (Table 1). The Curalan 50EG treatment did not reduce the severity of anthracnose basal rot symptoms when compared to the untreated control. However, all of the phosphonate/Curalan 50EG treatment combinations reduced anthracnose basal rot symptoms when compared to the untreated control. The 3336F treatment caused a slight, but significant, reduction in disease severity compared to the untreated control; and all phosphonate/3336F treatment combinations provided lower disease ratings than the 3336F treatment. Three-way combinations of phosphonates, Curalan EG50, and 3336F did not perform better with respect to anthracnose basal rot control than any of the phosphonate/Curalan 50EG or phosphonate/3336F treatments. All treatment combinations containing Chipco Signature (Chipco Signature + Curalan EG50, Chipco Signature + 3336F, and Chipco Signature + Curalan EG50 + 3336F) provided better control of anthracnose basal rot than all other treatment combinations. However, none of these Chipco Signature combination treatments provided better disease control than Chipco Signature alone.

Turfgrass quality:

Turf quality data in 2004 and 2005 revealed differences among treatments 14 d following the first application and on all subsequent rating dates (Table 2 and 3 and Fig. 1 - 6). Phosphonate treatments provided better quality than the untreated control on most rating dates (note that Curalan 50EG was added to these treatments beginning on 30 June, 2004 and throughout the remainder of the test due to dollar spot development). Although some statistically significant differences in turfgrass quality were noted among the Aliette, Alude, and the reagent-grade phosphorous acid/potassium hydroxide treatments in both years of the study, numerical values were usually within a single whole unit, indicating that these differences were very subtle. These results indicate that phosphorous acid and fosetyl Al have similar effects on turf quality when applied at equivalent amounts of phosphorous acid. On about half of the rating rates, Chipco Signature produced higher quality ratings than the other phosphonate treatments. On eight of the 16 rating dates, Chipco Signature ranked higher in turfgrass quality than Aliette (both were applied at the same rate of fosetyl Al) suggesting that the formulation of Chipco Signature has a positive effect on turfgrass quality.

Conclusions:

Of the phosphonate fungicide treatments included in this test, Chipco Signature generally provided the best control of anthracnose basal rot. The fact that Chipco Signature and Aliette treatments contained the same amount of active ingredient (fosetyl Al) indicates that differences in formulation may account for improved anthracnose control with Chipco Signature. When applied alone, Alude did not control anthracnose basal rot; however, when it was applied with 3336F, control was improved over 3336F alone. We are not surprised that most phosphonate treatments did not have a pronounced effect on anthracnose basal rot, given that our *in vitro* studies showed that phosphorous acid does not have a strong inhibitory effect on the causal pathogen, *Colletotrichum graminicola*.

Phosphonate treatments generally produced better turf quality than the untreated control during both years of the test; and Chipco Signature tended to produce better quality than the other phosphonate treatments at certain times during the study. Although the improvement in turfgrass quality may have been partly due to anthracnose control, Chipco Signature plots were greener and appeared healthier (fewer brown and thin areas) than the other treatments on several rating dates. The enhanced green-up may have been partially a result of residual pigment from the Chipco Signature formulation; however, we attempted to minimize this effect by taking ratings two weeks after treatments were applied. Currently, we are unsure why phosphonate fungicides improve turfgrass quality. Quality improvement does not appear to be due to a nutritional effect, but may be partially (or wholly) due to a reduction in minor pathogens present in putting green turf. More detailed research may shed light on how phosphonate fungicides improve turf quality, and provide insight into the environmental and management conditions under which this may occur.

Funding for this study was provided by the Pennsylvania Turfgrass Council, Cleary Chemical Corp., and Bayer Environmental Science

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Table 1. Treatments, rates, and anthracnose basal rot disease severity ratings for 2004 and 2005 anthracnose basal rot phosphonate fungicide trial.

Treatment	Rate (oz /1000ft^2)	Disease Severity 2004 22 June	Disease Severity 2004 30 June	Disease Severity 2005 5 July
		(0-10)[a]		
Control	----	2.8 ab[b]	2.5 a	5.5 ab
Curalan 50EG	1.0 oz	2.8 ab	2.8 a	4.8 bc
H_3PO_4/KOH	4.0 oz	3.3 a	2.8 a	6.3 a
H_3PO_3/KOH	43.6 fl oz	2.5 bc	2.0 ab	3.5 def
Alude	7.4 fl oz	2.8 ab	2.0 ab	4.5 bcd
Aliette	5.7 oz	2.5 bc	2.5 a	4.5 bcd
Chipco Signature	5.7 oz	1.5 de	1.0 c	2.0 gh
H_3PO_4/KOH + Curalan	4.0 + 1.0	3.3 a	2.5 a	5.0 bc
H_3PO_3/KOH + Curalan	43.6 + 1.0	2.3 bc	2.0 ab	3.5 def
Alude + Curalan	7.4 + 1.0	2.0 cd	1.8 ab	3.5 def
Aliette + Curalan	5.7 + 1.0	2.5 bc	1.8 ab	3.5 def
Chipco Signature + Curalan	5.7 + 1.0	1.0 e	0.5 c	1.3 h
3336F	6.0 oz	---	---	4.0 cde
3336F + H_3PO_3/KOH	6.0 + 43.6	---	---	2.8 fg
3336F + Alude	6.0 + 7.4	---	---	2.8 fg
3336F + Chipco Signature	6.0 + 5.7	---	---	1.3 h
3336F + Curalan	6.0 + 1.0	---	---	3.5 def
3336F + Curalan + H_3PO_3	6.0+1.0+43.6	---	---	3.0 efg
3336F+ Curalan + Alude	6.0+1.0+5.7	---	---	2.8 fg
3336F + Curalan + Signature	6.0+1.0+5.7	---	---	1.3 h

[a] Anthracnose basal rot disease severity ratings based on a 0-10 scale, 0 = no disease and 10 = very severe disease symptoms.

[b] Data means within the same column and followed by the same letter are not significantly different as determined by Fisher's Protected Least Significant Difference test at *P*=0.05.

Table 2. Treatments, rates, and quality ratings for the 2004 anthracnose phosphonate fungicide trial.

Treatment	Rate (oz/1000 ft^2)	Turf Quality 5/21	6/2	6/16	6/30	7/16	7/28	8/13	8/26
		(0-10)[b]							
Control[a]	----	5.8 a[c]	5.3 cd	4.8 e	4.3 g	4.8 d	4.8 c	4.3 f	4.3 g
Curalan	1.0 oz	5.8 a	6.0 b	6.0 cd	6.0 cd	5.5 d	5.0 c	5.3 de	4.8 g
H_3PO_4/KOH[a]	4.0 oz	5.5 a	5.8 bc	5.8 d	5.0 f	5.3 d	5.5 c	4.8 ef	5.0 fg
H_3PO_3/KOH[a]	43.6 fl oz	6.0 a	6.0 b	6.5 bc	5.5 def	7.8 bc	7.8 ab	5.8 cd	6.3 cde
Alude[a]	7.4 fl oz	5.8 a	5.0 d	5.5 d	5.0 f	7.0 c	7.3 b	5.8 cd	5.8 ef
Aliette[a]	5.7 oz	6.0 a	6.0 b	6.5 bc	5.8 de	8.0 bc	7.3 b	6.3 abc	6.3 cde
Signature[a]	5.7 oz	5.8 a	6.0 b	7.8 a	6.8 ab	8.3 ab	7.8 ab	6.5 ab	7.3 ab
H_3PO_4/KOH + Curalan	4.0 + 1.0	5.5 a	5.8 bc	6.5 bc	5.3 ef	5.5 d	5.3 c	5.0 e	4.5 g
H_3PO_3/KOH + Curalan	43.6 + 1.0	5.5 a	6.3 a	6.8 b	6.8 ab	7.8 bc	7.8 ab	6.5 ab	6.8 bcd
Alude + Curalan	7.4 + 1.0	5.5 a	5.8 bc	6.8 b	6.5 bc	7.5 bc	7.8 ab	6.0 bc	6.0 de
Aliette + Curalan	5.7 + 1.0	5.5 a	6.0 b	6.8 b	6.5 bc	8.3 ab	8.5 a	6.3 abc	7.0 abc
Signature + Curalan	5.7 + 1.0	5.8 a	6.8 a	7.8 a	7.3 a	9.3 a	8.5 a	6.8 a	7.8 a

[a] Dollar spot disease became problematic during late June in treatments that did not contain Curalan 50EG, thus Curalan 50EG (1.0 oz/1000 ft^2) was added to these treatments beginning with the 30 June application and throughout the remainder of the test.

[b] Turf quality ratings based on a 0-10 scale, 10 = excellent turf quality 0 = poor turf quality.

[c] Data means within the same column and followed by the same letter are not significantly different as determined by Fisher's Protected Least Significant Difference test at *P*=0.05.

Table 3. Treatments, rates, and quality ratings for the 2005 anthracnose phosphonate fungicide trial.

Treatment	Rate (oz/1000ft^2)	Turf Quality 5/4	5/17	5/31	6/15	6/28	7/13	7/29	8/10
		(0-10)[a]							
Control	----	6.0 a[b]	6.0 c	5.3 de	4.5 fg	5.3 e	4.5 j	4.5 d	4.3 g
Curalan	1.0 oz	6.0 a	6.3 bc	5.5 cd	5.0 def	5.8 cd	5.3 hi	5.3 d	4.5 g
H_3PO_4/KOH	4.0 oz	6.0 a	6.0 c	5.0 e	4.8 efg	5.8 cd	4.3 j	5.0 d	4.0 g
H_3PO_3/KOH	43.6 fl oz	6.0 a	6.0 c	5.3 de	5.0 def	6.0 bc	6.8 cde	7.0 bc	6.5 cdef
Alude	7.4 fl oz	6.0 a	6.0 c	5.8 bc	4.5 fg	6.0 bc	5.5 gh	6.5 c	5.8 f
Aliette	5.7 oz	6.0 a	6.0 c	5.5 cd	4.8 efg	5.5 de	6.8 cde	6.5 c	6.5 cdef
Chipco Signature	5.7 oz	6.0 a	7.0 a	6.8 a	6.0 ab	7.0 a	7.5 ab	7.3 abc	7.3 abc
H_3PO_4 + Curalan	4.0 + 1.0	6.0 a	6.3 bc	5.3 de	5.0 def	6.0 bc	4.8 ij	5.3 d	4.0 g
H_3PO_3 + Curalan	43.6 + 1.0	6.0 a	6.0 c	5.5 cd	5.0 def	6.0 bc	6.5 def	6.8 bc	6.0 ef
Alude + Curalan	7.4 + 1.0	6.0 a	6.0 c	6.0 b	5.5 bcd	6.0 bc	6.8 cde	6.8 bc	6.0 ef
Aliette + Curalan	5.7 + 1.0	6.0 a	6.3 bc	6.0 b	4.8 efg	5.8 cd	6.3 ef	6.8 bc	6.3 def
Signature + H_3PO_3	5.7 + 1.0	6.0 a	7.0 a	7.0 a	6.0 ab	7.0 a	6.8 cde	7.3 abc	7.5 ab
3336F	6.0 oz	6.0 a	6.0 c	5.8 bc	4.3 g	6.3 b	6.5 def	7.0 bc	5.8 f
3336F + H_3PO_3	6.0 + 43.6	6.0 a	6.0 c	5.8 bc	5.3 cde	6.3 b	7.5 ab	7.3 abc	6.8 bcde
3336F + Alude	6.0 + 7.4	6.0 a	6.0 c	6.0 b	4.3 g	6.0 bc	7.0 bcd	7.5 ab	6.8 bcde
3336F+Signature	6.0 + 5.7	6.0 a	7.0 a	7.0 a	5.8 bc	7.0 a	7.5 ab	8.0 a	8.0 a
3336F + Curalan	6.0 + 1.0	6.0 a	6.0 c	6.0 b	4.5 fg	6.0 bc	6.0 fg	6.5 c	6.0 ef
3336F + Curalan + H_3PO_3	6.0 + 1.0 + 43.6	6.0 a	6.3 bc	6.0 b	4.8 efg	6.0 bc	7.0 bcd	7.5 ab	7.0 bcd
3336F + Curalan + Alude	6.0+1.0+7.4	6.0 a	6.5 b	6.0 b	4.3 g	6.0 bc	7.3 bc	7.0 bc	7.0 bcd
3336F + Curalan + Signature	6.0+1.0+5.7	6.0 a	7.0 a	7.0 a	6.5 a	7.0 a	8.0 a	8.0 a	8.0 a

[a] Turf quality ratings based on a 0-10 scale, 10 = excellent turf quality 0 = poor turf quality.

[b] Data means within the same column and followed by the same letter are not significantly different as determined by Fisher's Protected Least Significant Difference test at *P*=0.05.

Fig. 1. Influence of Chipco Signature, Alude, and the untreated control on putting green turf quality during 2004. Vertical bars indicate the Fisher's protected LSD value at $P = 0.05$. Lack of vertical bars indicates no significant differences between two treatments were detected on that rating date.

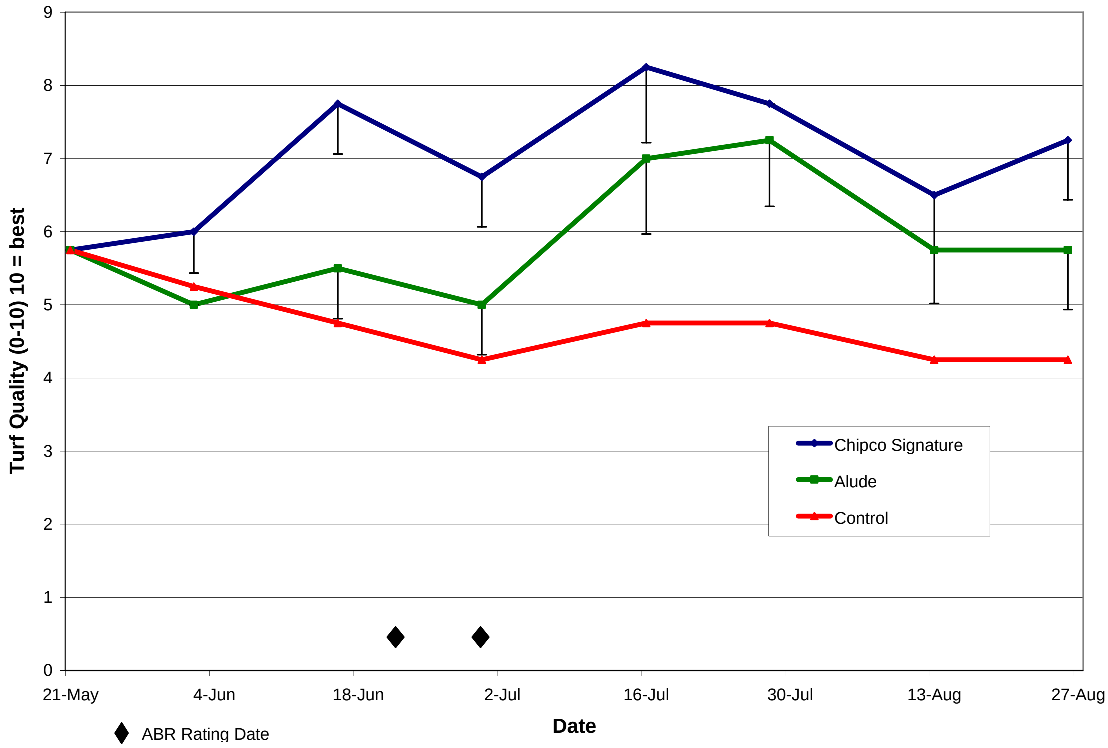


Fig. 2. Influence of the phosphorous acid/potassium hydroxide standard (H_3PO_3/KOH), Alude, and the untreated control on putting green turf quality during 2004. Vertical bars indicate the Fisher's protected LSD value at P = 0.05. Lack of vertical bars indicates no significant differences between two treatments were detected on that rating date.

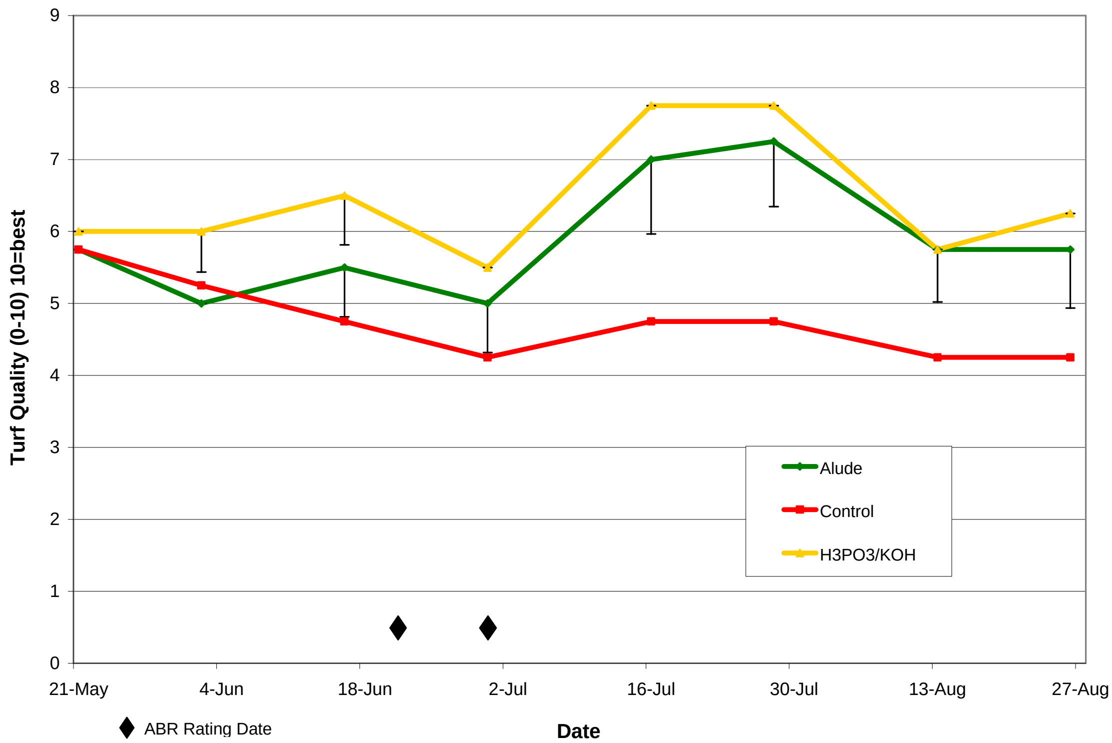


Fig. 3. Influence of the Chipco Signature, Aliette, and the untreated control on putting green turf quality during 2004. Vertical bars indicate the Fisher's protected LSD value at *P* = 0.05. Lack of vertical bars indicates no significant differences between two treatments were detected on that rating date.

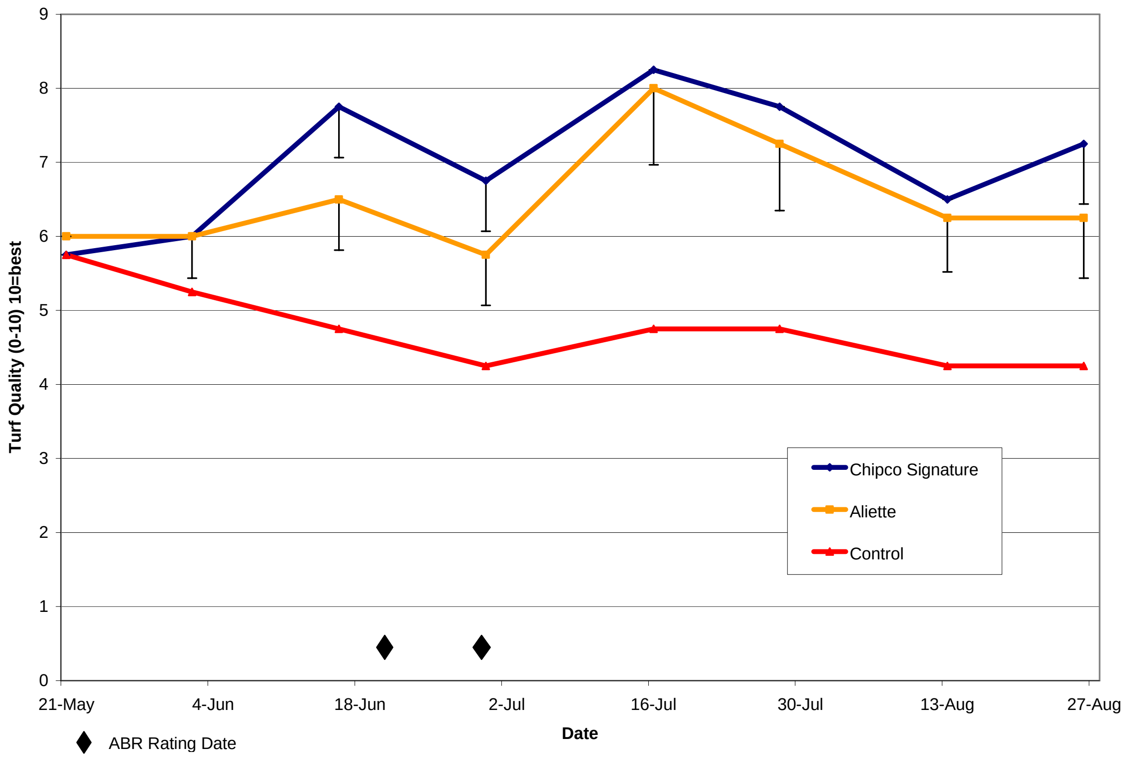


Fig. 4. Influence of Chipco Signature, Alude, and the untreated control on putting green turf quality during 2005. Vertical bars indicate the Fisher's protected LSD value at *P* = 0.05. Lack of vertical bars indicates no significant differences between two treatments were detected on that rating date.

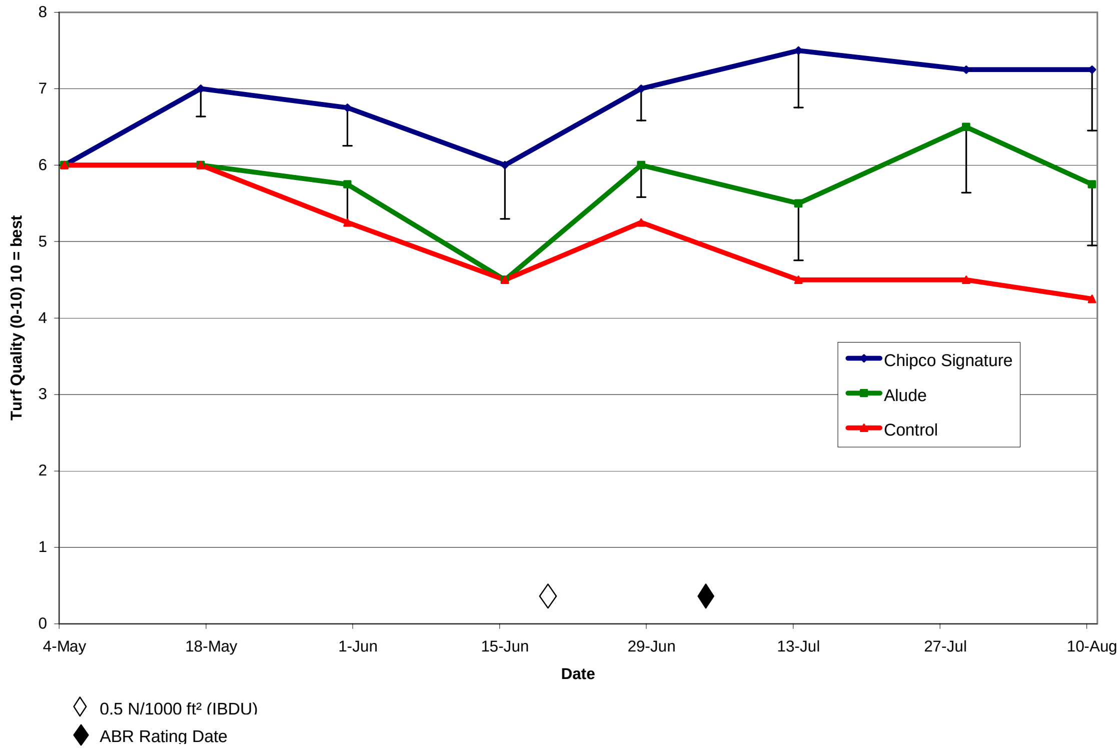


Fig. 5. Influence of the phosphorous acid/potassium hydroxide standard (H_3PO_3/KOH), Alude, and the untreated control on putting green turf quality during 2005. Vertical bars indicate the Fisher's protected LSD value at *P* = 0.05. Lack of vertical bars indicates no significant differences between two treatments were detected on that rating date.

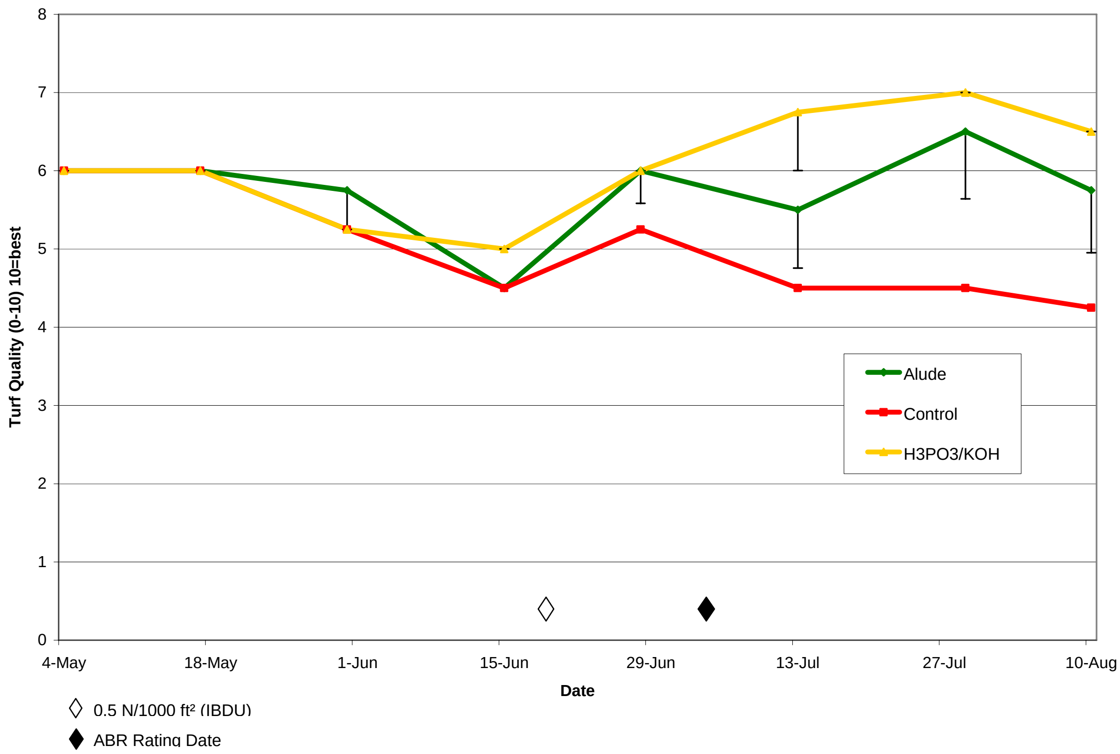
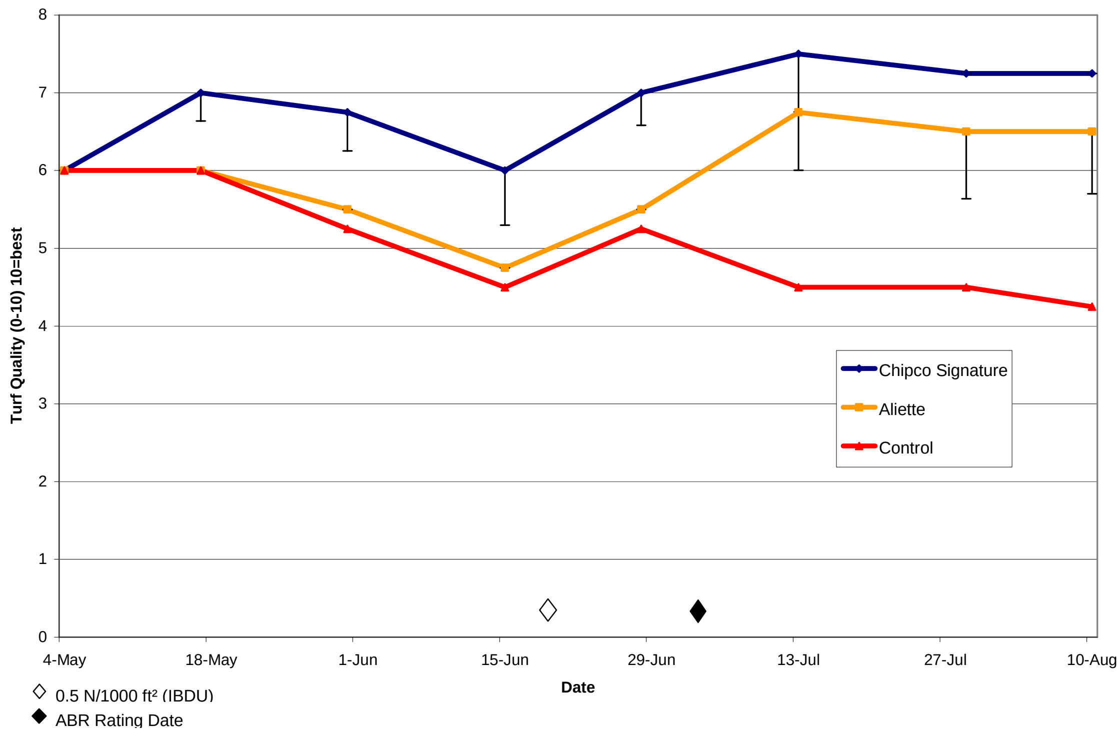


Fig. 6. Influence of Chipco Signature, Aliette, and the untreated control on putting green turf quality during 2005. Vertical bars indicate the Fisher's protected LSD value at P = 0.05. Lack of vertical bars indicates no significant differences between two treatments were detected on that rating date.



Evaluation of Phosphonate Fungicides for Control of Pythium Blight on Creeping Bentgrass and Perennial Ryegrass

Joshua Cook, Research Technician; Peter Landschoot, Professor of Turfgrass Science; and Maxim Schlossberg, Assistant Professor of Turfgrass Nutrition and Soil Fertility; Dept. of Crop and Soil Sciences, Pennsylvania State University

Introduction

Phosphonate fungicides are used by golf course managers to control Pythium diseases, suppress anthracnose basal rot, alleviate summer stress, and improve turf quality. In many areas of the northeast, phosphonate products are applied at regular intervals throughout the summer as part of a fairway and putting green management program. Currently, over a dozen phosphonate fungicides and fertilizers are available on the golf turf market. Although these products have similar active ingredients and modes of action, they differ in trade name, formulation, label terminology, uses, and price. Understanding the different phosphonate products and how they perform in the field should help superintendents decide which product is most suitable for their particular need.

The objective of this study was to determine if active ingredient and formulation of phosphonate fungicides [potassium phosphite (Alude) or fosetyl Al (Aliette and Chipco Signature)] provide similar control of Pythium blight when applied at equivalent rates of phosphorous acid, the active compound for controlling this disease.

Materials and Methods

This study was conducted at the Joseph Valentine Turfgrass Research Center, University Park, PA during 2004 and 2005. The soil at the test site is a Hagerstown silt loam with a pH of 6.8, 150 lb Mehlich-3 P/acre (75 ppm Mehlich-3 P), 0.54 meq K/100 g soil (210 ppm K), and a CEC of 13.4 meq/100 g soil. The turfgrasses used in this study were ‘Integra’ perennial ryegrass and ‘Penncross’ creeping bentgrass. Both species were established on the test site from seed (4.0 lb perennial ryegrass seed/1000 ft^2 and 1.0 lb creeping bentgrass seed/1000 ft^2) during Sep, 2003 and in Sep, 2004. The turf was mowed at 1.0 inch every other day with a rotary mower (clippings returned), and fertilized twice per year (spring and summer) with 1.0 lb N as IBDU/1000 ft^2 per application.

Prior to treatment application in 2004 and 2005, a 30 ft by 48 ft chamber constructed of an aluminum frame and covered with clear polyethylene plastic was placed over the test site (Fig. 1). An automatic misting system designed to increase humidity and cool the turf was suspended from the chamber frame. After treatments were applied, the two open ends of the chamber were sealed with preassembled wooded frames covered with clear polyethylene plastic. Each end was equipped with a hinged window that could be opened or closed to facilitate heating or cooling. Two electric heaters equipped with fans and thermostats were placed on either side of the chamber to aid in heating when nighttime temperatures dropped below 60^{o}F.

Fig. 1. Pythium chamber with plastic-covered wooden frames sealing the ends of the chamber.

Treatments included commercial formulations of three phosphonate fungicides; Alude (Cleary Chemical Corp., Dayton, NJ), Aliette (Bayer Environmental Science, Montvale, NJ), and Chipco Signature (Bayer Environmental Science, Montvale, NJ); a 1.0 M solution of reagent-grade phosphorous acid (H_3PO_3) adjusted to a pH of 6.2 with 10.0 M potassium hydroxide (KOH); a solution of reagent-grade phosphoric acid (H_3PO_4) adjusted to a pH of 6.2 with 10.0 M potassium hydroxide; Subdue MAXX, a commercial formulation of mefenoxam (Syngenta Crop Protection, Inc., Greensboro, NC); and an untreated control. All phosphonate fungicides and the reagent-grade phosphorous acid/potassium hydroxide treatment were applied at equivalent amounts of phosphorous acid (based on the phosphorous acid equivalent listed on the Alude label and according to the chemical formula and amount of fosetyl Al listed on the Aliette and Chipco Signature labels). The rate of phosphorous acid used in this study was based on the intermediate product rate (7.4 fl oz/1000 ft^2) listed on the Alude label for Pythium diseases. The rates of product and phosphorous acid for all phosphonate treatments are provided in Table 1. The rates of the reagent-grade phosphoric acid/potassium hydroxide treatment and Subdue MAXX are also listed in Table 1.

The experimental design was a split block design with fungicide treatments serving as whole plots and grass species as sub plots. Each treatment was replicated four times. The whole plots were 3 ft by 8 ft and sub plots were 3 ft by 4 ft.

Prior to inoculation and treatment application, 3336 F (thiophanate methyl, Cleary Chemical Corp., Dayton, NJ) was sprayed at 4 fl oz/1000 ft^2 to prevent brown patch and dollar spot. Previous studies have shown that benzimidazole fungicides suppress brown patch and dollar spot and sometimes enhance Pythium blight development.

Treatments were applied on 30 Aug, 2004 and 18 July, 2005 with a CO_2-powered backpack sprayer equipped with a single boom and 11008E nozzle. Applications were made at 40 psi with a dilution rate equivalent to 2 gal water/1000 ft^2. On 31 Aug, 2004 and 19 July, 2005, the open ends of the chamber were sealed with the plastic-covered end frames. The entire test area was inoculated on 1 Sep, 2004 and 20 July, 2005 with 36 qt of a mycelia and rye grain slurry made from a five-isolate pool (P-3, P-20, P-38, P-40, and P-41) of *Pythium aphanidermatum*. The slurry was distributed over the test area by hand using a jar with a perforated lid. To insure uniform coverage, four passes were made over the entire test area in different directions.

Immediately following inoculation, the misting system was activated for approximately five minutes and the chamber was sealed to maintain high temperatures and humidity. The misting system was activated periodically during the test period to cool turf and increase humidity. Test plots were not mowed between the day of treatment application and disease assessment (12 d).

Disease assessments were made on both grass species on 10 Sep, 2004 (10 d after inoculation and 12 d after treatments were applied) and 29 July, 2005 (9 d after inoculation and 11 d after treatments were applied). Visual assessments were based on the percentage of plot area showing Pythium blight symptoms (% blighting). Data were subjected to analysis of variance and means were separated using Fisher's Protected Least Significant Difference Test at the 0.05 level of significance.

Table 1. Treatments and rates used in the Pythium blight phosphonate fungicide study in 2004 and 2005.

Treatment	Rate/1000 ft^2	H_3PO_3 equivalent/1000 ft^2
Control	----	---
H_3PO_4/KOH solution	4.0 oz	---
H_3PO_3/KOH solution	43.6 fl oz	89.4 g
Alude	7.4 fl oz	89.4 g
Aliette	5.7 oz	89.4 g
Chipco Signature	5.7 oz	89.4 g
Subdue MAXX	1.0 fl oz	----

Results

Results for 2004: Analysis of variance of 2004 percent blighting data indicates that the main effects of turf species and fungicide treatment were significant ($P \leq 0.01$) (Table 2). Disease symptoms (expressed as percent blighting) were more severe on perennial ryegrass than creeping bentgrass and fungicides provided better control of Pythium blight on creeping bentgrass than on perennial ryegrass (Fig. 2 & 3). All fungicide treatments (including the reagent grade phosphorous acid/potassium hydroxide solution) provided good control (> 89%) of Pythium blight on creeping bentgrass and perennial ryegrass relative to the untreated control. The phosphoric acid/potassium hydroxide treatment did not differ in percent blighting from the untreated control on either species, indicating that plant-available phosphorus and potassium were not responsible for disease inhibition.

On creeping bentgrass, no differences in percent blighting were detected among any of the fungicides used in this test (Fig. 2). However, on perennial ryegrass, Subdue MAXX provided better control of Pythium blight than the phosphorous acid/potassium hydroxide treatment and Alude; but was not different from the Aliette and Chipco Signature treatments (Fig. 3). No differences in percent blighting were detected among any of the phosphonate treatments on either turfgrass species in 2004, regardless of active ingredient or formulation.

A significant treatment by species interaction ($P \leq 0.001$) indicates that differences in blighting occurred between perennial ryegrass and creeping bentgrass in the untreated control and phosphoric acid/potassium hydroxide treatment; whereas no differences in percent blighting occurred between the two species when treated with any phosphonate treatment or Subdue MAXX (Table 2).

Results for 2005: Analysis of variance of 2005 data show that the main effect of turf species was not significant, but the main effect of fungicide treatment was significant at $P \leq 0.001$ (Table 2). In contrast to 2004, percent blighting in 2005 was similar on both species (Fig. 4 & 5). All fungicide treatments (including the reagent grade phosphorous acid/potassium hydroxide treatment) provided better control of Pythium blight than the untreated control and phosphoric acid/potassium hydroxide treatment on creeping bentgrass and perennial ryegrass. Although Pythium blight control with the phosphonate fungicide treatments was not as pronounced in 2005 as in 2004, no differences in percent blighting occurred among these fungicides (regardless of active ingredient or formulation) on either turfgrass species.

On creeping bentgrass, Subdue MAXX provided better control of Pythium blight than the Alude treatment, but was not different from the Aliette, Chipco Signature, and phosphorous acid/potassium hydroxide treatments (Fig. 4). On perennial ryegrass, Subdue MAXX provided better control of Pythium blight that all other treatments (Fig. 5).

A significant treatment by species interaction ($P \leq 0.05$) indicates some differences in efficacy occurred among fungicide treatments on the two grass species (Table 2). Whereas no differences in percent blighting were detected between perennial ryegrass and creeping bentgrass for the untreated control, phosphoric acid/potassium hydroxide, Alude, and Subdue treatments; blighting was more severe in perennial ryegrass than creeping bentgrass in the Aliette, Chipco Signature, and phosphorous acid/potassium hydroxide treatments.

Conclusions

Results of this study showed that when phosphonate fungicides with different active ingredients and formulations [potassium phosphite (Alude and the phosphorous acid/potassium hydroxide treatment) and fosetyl Al (Aliette and Chipco Signature)] were applied at the same rate of phosphorous acid, no differences in Pythium blight control occurred among these products.

Differences in the degree of *overall* Pythium blight control between 2004 and 2005 was detected with the phosphonate fungicides, with much better control occurring in 2004. Differences between years may be explained by variation in the temperature and humidity levels inside of the chamber between the 2004 and 2005 test periods. Previous studies by Nutter and associates in Pennsylvania found that Pythium blight was more likely to occur when the maximum daily temperature was greater than 86°F, followed by at least 14 hours of relative humidity greater than 90%, and the minimum nighttime temperature was 68°F. In 2004, there were only 57 hours with temperatures over 86°F and 59 hours under 68°F inside of the chamber; whereas in 2005, there were 75 hours over 86°F and only 42 hours under 68°F in the chamber. This suggests that conditions in 2005 were more conducive for Pythium blight development than in 2004, and may explain the breakdown in control during 2005.

The Pythium chamber described in this report provides a severe test of fungicide performance. The chamber was used to sustain temperatures and humidity levels that would ensure maximum sustained disease development over a short period. Such conditions are unlikely to occur in Pennsylvania; thus, we believe that these data are more meaningful for comparing fungicide performance under extreme disease-conducive conditions than predicting the overall level of disease control in the field.

Table 2. Analysis of variance of % blighting data as influenced by fungicide treatments and turfgrass species.

Source	df	Mean squares of % blighting of turf 2004	2005
Replication (R)	3	223.06 ^{NS}	115.35^{NS}
Species (S)	1	4305.02 **	2046.11^{NS}
R x S	3	104.73 ^{NS}	275.49^{NS}
Treatment (T)	6	9903.82 ***	8632.25***
T x S	6	796.06 ***	484.03*
Error	18	82.82	141.10
Corrected total	55	-----	-----

^{NS} = Non-significant; * = significant at $P \leq 0.05$; ** = significant at $P \leq 0.01$; *** = significant at $P \leq 0.001$

Fig. 1. Alude-treated perennial ryegrass plots compared with Chipco Signature plots and the untreated control.

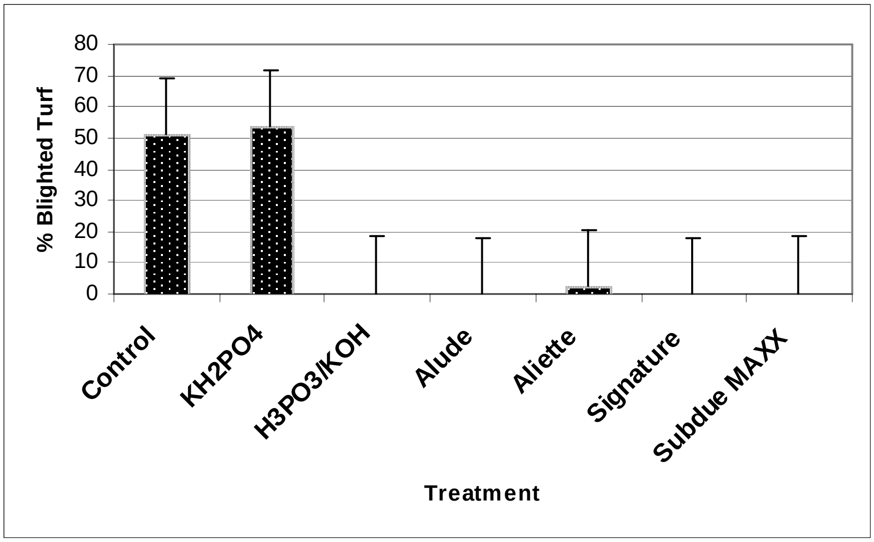


Fig. 2. Effect of phosphonate fungicides on Pythium blight development of ‘Penncross’ creeping bentgrass in 2004, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 18.0)

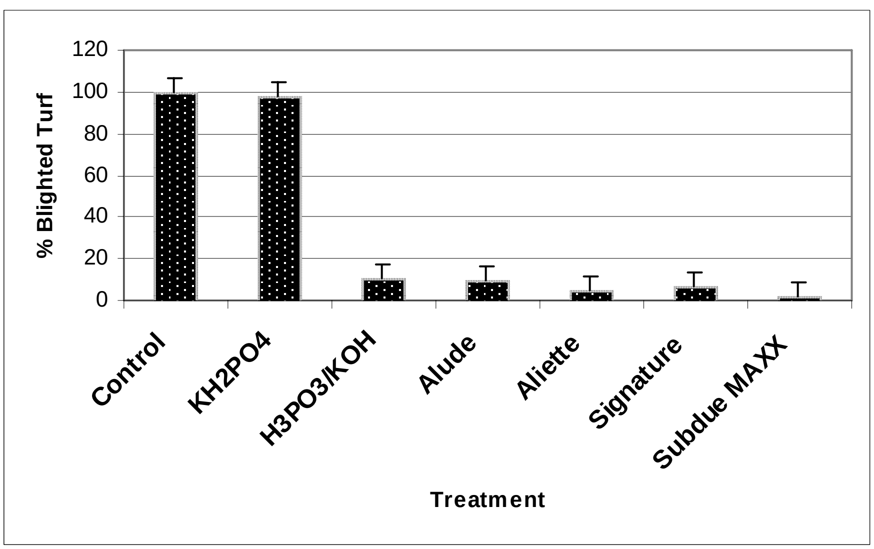


Fig. 3. Effect of phosphonate fungicides on Pythium blight development on ‘Integra’ perennial ryegrass in 2004, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 6.9)

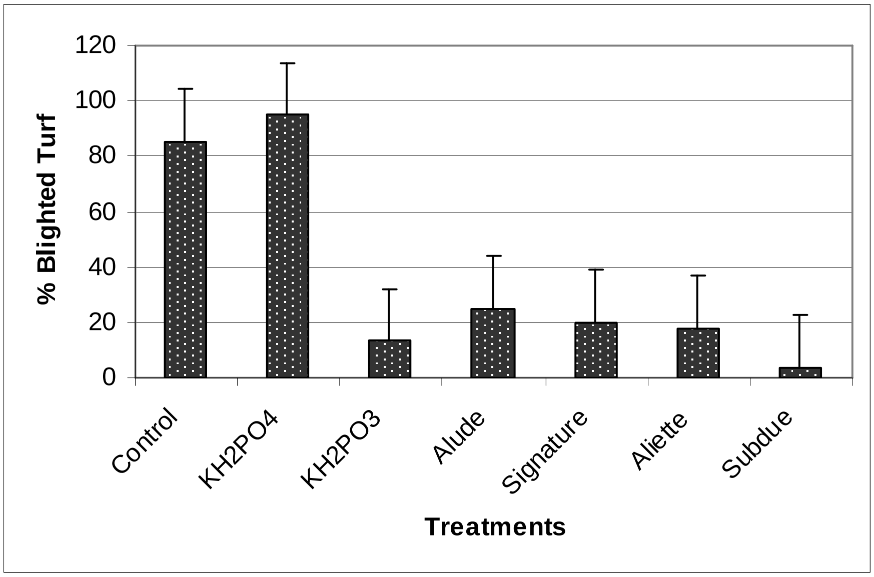


Fig. 4. Effect of phosphonate fungicides on Pythium blight development of 'Penncross' creeping bentgrass in 2005, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 18.6)

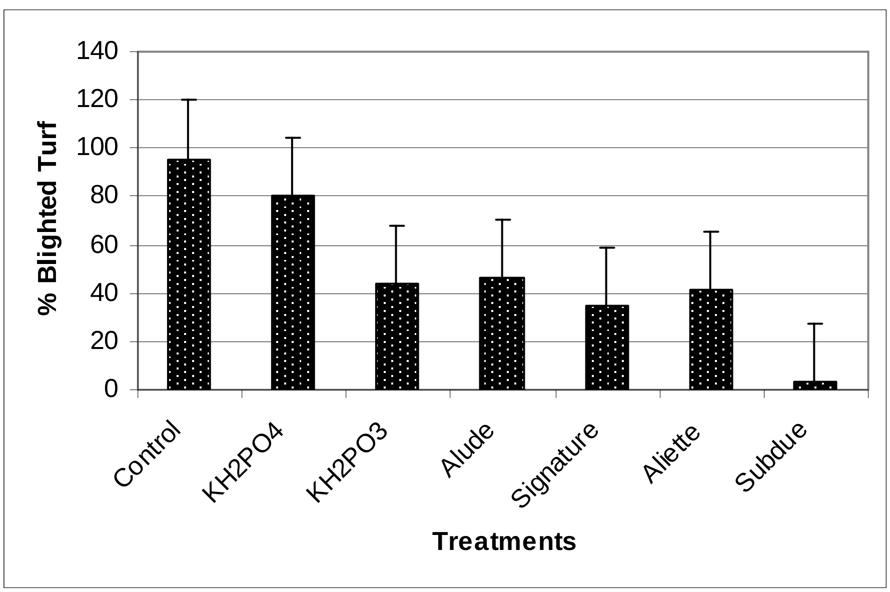


Fig. 5. Effect of phosphonate fungicides on Pythium blight development on 'Integra' perennial ryegrass in 2005, expressed as % blighted turf. Bars above columns indicate LSD at 0.05 level of significance (LSD = 24.2)

Cultivar Development and Extreme Temperature Tolerance of Greens-type *Poa annua*

David R. Huff, Roy Knupp, Ambika Chandra, Jing Dai and Jon LaMantia, Dept of Crop and Soil Sciences, 116 Agric. Sci. and Industry (ASI) Bldg, Pennsylvania State University, University Park, PA 16802.

<u>Objectives</u>:

1. Collect, select, breed, and develop genetically-stable and phenotypically-uniform cultivars of greens-type *Poa annua* for commercial production.

2. Develop techniques to screen large numbers of progenies and germplasm accessions for tolerance to extreme temperature.

3. Identify molecular markers associated with genetic loci (genes) controlling agronomically-important traits and specific stress tolerances in order to aid in the breeding and development of improved cultivars of greens-type *Poa annua*.

<u>Summary</u>:

Poa annua L. has been part of the game of golf for over 130 years, however despite repeated attempts to breed improved strains, currently there are no commercial sources available of high quality greens-type *Poa annua*. The purpose of this research is not to replace creeping bentgrass as a putting surface but rather to offer an alternative grass to those golf courses where *Poa annua* L. is simply a better choice. One of the main problems with *Poa annua* greens is that it normally takes a long period of time to evolve strains of high quality, defined here as those strains with high shoot density and a range of stress tolerances. In addition, a patch-work of different strains normal results in a non-uniform putting surface due to differences among the strains in texture, seed head production, and vertical leaf extension rates after mowing. Differences in pest and environmental stress tolerance among the various strains also complicate the management of such a diverse population of plants. The main focus of this project is to develop commercial seed sources of uniform and stable cultivars of greens-type *Poa annua*. Such products would allow superintendents and architects an opportunity to utilize *Poa annua* putting surfaces rather than having to wait out the natural evolution of greens-types from the wild and weedy invasive annuals. Major progress in 2005 included initiating genetic analysis of mapping populations, discovery of salinity tolerance in *Poa annua*, improved genetic purity of seed production, and establishing several collaborative greens-type *Poa annua* research projects.

2005 REPORT

<u>Greens-type *Poa annua* evaluation trials</u>: In 2005, we began the process of renovating and constructing new research putting greens at the Joseph Valentine Research Facility. These plots are expected to be completed and established with plots for quality and stress tolerance evaluation by Summer 2006. Currently, we have the 2002 Landscape Management Research Center (LMRC) putting green trial that remains ongoing, as well as, we transplanted the 2001 trial into our newly acquired greenhouse at the LMRC. This greenhouse-sodded Poa is being grown on a sand-based root zone and maintained at an 1/8 inch (3.2mm) mowing height. The greenhouse-sod has will provide us with fresh

plant material, maintained at a greens height of cut, throughout the winter months for testing and evaluation purposes; including, salinity tolerance testing (NaCl), various disease inoculations, and tolerance to winter damage (Hardened vs. non-hardened comparisons).

Collaborative studies:
Collaborative studies continue with:

- Dr. Sowmya-Mitra, Cal-Poly – Ponoma, on management of Poa greens.
- Dr. Yves Castonguay, AG-Canada, Laval University on winter damage of Poa greens.
- Dr. David Aldous, University of Melbourne, Australia and Mr. John Neylan, Australian Golf Course Superintendent's Association, salinity tolerance and management of Poa greens.

In 2005, the breeding program began supplying necessary germplasm required for the following new collaborative studies:

- Dr. Trygve Aamlid, The Norwegian Crop Research Institute, in the areas of Pink Snow Mold (*Microdocium nivale*) tolerance and winter hardiness.
- The "new" NE Regional Project. This new multi-year, multi-state, multi-university Northeast Regional project is being focused on the influence on management practices on 1.) the development of Anthracnose disease on *Poa annua* and 2.) feeding of Annual Bluegrass Weevil, *Listronotus maculicollis* (formerly known as 'Hyperodes weevil') on *Poa annua*.
- Dr. Scott Warnke, USDA-ARS, Beltsville, MD. Together we are performing genetic analysis of the *Poa annua* genome in relation to potential fitness differences among between genotypes on the putting green.

Collaborative trials and On-site testing:

Continuing collaborations for turf quality evaluations include Dr. David Green, Cal Poly-San Luis Obispo; Dr. Gwen Stahnke, Washington State Univ.; Dr. David Aldous, University of Melbourne, Australia; Mr. John Neylan, Australian Golf Course Superintendent's Association; Dr. Frank Rossi, Cornell Univ.; and, Dr. Jim Murphy, Rutgers University.

Demand for seed of our greens-type Poa cultuivars, for on-site testing at golf courses and evaluation plots at Universities, continues to exceed our capacity to produce. Every year we continue to miss opportunities for establishing plots, across the USA and abroad, due to a lack of seed.

2005 Seed Harvest:

We are continuing our efforts to ensure the genetic purity of the greens-type *Poa annua* lines that are cultivated in the project. This effort, initiated in 2004, will begin to pay dividends for the 2005 seed harvest by providing genetically pure seed.

The 2005 seed harvest is still in the process of being cleaned. However, we predict that enough seed was produced this year to supply the ongoing collaborative research projects and the three new collaborative projects with seed for testing and evaluation purposes. This year we also shipped small samples of 2004 seed, we believed to be genetically pure, to the seed company DLF International in Oregon for evaluating commercial production potential of our best experimental cultivars. In the future, we will begin to rely more heavily on our collaborative seed-producing partner, DLF, to produce the quantity and quality of seed necessary to satisfy the demand of research and evaluator interests.

Space-plant Nurseries:

In 2005, we began the process of moving our space-plant nursery from its former location to the Landscape Management Research Center at University Park campus where we currently have nine acres of irrigated space-plant nursery. We expect to increase this area to a total of 12 acres over the next several years.

Germplasm collections:

We currently maintain a world's collection of greens-type *Poa annua* which forms the basis of the breeding program as germplam for performing crosses and other associated genetic analyses. Even so, we are constantly collecting additional germplasms on a continual basis. A proposal was submitted in 2005 to the National Forage and Turfgrass Crop Germplasm Committee for a European Poa germplasm collection trip. By all accounts, the funding of this 2006 collection trip seems likely. This proposal is in collaboration with Dr. R.C. Johnson, USDA-ARS, Washington State University, for the purpose of collecting species of Poa closely related to *Poa annua*. Such germplasm simply does not exist within the nation's Plant Germplasm Introduction System and will be a valuable source of material for genetic analyses of the *Poa annua* genome.

Genetic research:

Studying *Poa annua*'s evolutionary history as a species and it's evolution of greens-types will greatly enhance our knowledge and ability to manipulate the species through traditional breeding efforts. With a world's collection in place, we have begun to study its genetic variability, higher and lower states of polyploidy, and gene function and regulation of biotic and abiotic stress tolerance. Mr. Jonathan LaMantia (PhD, Ecol.& Mol. Plant Phys. program) is the graduate student who has been brought on board to investigate and perform in this genetic research arena. Jon is using a combination of molecular techniques (genetic markers and flow cytometry) to further our understanding of the genetics underlying greens-type *P. annua* evolution.

Mapping populations, a necessary tool for our genetic analyses, have been constructed for the traits of annual and perennial life histories and for two diseases, Anthracnose and Dollarspot. Analysis of the mapping populations created in 2004 has commenced and has become part of the collaborative research work with Dr. Scott Warnke.

Environmental Stress Tolerance: Mr. Jon LaMantia and Ms. Jing Dai (MS, Agronomy), are currently evaluating our germplasm and mapping populations for salt tolerance and disease resistance (Anthracnose and Dollar Spot).

Evaluation of Playing Surface Characteristics
of Various In-Filled Systems

Andrew S. McNitt, The Pennsylvania State University
Dianne Petrunak, The Pennsylvania State University

Note: First-time visitors to this site may want to start by reading "Summary and Considerations". Detailed information about a particular topic can then be found in the "Table of Contents".

Table of Contents

INTRODUCTION

Since synthetic turf was first installed in the Houston Astrodome in 1966, numerous studies have been conducted to evaluate the safety and playability of synthetic surfaces. These studies have included material tests on the traction and hardness of these surfaces (Valiant, 1990; Martin, 1990), human subject tests where an athlete performs various maneuvers on the surface (Cole et al., 1995; Nigg, 1997; Nigg and Segesser, 1988), and epidemiological studies that have counted athlete injuries on synthetic versus natural turfgrass (Powell and Schootman, 1992; Powell and Schootman, 1993).

Various methods have been developed to measure the playing surface quality of sports surfaces. For example, different methods of measuring playing surface hardness have been developed for synthetic turf versus natural turfgrass surfaces. For synthetic turf surfaces the U.S.A. standard is the F355 method (American Society for Testing and Materials, 2000a). For natural turfgrass the standard method is the Clegg Impact Soil Tester (CIST) (American Society for Testing and Materials, 2000b). Although both methods determine hardness by dropping a weighted accelerometer on the turf surface, some have stated that these two methods should not be correlated (Popke, 2002).

A new configuration of synthetic turf has been introduced into the market place. Termed 'infill' systems, these synthetic surfaces are comprised of a horizontal backing supporting numerous vertical nylon, polypropylene, or polyethylene fibers. These vertical fibers (pile) are much longer than those of traditional synthetic turf and can be filled with varying types of granulated material (infill media), typically sand or crumb rubber. It is believed that these new infill systems provide athletes with a surface that performs more like natural turfgrass than traditional synthetic turf (Popke, 2002).

As more synthetic turf systems using infill are introduced into the sports surface market, independent data regarding playing surface quality are required to enable consumers to make informed decisions.

Athlete Performance and Safety

For a brief review of Athlete Performance and Safety of Infilled Synthetic Turf Systems follow this link.

Objectives

This study was designed to evaluate the playing surface quality of various infill systems over time. Surface quality will be periodically evaluated as the systems are exposed to weather and simulated foot traffic. The effects of various maintenance practices on the playing surface quality of these systems will also be evaluated.

Next Page

A Method to Estimate the Percentage of Calcined Clay in a Baseball Infield Mix

J.T. Brosnan and A.S. McNitt

Introduction

Baseball infield mixes are often amended with inorganic materials such as calcined clay due to their ability to increase the moisture retention and porosity of a soil profile. Some field managers also use calcined clay for aesthetic reasons. During athletic field construction, rootzone mixes are often amended with similar inorganic amendments to increase both the total and capillary porosity of the rootzone (Bigelow et. al, 2004). Amendments can be incorporated into a soil with a high level of precision prior to construction. However, there is no method to measure the amount of inorganic amendment in a soil mix after it has been installed in the field.

Objective

Develop a method to estimate the percentage of calcined clay in a baseball infield mix.

Materials and Methods

Twenty one different baseball infield mixes were constructed for this project. Diamond Tex Professional infield mix (Diamond-Tex, Inc., Honeybrook, PA 19334) served as the principal component for all the mixes. Soil textural analysis according to the methods of ASTM 1632 (ASTM, 2005) indicated that Diamond Tex Professional infield mix measured approximately 50-60% sand, 25-35% silt, and 10-25% clay. Calcined clay (heat treated, 865°C, illite clay, 74% SiO_2, Profile Products Corp., Buffalo Grove, IL) was blended into the Diamond Tex Professional infield mix at twenty one different rates, ranging from 0% (v/v) to 100% (v/v) in increments of 5%. Thus, creating twenty one different baseball infield mixes.

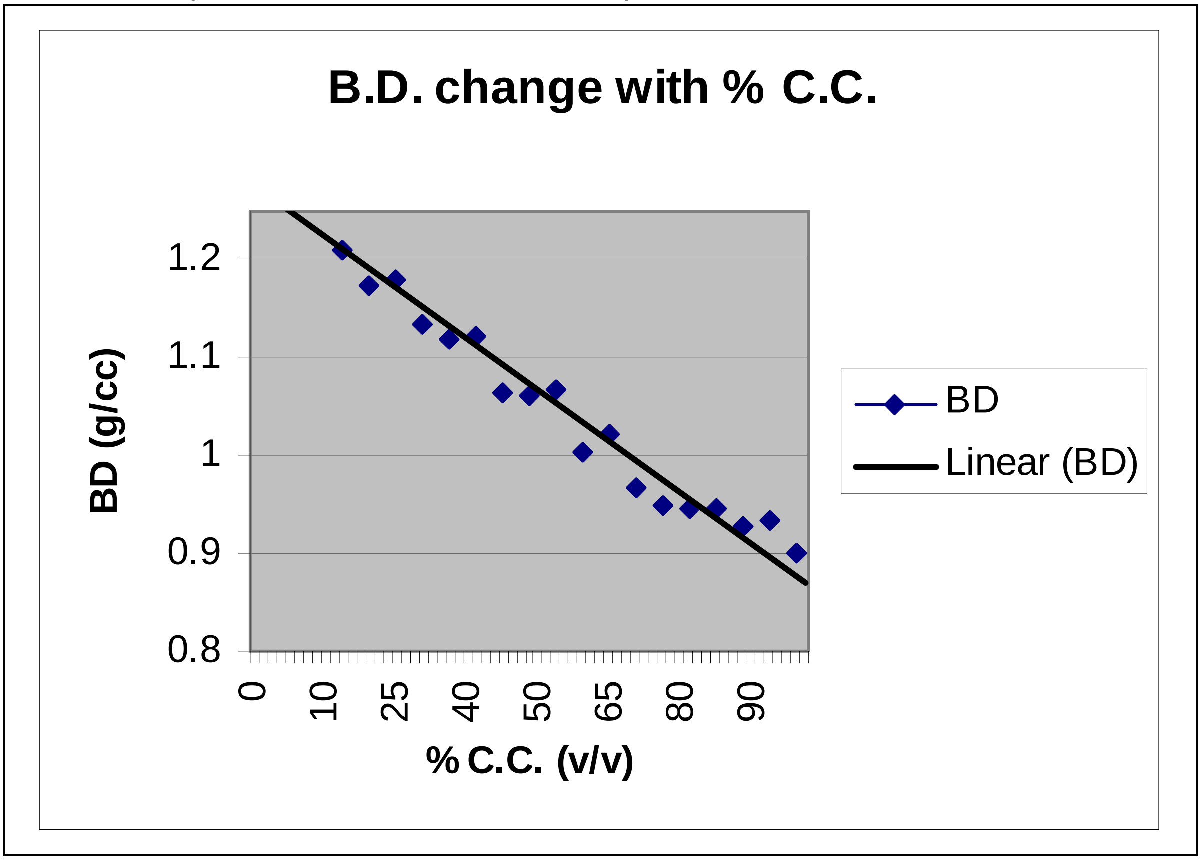
Three sub-samples of each Diamond Tex – calcined clay infield mix were measured for loose bulk density in a graduated cylinder. The mean bulk density for the three sub-samples was then plotted (Figure 1). This created a scale which measured the change in bulk density that corresponded with increasing calcined clay content.

Results

The relationship between loose bulk density and calcined clay content was significant ($p < 0.001$). A regression equation was developed to estimate the percentage of calcined clay in a baseball infield mix using measurements of loose bulk density. That equation can be seen below. The R^2 value for this equation was 0.9754

$$\%\ \text{Calcined Clay} = 315.43 - 247.52 \times \text{Loose Bulk Density}$$

Figure 1: Linear relationship between loose bulk density and the percentage of calcined clay in baseball infield mixes comprised of Diamond-Tex Professional



Conclusion

A method was developed to estimate the percentage of calcined clay in a baseball infield mix. Measuring the loose bulk density of a sample in a graduated cylinder and using the regression equation, one can estimate of the percentage of calcined clay present in the sample. The relationship between loose bulk density and calcined clay content was linear, with bulk density decreasing with increased calcined clay content. Previous research supports this relationship (Bigelow et. al, 2005)

The regression equation is not applicable to soils containing very low percentages of calcined clay, as it will generate negative values. This may be due to the fact that only one soil was used as the principal component for each mix. Additional research is needed using more soils and different amendments in order to develop a more accurate model for estimating the percentage of calcined clay in a baseball infield mix.

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Developing an Apparatus to Evaluate the Pace of Baseball Field Playing Surfaces

J.T. Brosnan, A.S. McNitt and D.W. Livingston

Introduction

Baseball is popular sport in the United States played by numerous individuals. During a baseball game, the ball will strike the playing surface at a variety of speeds and angles. The speed at which the ball is moving after impact with the playing surface can be referred to as the pace of the surface. Wide variations in pace can reduce the safety and playability of baseball field surfaces.

Baseball playing surface pace has rarely been measured directly. Baseball playing surface pace has been indirectly evaluated through measurements of vertical ball rebound and ball to surface friction (Baker and Canaway, 1993; Goodall et al, 2005). Surface pace has been characterized qualitatively by asking players to rate surfaces as having a "fast" pace or a "slow" pace (Bell et. al, 1985).

Playing surface pace has been measured directly in sports such as tennis and cricket (Thorpe and Canaway, 1986b; Baker et. al 1998). Pace has been quantified by measuring the coefficient of restitution. The coefficient of restitution is defined as the ratio of two velocities; the velocity of a ball after impact with the surface divided by the velocity of the ball prior to impact (ASTM, 2005). No data of this nature has been collected on baseball field playing surfaces.

Objective

The principle objective of this project was to develop an apparatus to accurately measure the pace of different baseball field playing surfaces.

Materials and Methods

Machine Development

PENNBOUNCE is comprised of four ballistic screens (Model M-57, Oehler Research, Austin TX 78766) and an air cannon (Model # Storm 300, Air Cannon Inc., Denver, CO 80202) used to propel baseballs towards the playing surface. The inside diameter of the cannon is 74-mm, as it was designed specifically for the purpose of propelling baseballs. It is powered with compressed CO_2, and the pressure can be adjusted from 345 to 2760 kPa with the use of a high pressure regulator. Preliminary calibration determined that 2070 kPa generated a ball velocity of approximately 40.2 m s^{-1} (90 mph), while 896 kPa generated a ball velocity of approximately 31.0 m s^{-1} (70 mph).

A single screen stands 914-mm tall and 457-mm wide, with a testing area of 609-mm by 406-mm. Each screen contains a circuit board that houses a line 72 infrared emitting diodes. The screen is equipped with visible red diodes that indicate that the apparatus is functioning properly. Screens are powered using 120 volt AC power supplied using a standard 12 volt automobile battery (Type 31T190, New Castle Battery Mfg, New Castle, PA 16105) and a power inverter (Model# VECO34, Vector Inc., Ft. Lauderdale, FL 33312).

While in use, the 72 infrared emitting diodes create a plane of infrared light. When a baseball is propelled through the screen, the plane of infrared light is broken. This sends a nominal +12 volt pulse to a 35 x 2 chronograph (Oehler Research, Austin, TX 78766) mounted above the screen. If two screens are placed a set distance apart from one another (in the same plane), the ball will break both planes of light and two pulses will be sent to the chronograph. The chronograph then measures the time between these pulses (the time required to break both planes of light) in order to determine the velocity at which the ball is moving. PENNBOUNCE uses four ballistic screens in an arrangement such that one pair calculates the velocity of the ball prior to impacting the playing surface and the second calculates the velocity of the ball after contacting the playing surface (Figure 1).

Figure 1: PENNBOUNCE measuring the pace of a skinned (grass-free) infield surface

Two boxes, 965-mm high and 470-mm inches wide, were constructed to hold each pair of screens, with each screen bolted to the inside of the box. One box is equipped with a holster for the air cannon. This holster is comprised of a 216-mm long piece of 76.2-mm diameter pipe in which the cannon rests. This pipe is fastened to a metal sled piece with four 305-mm long pieces of angle iron. Channels are cut into this sled piece that allow for the cannon to move freely along the outside of the box frame, as the impact angle is changed.

These boxes are placed into a frame made of 3.17-mm thick angle iron. The frame measures 2388-mm long and 483-mm wide. This frame also houses the battery as well as a 30 liter CO_2 tank. While in the frame, the boxes are hitched in two places allowing them to move either closer or further away from the testing surface. This feature allows for evaluations of playing surface pace to be made at angles of inclination of 0.26, 0.44, 0.61 radians (15, 25, and 35 degrees).

The frame is also equipped with four wheels, 254-mm in diameter. The rear wheels are fastened to 864-mm long arms that are pinned to the frame during transport, thus lifting the frame approximately 102-mm off the surface. During testing the pins are removed, and the frame rests on the surface.

A steel plate (533 x 244-mm) extends from the front of the base frame. This plate is fastened to the frame using a hitch that allows it to rise and lower freely. The front wheels are attached to a 1118-mm long axel that is connected to this steel plate. The plate is equipped with a friction bearing and grease fittings that allow the machine to turn easily. While in transport, two metal bars (311-mm long and 19-mm in diameter) located on the outside edge of the frame restrict the vertical movement of the steel plate. The frame is switched from a transport position to a testing position by pushing down on the 978-mm long handle attached to the steel plate. This lifts the weight of the frame off the steel bars, which can then be slid back allowing the machine to be lowered to the testing surface.

A roller, 584-mm in length and 51-mm in diameter, is attached to the rear of the frame to allow for it to be moved to different testing locations without having to raise the frame back into the transport position. The roller also prevents the edge of the frame from cutting into the testing surface. A batting cage net (Jugs Inc., Tualatin, OR 97062) is also attached to the rear of the frame. The net is attached to a 1029-mm by 521-mm aluminum frame that fastens to the angle iron base frame.

Experimental Design

A study was conducted in April 2005 to determine the efficacy of PENNBOUNCE in determining the pace of different playing surfaces. Two synthetic surfaces, Astroturf (SRI Sports, Dalton, GA 37021) and Fieldturf (FTOS1-F, Dalton, GA 30721), were evaluated at the Joseph Valentine Turfgrass Research Center, University Park, PA. Natural turfgrass and skinned (grass-free) soil surfaces were tested at Beaver Baseball Field, University Park, PA. Surface pace was quantified by measuring the coefficient of restitution of baseballs propelled at the surface at angles of 0.44 and 0.61 radians of inclination and at velocities of 31.0 m s^{-1} and 40.2 m s^{-1} (70 and 90 mph). Replications were randomly assigned within each playing surface type. Six evaluations were made at each angle-velocity combination within each replication

Results and Discussion

Significant differences in pace were associated with playing surface type (Table 1). Skinned infield soil surfaces exhibited the highest coefficient of restitution, 0.598, while natural turfgrass systems exhibited the lowest coefficient of restitution, 0.378 (Table 2). Practically, this indicates that balls striking skinned infield soil surfaces will move forward at a greater velocity than any of the other surfaces tested. There were no significant differences between skinned surfaces and Astroturf, nor were there significant differences between Astroturf and Fieldturf (Table 2).

TABLE 1: Mean squares for coefficient of restitution measurements made on different playing surfaces in 2005

Source	DF	Mean Square
Surface (S)	3	0.115***
Replication (R)	2	0.008
Angle (A)	1	0.055*
Velocity (V)	1	0.012
S x A	3	0.016
S x V	3	0.003
A x V	1	0.018
S x A x V	3	0.012
Error	47	0.009

†,*,**,***Significant at $P \leq$ 0.10, 0.05, 0.001 levels, respectively

The impact angle at which the ball struck the surface was also significant (Table 3). Balls contacting the surface with a angle of incidence of 0.44 radians exhibited a coefficient of restitution of 0.539, while those striking the surface at an angle of 0.61 radians exhibited a coefficient of restitution of 0.474 (Table 3). This is likely due to the fact that at shallower angles of inclination a smaller percentage of the surface area of the ball contacted the testing surface. This would result in less energy being lost to the surface, thus potentially explaining why balls move forward at a greater velocity at shallower impact angles.

TABLE 2: Mean coefficient of restitution values (COR) tested on different playing surfaces in 2005

Surface	N	COR*
Skinned infield soil	12	0.598 a
Astroturf	12	0.562 ab
Fieldturf	12	0.487 b
Natural turfgrass	12	0.378 c

*Means with different letters are significantly different from one another (Duncan's nMRT, p≤0.05)

The velocity at which the ball approached the surface was insignificant, as there was no statistically significant difference in the coefficient of restitution of balls approaching the surface at 31.0 m s^{-1} and 40.2 m s^{-1} (Table 3). All interactions between surface, velocity, and angle were insignificant (Table 1). This indicates that a single test angle and ball velocity be used when evaluating the pace of other playing surfaces in future studies.

TABLE 3: Mean coefficient of restitution values tested at different angles and velocities in 2005

Angle of incidence	N	COR*
0.44 radians (25 degrees)	24	0.539 [a]
0.61 radians (35 degrees)	24	0.474 [b]
Velocity	**N**	**COR***
31.0 m s^{-1} (70 mph)	24	0.523 [a]
40.2 m s^{-1} (90 mph)	24	0.489 [a]

*Means with different letters are significantly different from one another (Duncan's nMRT, p≤0.05)

Conclusion

A machine referred to as PENNBOUNCE was developed to evaluate the pace of baseball field playing surfaces through measurements of the coefficient of restitution. PENNBOUNCE uses ballistic screens to measure the velocities of baseballs propelled at the surface both before and after impact, in order to calculate the coefficient of restitution. Differences in surface pace (coefficient of restitution) were associated with variation in playing surface type. Surface pace (coefficient of restitution) was highest on skinned infield surfaces, intermediate on infilled synthetic turf, and lowest on natural turfgrass surfaces. No significant coefficient of restitution differences were found between traditional and synthetic turf surfaces. With a method of directly measuring playing surface pace now in place, future research can be conducted to explore how characteristics of different playing surfaces alter playing surface pace.

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An Evaluation of Baseball Field Surface Conditions in the Northern United States

J.T. Brosnan and A.S. McNitt

Introduction

The surface condition of any particular baseball field will vary according to a number of different factors. For example, skinned areas can vary based on soil texture and moisture content. Infield surfaces, which can be either natural or artificial in nature, vary as well. Natural turfgrass playing surfaces differ by species, variety, cutting height, moisture content, etc. Artificial surfaces can vary by manufacturer or construction method. These variations can affect the quality of the playing surface. Adverse effects associated with surface quality can jeopardize both the integrity of the game, as well as the safety of the players (Waddington et al., 1997; Rogers et. al, 1993).

The quality of a playing surface can be defined as the suitability of a surface for a particular sport (Baker et. al, 1993). It can be measured or perceived in terms or the interactions between the player and the surface, and the ball and the surface. Certain parameters can have a significant effect on these interactions (Baker et. al, 1993). These parameters include but are not limited to: surface hardness and ball response.

The ability a surface has to absorb energy created by a player upon impact is referred to as surface hardness, or impact attenuation (McNitt, 2000). Playing surface hardness is a key factor in determining field safety, as increased surface hardness has been linked to the potential for lower body injuries (Nigg, 1990; Boden et. al, 2000).

Energy that is not absorbed by the surface upon impact is referred to as ground reaction force (GRF). This energy is returned to the player's body and places a loading stress on the on the system which weakens bones, ligaments, and tendons. Ground reaction forces are involved in the mechanisms of chronic injuries and acute injuries, principally delayed onset muscle soreness and anterior cruciate ligament (ACL) rupture (Boden et. al 2000; LaStayo et. al 2003). Harder playing surfaces that absorb less energy will generate greater ground reaction forces, potentially increasing the incidence of surface related injuries. This demonstrates the importance of surface hardness in determining a field's level of safety.

Ball response is also an important factor in determining a field's level of safety. During a baseball game, the ball will strike the playing surface at a variety of speeds and angles. The speed at which the ball is moving after impact with the playing surface can be referred to as the pace of the surface (Thorpe and Canaway, 1986b). Fields exhibiting excessive pace can jeopardize player safety, and inconsistencies in ball bounce may affect the integrity of the game. The US Consumer Product Safety Commission found that 77 percent of youth baseball injuries result from being struck by the baseball (NYSSF, 2000)

It is well documented that characteristics of both natural and synthetic turf surfaces are greatly influenced not only by surface type but also maintenance procedures, with certain field maintenance procedures commonly being used at all levels of competition. Although these procedures are commonplace throughout the industry, little is known in regards to the degree to which they can alter surface quality. For example, irrigating the skinned portion of the infield will certainly make the surface softer. How much softer will the area play if one was to irrigate at a rate of 10 gallons per 1000 ft^2 compared to 8 gallons per 1000 ft^2? How will this increase in moisture affect the amount of traction experienced by the athlete? Answers to questions of this nature are currently unknown.

The goal of this project was to measure the surface hardness and ball bounce properties of varying baseball field playing surfaces, as well as the surface characteristics that affect them. Average levels of surface playing quality (hardness and pace) were determined and research plots were constructed at the Joseph Valentine Turfgrass Research Center, University Park, PA to represent these averages. Future research will be conducted on these plots in 2006 to explore the degree to which maintenance procedures can affect surface quality.

Materials and Methods

During the 2005 season, a survey was conducted of baseball fields used at all levels of competition, with both natural and infilled synthetic turfgrass fields included in the evaluation. Four Major League Baseball fields (MLB), four minor league baseball field (Professional), six National Collegiate Athletic Association (NCAA), and one municipal field were evaluated. Surface quality (hardness and pace) measurements were made throughout the infield, outfield, and skinned infield portions of each field. Within each one of these locations, smaller sampling zones were selected. Sampling zones consisted of 400 ft^2 areas strategically picked within each location. The infield sampling zones included an area 10 ft in front of homeplate and two areas situated 10 ft inside of the 45 ft mark of the second and third baselines (Figure 1). Outfield sampling zones were located 275 feet off first base and third base, with one zone equidistant between the two (Figure 1). Skinned infield sampling zones were placed 10ft off the first and third bases, with the second base sampling zone centered upon second base (Figure 1).

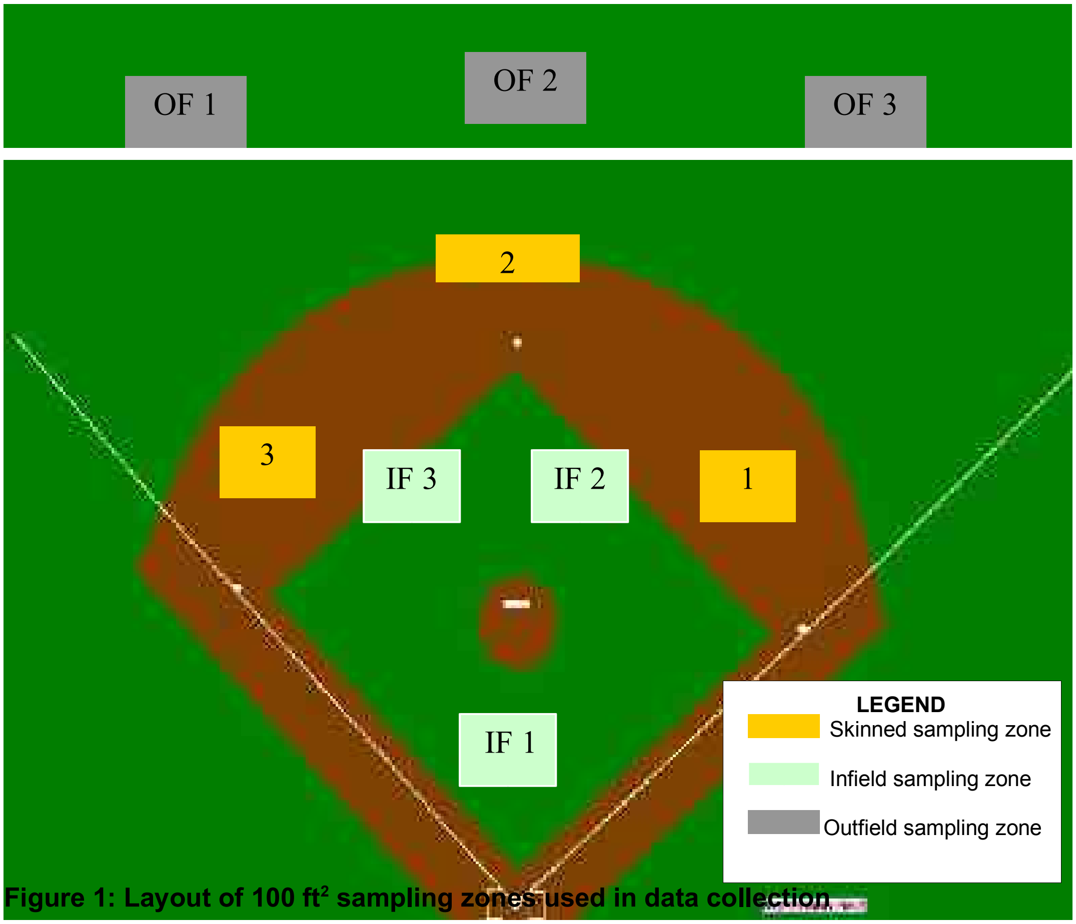

Figure 1: Layout of 100 ft^2 sampling zones used in data collection

Surface hardness measurements were made in each sampling zone. Surface hardness was measured using both a Clegg Impact Soil Tester (Clegg, 1976) (American Society for Testing and Materials, 2000a) and the ASTM F-355 method (American Society for Testing and Materials, 2000b). Impact attenuation, as measured by an accelerometer mounted on the missiles, was used to indicate surface hardness and was reported as Gmax. Gmax is defined as the ratio of maximum negative acceleration on impact in units of gravities relative to the acceleration due to gravity (Henderson et al., 1990). The average of six Clegg measurements and two F355 measurements taken at each sampling zone were used to represent the surface hardness of that sampling zone. A single F355 measurement consisted of dropping the missile three times in the same location, with a three minute interval between each drop. The value reported as Gmax was the average of the second and third drop in the same location.

Playing surface pace was quantified by measuring the coefficient of restitution (COR). The coefficient of restitution is defined as the ratio of two velocities; the velocity of a ball after impact with the surface divided by the velocity of the ball prior to impact (ASTM, 2005a). Coefficient of restitution measurements were attained using an apparatus termed PENNBOUNCE. Preliminary experiments conducted with the device revealed significant differences between various playing surfaces ($p < 0.001$). Measurements were made at a 25º impact angle and a testing velocity of 90 mph (132 ft/sec). Six measurements were conducted within each sampling zone.

Surface characteristics affecting playing quality (hardness and pace) were also measured, using six observations within each sampling zone to represent the average for that zone. For natural turfgrass areas, mowing height, thatch thickness, and volumetric soil moisture content were measured.

Volumetric soil moisture content observations were made using a capacitance probe (Dynamax Inc., Houston, TX). For synthetic surfaces, the depth of infill material was measured, and the manufacturer and age of each surface was also documented. For skinned areas, volumetric soil moisture content, and the depth of loose material (looseness) were measured. Soil texture and particle size analysis was also conducted according the methods described in ASTM F-1632-99 (ASTM, 2005b)

Results

Significant differences were observed between all fields. These differences were a result of a number of different factors including the nature of the materials comprising each surface, management practices, and climate.

Skinned (grass-free) Surfaces

Significant differences were found between all skinned (grass-free) surfaces for the coefficient of restitution, surface hardness (Gmax), volumetric soil moisture content, and depth of loose material (Table 1). Coefficient of restitution measurements ranged from 58.411 % to 51.429 %, indicating that approximately 45% of the velocity of an approaching baseball is lost to the surface on the first bounce at 25 degree angle of inclination. Differences were also observed across the different skinned sampling zones, with coefficient of restitution values lowest at the second base sampling zone (Table 2).

Table 1: Surface quality means for skinned (grass-free) surfaces evaluated in 2005

Field	**COR**[†]	**Gmax**[§]	**Volumetric Moisture Content (%)**	**Depth of loose material (mm)**
MLB #1	54.82 ab[*]	134.28 f	9.5 f	8.73 cd
MLB #2	52.61 bc	92.71 h	29.9 a	25.07 a
MLB #3	51.43 c	114.77 g	28.3 a	11.87 b
MLB #4	56.60 a	177.46 e	23.1 b	8.22 cde
Professional #1	58.41 a	215.29 b	16.0 de	5.39 gh
Professional #2	57.65 a	132.77 f	24.2 b	6.56 efgh
Professional #3	57.55 a	241.51 a	5.1 g	5.78 fgh
Professional #4	57.48 a	203.62 bcd	8.7 f	6.61 defgh
NCAA #1	55.73 ab	196.41 cd	16.9 d	7.67 cdef
NCAA #2	57.04 a	193.83 cd	16.1 de	7.40 cdefg
NCAA #3	57.31 a	205.34 bc	8.4 f	4.78 h
NCAA #4	57.52 a	215.43 b	14.4 e	6.94 defg
NCAA #5	58.08 a	189.61 de	4.6 g	8.33 cde
NCAA #6	54.88 ab	106.02 gh	19.8 c	11.89 b
Other	56.56 a	145.52 f	22.8 b	9.13 c
Overall Mean	**56.24**	**170.97**	**16.5**	**8.95**

[†] Coefficient of restitution (COR) = (outbound velocity/inbound velocity) x 100

[§] Gmax = the ratio of maximum negative acceleration on impact in units of gravities to the acceleration due to gravity, measured with the Clegg Soil Impact Tester

* Means with different letters are significantly different from one another (Duncan's nMRT, $p \leq 0.05$)

Table 2: Surface quality means for each section of skinned (grass-free) surfaces evaluated in 2005

Base	COR†	Gmax§	Volumetric Moisture Content (%)	Depth of loose material (mm)
First base	56.837 a*	179.58 a	16.5 a	9.478 a
Second base	55.271 b	171.91 b	16.4 a	8.333 b
Third Base	56.678 a	161.45 c	16.6 a	9.062 ab

† Coefficient of restitution (COR) = (outbound velocity/inbound velocity) x 100

§ Gmax = the ratio of maximum negative acceleration on impact in units of gravities to the acceleration due to gravity, measured with the Clegg Soil Impact Tester

* Means with different letters are significantly different from one another (Duncan's nMRT, $p \leq 0.05$)

Gmax values ranged from 245.511 to 92.711, with a mean of 170.97 (Table 1). Gmax values were also significantly different across the skinned infield, with values at the third base sampling zone being lower than those at the first and second base zones, 161.450, 179.577, and 171.910, respectively. (Table 2) Gmax values were highest at the first base zone (Table 2).

Differences in volumetric soil moisture content were also observed between skinned infield surfaces, with values ranging from 29.99% to 4.65%, with a mean of 16.5% (Table 1). No volumetric soil moisture content differences were observed across the different skinned infield sampling zones (Table 2).

Significant differences were also observed when measuring the depth of loose material on the surface. The deepest skinned surface was 25.066-mm and the shallowest was 4.778-mm, with a mean of 8.95-mm (Table 1). Significant differences were also observed across the different skinned sampling zones, with the first and third base sampling zones having more loose material (9.4778 and 9.0620-mm, respectively) than the second base zone of 8.333-mm (Table 2).

Skinned mixes varied in soil texture, particle size, and calcined clay content (Table 3). Samples exhibited an average of 7.963 % gravel, 66.583% sand, 18.147 % silt, 7.308 % clay, and 26.77% calcined clay (Table 3) across the various levels of play. Sand size varied within the sand content of skinned infield mixes also. Significant differences were observed in very coarse sand (2.0-1.0 mm diameter), coarse sand (1.0-0.5 mm in diameter), medium sand (0.5-0.25 mm in diameter), fine sand (0.25-0.15mm in diameter), and very fine sand (0.15-0.05 mm in diameter) (Table 5). Yet, the ratio of coarse particles (gravel and sand) to fines (silt and clay combined) was consistent across mixes, with the percentage of coarse particles in the mix averaging 75% and the percentage of fines in the mix averaging approximately 25% (Table 3)

Table 3: Soil texture[†] and percent calcined clay of skinned (grass-free) surfaces[§] evaluated in 2005

Field	% Gravel	% Sand	% Silt	% Clay	% Calcined Clay
MLB #1	13.213 ab*	76.272 a	9.582 gh	0.933 g	24.02 cde
MLB #2	2.393 fg	67.445 cde	19.452 cd	10.707 b	92.63 b
MLB #3	6.353 def	72.052 b	18.400 cd	3.200 f	100.00 a
MLB #4	5.503 defg	72.575 ab	12.295 fg	9.627 bc	27.47 cde
Professional #1	3.418 fg	60.215 f	29.380 a	6.987 e	0.00 f
Professional #2	7.700 de	70.745 bc	20.997 bc	0.560 g	20.90 cdef
Professional #3	1.500 g	65.817 de	28.178 a	4.506 f	7.02 def
Professional #4	4.642 efg	53.775 g	30.842 a	10.747 b	0.00 f
NCAA #1	16.068 a	68.527 bcde	7.312 h	8.093 cde	0.00 f
NCAA #2	8.937 cd	64.618 e	18.753 cd	7.693 cde	3.76 f
NCAA #3	13.113 ab	59.682 f	14.000 ef	13.200 a	30.75 cd
NCAA #4	5.895 def	56.197 fg	24.215 b	13.693 a	28.65 cde
NCAA #5	3.093 fg	71.708 bc	15.998 de	9.200 bcd	0.00 f
NCAA #6	15.668 ab	69.785 bcd	11.172 fg	3.733 f	0.00 f
Other	11.942 bc	69.332 bcd	11.635 fg	7.093 de	39.08 c
Overall Mean	**7.963**	**66.583**	**18.147**	**7.308**	**26.77**

[†]Soil texture determined according to the ASTM F1632-03 specification
[§] Soil samples collected at a depth of 0.50 inches
* Means with different letters are significantly different from one another (Duncan's nMRT, $p \leq 0.05$)

Table 4: Soil texture[†] and percent calcined clay for each area of skinned (grass-free) surfaces[§] evaluated in 2005

Base	% Gravel	% Sand	% Silt	% Clay	% Calcined Clay
First Base	8.721 a*	66.371 a	18.169 ab	6.739 b	32.01 a
Second Base	7.695 a	66.266 a	18.953 a	7.312 ab	22.78 a
Third Base	7.471 a	67.112 a	17.319 b	7.872 a	25.52 a

[†]Soil texture determined according to the ASTM F1632-03 specification
[§] Soil samples collected at a depth of 0.50 inches
* Means with different letters are significantly different from one another (Duncan's nMRT, $p \leq 0.05$)

Table 5: Particle size analysis† for the sand fraction of skinned (grass-free) surfaces§ evaluated in 2005

	Millimeters in diameter					
Field	**>2.0**	**2.0-1.0**	**1.0-0.5**	**0.5-0.25**	**0.25-0.15**	**0.15-0.05**
	--%--					
MLB #1	13.213 ab*	26.879 c	23.721 a	15.435 bc	7.578 cde	2.657 f
MLB# 2	2.393 fg	26.001 cd	18.942 b	9.525 ef	4.486 fg	8.494 d
MLB #3	6.353 def	43.837 a	13.513 e	5.904 f	3.777 g	5.019 e
MLB #4	5.503 defg	13.807 f	10.207 fg	15.215 bc	18.955 a	14.393 b
Professional #1	3.418 fg	14.605 ef	10.975 f	8.967 ef	6.898 cdef	18.771 a
Professional #2	7.700 de	24.098 cd	15.923 cd	10.444 de	6.800 cdef	13.480 b
Professional #3	1.500 g	10.165 f	10.099 fg	22.438 a	11.624 b	11.492 c
Professional #4	4.642 efg	12.911 f	8.430 g	6.528 ef	6.070 ef	19.835 a
NCAA #1	16.068 a	13.276 f	17.287 bc	21.977 a	9.157 c	6.831 de
NCAA #2	8.937 cd	10.078 f	8.697 fg	23.332 a	11.439 b	11.073 c
NCAA #3	13.113 ab	14.784 ef	14.785 de	18.310 b	6.659 def	5.145 e
NCAA #4	5.895 def	14.975 ef	13.514 e	14.926 bc	6.744 cdef	6.038 e
NCAA #5	3.093 fg	12.416 f	19.017 b	25.464 a	8.915 cd	5.899 e
NCAA #6	15.668 ab	20.393 de	17.053 bcd	13.327 cd	8.106 cde	10.907 c
Other	11.942 bc	35.281 b	17.424 bc	8.035 ef	3.698 g	4.893 e
Overall Mean	**7.963**	**19.567**	**14.639**	**14.655**	**8.060**	**9.662**

Table 6: Particle size analysis† for the sand fraction of each area of skinned (grass-free) surfaces§ evaluated in 2005

	Millimeters in diameter					
Base	**>2.0**	**2.0-1.0**	**1.0-0.5**	**0.5-0.25**	**0.25-0.15**	**0.15-0.05**
	--%------------------------------------					
First Base	8.720 a*	19.982 a	14.612 a	14.562 a	7.808 a	9.408 a
Second Base	7.470 a	18.719 a	14.836 a	15.115 a	8.021 a	9.575 a
Third Base	7.696 a	20.001 a	14.468 a	14.287 a	8.353 a	10.002 a

†Particle size analysis determined according to the ASTM F1632-03 specification

§ Soil samples collected at a depth of 0.50 inches

* Means with different letters are significantly different from one another (Duncan's nMRT, p≤0.05)

Infilled Synthetic Turf Surfaces

Significant differences were found between all infilled synthetic turf surfaces for the coefficient of restitution, surface hardness (Gmax), and infill depth (Table 7). Coefficient of restitution measurements ranged from 54.919 % to 49.427 %, with an average of 51.97%. Coefficient of restitution values indicated that approximately 48% of the velocity of an approaching baseball is lost to the surface on the first bounce at 25 degree angle of inclination. Coefficient of restitution differences were also observed across the different sampling zones. For all fields evaluated, there were no differences were observed in the mean coefficient of restitution value between the infield and outfield sampling zones. Slight differences were apparent in the mean coefficient of restitution values found between the sampling zones across the entire field (Table 8). Within each individual field, no differences were observed in the coefficient of restitution across the playing surface (data not shown).

Significant differences were observed in surface hardness using both the Clegg Soil Impact Tester as well as the F-355 specification. Gmax values ranged from 77.892 to 51.967, with an average of 66.33 using the Clegg Soil Impact Tester (Table 7). Gmax values derived following the F-355 specification ranged from 148.767 to 106.925 with an average of 136.75 (Table 7). Using both instruments, Gmax values were also significantly different across the field, with values across the infield sampling zones being lower than those in the outfield sampling zones (Table 8).

Table 7: Surface quality means for infilled synthetic surfaces evaluated in 2005

Field	**COR**[†]	**Gmax**[§]	**Gmax (F-355)**[¶]	**Infill Depth (mm)**
MLB #1	51.82 bc[*]	60.43 b	143.383 a	39.06 b
NCAA #3	54.92 a	77.89 a	143.900 a	26.58 d
NCAA #4	49.43 d	51.97 c	106.925 b	42.50 a
NCAA #5	53.48 e	77.24 a	140.767 a	33.50 c
NCAA #6	50.24 cd	64.14 b	149.767 a	34.81 c
Overall Mean	**51.97**	**66.33**	**136.748**	**35.28**

† Coefficient of restitution (COR) = (outbound velocity/inbound velocity) x 100

§ Gmax = the ratio of maximum negative acceleration on impact in units of gravities to the acceleration due to gravity, measured with the Clegg Soil Impact Tester

¶ Gmax measured according to ASTM F-355 specification

* Means with different letters are significantly different from one another (Duncan's nMRT, $p \leq 0.05$)

Table 8: Surface quality means for each area of infilled synthetic turf surfaces evaluated in 2005

Area	COR†	Gmax§	Gmax (F-355)¶	Infill Depth (mm)
Infield	51.99 a*	63.11 b	135.023 a	35.42 a
IF 1	50.58 b	61.85 c	137.880 ab	34.63 b
IF 2	52.79 a	65.13 bc	135.320 ab	36.76 a
IF 3	52.51 ab	62.35 bc	131.870 b	34.86 b
Outfield	51.96 a	69.55 a	138.473 a	35.15 a
OF 1	51.95 ab	68.38 ab	142.960 a	35.60 ab
OF 2	51.74 ab	67.63 abc	139.320 ab	35.00 b
OF 3	52.30 ab	72.65 a	133.140 b	34.87 b

† Coefficient of restitution (COR) = (outbound velocity/inbound velocity) x 100
§ Gmax = the ratio of maximum negative acceleration on impact in units of gravities to the acceleration due to gravity, measured with the Clegg Soil Impact Tester
¶ Gmax measured according to ASTM F-355 specification
* Means with different letters are significantly different from one another Duncan's nMRT, $p \leq 0.05$)

Significant differences were also observed when measuring infill depth. The deepest infill arrangement was 42.50-mm and the shallowest was 26.58-mm, with a mean depth of 35.28-mm (Table 7). No differences were observed in infill depth between the infield and outfield sampling zones, with slight differences in infill depth found between the sampling zones across the entire field (Table 8).

Natural Turfgrass Surfaces
Significant differences were found between all natural turfgrass surfaces for the coefficient of restitution, surface hardness (Gmax), volumetric soil moisture content, thatch (organic layer), and cutting height (Table 9). Coefficient of restitution values averaged 47.87 % on these surfaces, indicating that approximately 53% of the velocity of a baseball is lost to the surface on the first bounce at 25 degree angle of inclination on natural turfgrass. Coefficient of restitution differences were also observed across the different sampling zones (Table 10). The home plate sampling zone had a higher coefficient of restitution value than the rest of the playing surface (Table 10). Within each individual field, differences were observed in the coefficient of restitution across the playing surface (data not shown).

Table 9: Surface quality means for natural turfgrass surfaces evaluated in 2005

Field	COR†	Gmax§	Volumetric Moisture Content (%)	Cutting Height (in)	Thatch layer (in)
MLB #3	43.21 d*	60.83 b	26.9 b	1.25 d	0.52 b
MLB #4	42.85 d	59.21 b	26.9 b	1.00 e	0.04 de
Professional #1	49.04 c	72.13 a	17.9 d	1.50 b	0.28 c
Professional #2	44.35 d	60.41 b	25.7 b	1.87 a	0.50 b
Professional #3	49.76 bc	71.10 a	22.9 c	1.25 d	0.78 a
Professional #4	44.88 d	60.79 b	22.9 c	1.50 b	0.12 d
NCAA #1	50.98 abc	69.71 a	23.1 c	1.50 b	0.02 e
NCAA #2	52.46 ab	69.44 a	26.1 b	1.31 c	0.05 de
Other	53.34 a	57.89 b	29.4 a	1.53 b	0.85 a
Overall Mean	**47.87**	**64.61**	**24.6**	**1.41**	**0.35**

† Coefficient of restitution (COR) = (outbound velocity/inbound velocity) x 100
§ Gmax = the ratio of maximum negative acceleration on impact in units of gravities to the acceleration due to gravity, measured with the Clegg Soil Impact Tester
* Means with different letters are significantly different from one another (Duncan's nMRT, $p \leq 0.05$)

Table 10: Surface quality means for each area of natural turfgrass surfaces evaluated in 2005

Area	COR†	Gmax§	Volumetric Moisture Content (%)	Cutting Height (in)	Thatch layer (in)
Infield	48.37 a*	69.27 a	25.1 a	1.43 a	0.388 a
IF 1	50.96 a	73.22 a	26.0 a	1.39 bc	0.382 ab
IF 2	48.11 b	68.64 b	24.0 c	1.37 c	0.381 ab
IF 3	47.14 b	65.95 b	23.2 c	1.40 bc	0.400 a
Outfield	47.38 a	59.95 b	24.2 b	1.38 b	0.317 b
OF 1	48.11 b	59.95 cd	24.5 bc	1.43 ab	0.326 abc
OF 2	46.53 b	57.88 d	25.1 ab	1.44 a	0.320 bc
OF 3	47.51 b	62.02 c	25.8 ab	1.45 a	0.305 c

† Coefficient of restitution (COR) = (outbound velocity/inbound velocity) x 100
§ Gmax = the ratio of maximum negative acceleration on impact in units of gravities to the acceleration due to gravity, measured with the Clegg Soil Impact Tester
* Means with different letters are significantly different from one another (Duncan's nMRT, $p \leq 0.05$)

Gmax values measured with a Clegg Soil Impact Tester ranged from 72.125 to 57.894, with a mean of 64.61 (Table 9). Gmax values were also significantly different across the playing surface, with outfield values testing lower than those derived across the infield sampling zones, 59.954 to 69.269, respectively (Table 10). Significant differences in surface hardness were observed at different sampling locations across the field. Left and right field sampling zones had higher Gmax values than the centerfield sampling zone, 62.014 and 59.954 compared to 57.853, respectively (Table 10). Surface hardness values tested highest at the home plate sampling zone, with Gmax values averaging 73.219 (Table 10).

Differences in volumetric soil moisture content were also observed between natural turfgrass surfaces, with values ranging from 29.45% to 17.93% (Table 9). Volumetric soil moisture content differences were observed across the different field sampling zones, with the infield areas measuring lower in moisture content than outfield areas, 24.22% to 25.10% respectively (Table 10). The home plate sampling zone had the highest moisture content of any other zone, with a volumetric soil moisture content of 25.97% (Table 10).

Natural turfgrass surfaces also differed significantly in the amount thatch present. The deepest thatch layer was 0.854-in and the shallowest was 0.020-in (Table 9). Thatch layer differences were observed across the different field sampling zones, with the infield possessing a thicker thatch layer than the outfield, 0.387-in compared to 0.317-in respectively (Table 10).

Differences in cutting height were also observed between natural turfgrass surfaces, with values ranging from 1.875-in to 1.000-in (Table 9). Cutting height differences were observed across the different field sampling zones, with the infield possessing a lower average cutting height than the outfield, 1.385 to 1.439-in respectively (Table 10).

Discussion

Skinned Surfaces

The infield mix with the fastest pace had a coefficient of restitution value of 58.411 %, while the slowest surface had a coefficient of restitution of 51.429 % (Table 1). This translates into the ball reaching the player at approximately a 7% slower velocity. A velocity change of this magnitude allows the player to travel approximately one foot further to reach an approaching ground ball. This small difference can drastically affect a game, as it could potentially serve as the difference between a ground ball being fielded adequately or traveling past an infielder into the outfield.

Differences in surface pace (coefficient of restitution) values were observed across skinned infield soil mixes used at varying levels of competition. The mixes were significantly different in sand, silt and clay content from one another, yet the relative ratio between coarse (gravel and sand) and fine particles (silt and clay) was similar in all mixes evaluated. Mixes contained 75% coarse particles (gravel and sand) and 25% fines on average (Table 3). This similarity between the skinned mixes suggests that other factors are responsible for variations in surface hardness and pace, principally surface characteristics altered through maintenance procedures.

Gmax values were extremely high when looking across a wide range of mixes and moisture contents, with an overall mean of 170.978 (Table 1). Surfaces of this nature, those with Gmax values approaching 200, have been found to exhibit increased injury potential (ASTM 2000c), and often require re-surfacing due to the fact that little energy is absorbed by the surface. The majority of this energy is returned to the athlete's body in the form of ground reaction force.

This ground reaction force places a loading stress on the on the body which weakens bones, ligaments, and tendons. Increased ground reaction force is indicated as a factor in the onset of chronic (wear and tear) type injuries (LaStayo et. al, 2003). Upon striking the surface, the quadriceps muscles undergo an eccentric muscle contraction to balance the ground reaction force exerted onto the body. These contractions stretch muscle fibers often leading to the soreness and pain associated with chronic injuries. This is highly important as majority of injuries in baseball can be classified as chronic in nature (Dick, 2005).

Gmax values also varied across the different skinned infield sampling zones. The first base sampling zone had the highest Gmax value (179.577), while the second base zone had the second highest (171.910), and third base had the lowest Gmax value (161.450) (Table 2). This is likely related to soil compaction. More runners reach first base than any other base on the diamond. Thus, the soil is subject to traffic from both the fielder and the runner, likely causing Gmax values to be higher.

The reason for the observed differences in playing surface pace is not clear. For example, the skinned surface of Professional field #2 and NCAA field #5 had drastically different Gmax and moisture content values. Professional field #2 registered a Gmax value of 132.767 and 24.27% moisture content, while NCAA #5 registered a Gmax of 189.611 and 4.65% moisture (Table 1). Many field managers feel that applying moisture will affect the pace of the playing surface. If moisture content was the key factor in determining the pace of the skinned surface, Professional field #2 would have had a slower pace (lower coefficient of restitution) than NCAA #5, yet the two fields did not have significantly different coefficient of restitution values, 57.654 and 58.078, respectively (Table 1).

The reason for the similar ball response may be due to the fact that the sub-base layers of both fields were compacted to a similar degree. Regardless of the content of the material on the surface (i.e. – calcined clay), the ball works through this loose material and "bottoms out" with the sub-base below. As previously indicated, this base layer is often a highly trafficked compacted soil that doesn't receive any compaction relief. Applied moisture will likely not doing anything to soften the sub-base layer, as infiltration into highly compacted clay soils has been proven to be very slow. Applying water will likely just maintain the structural integrity of the loose layer above, and not infiltrate into the compacted sub-base. Testing equipment will only measure moisture content in the upper layers of the profile, not the sub-base. This could potentially explain why skinned surfaces with very different moisture contents exhibit a similar ball response.

Future research is needed to determine the volume of water needed to effectively soften the compacted sub-base layer common to skinned surfaces.

Infilled Synthetic Turf Surfaces

Significant differences were found in surface pace across infilled synthetic turf surfaces. The infilled surfaces with the fastest pace had a coefficient of restitution values of 54.912% (Table 7), while the slowest surface had a coefficient of restitution of 49.427 % (Table 7). As with skinned surfaces, this translates into the ball moving forward at a slower velocity, and thus allowing the player to travel further to reach an approaching ball. Again, this small difference can drastically affect a game, as it could potentially serve as the difference in whether or not a ground ball is fielded adequately.

Differences in surface pace were associated with surface hardness (Gmax) and infill depth. Harder surfaces will absorb less energy, thus returning more energy to the ball after impact. This will potentially allow for the velocity of the ball after impact to be greater, which will in turn generate a higher coefficient of restitution value. Increasing the amount of loose material will not only soften the surface, but similar to skinned surfaces, provide the ball with a thicker layer to travel through before impact.

Surface pace within each individual infilled synthetic turf system was very consistent, with no significant differences in pace apparent at different locations across the playing surface (Data not shown). This consistent pace was only evident on fields that were greater than one year of age. An evaluation of the total number of errors made on infilled synthetic turf systems in Major League Baseball from 2002 through 2004, discovered that significantly less errors were made on infilled synthetic turfgrass systems compared to cool season turfgrass fields (James, 2005). Consistent pace is likely a factor in the reduced error rate which was observed. Fields younger than one year of age did not exhibit a consistent pace across the playing surface. Likely, it takes approximately a year of time for loose rubber and sand infill material to settle into the carpet and form a uniform layer with which the ball can react with upon impact.

While consistent pace was observed across the playing surface of each individual infill system, this was not the case when evaluating infill systems as a group. Differences were found in surface pace and Gmax when comparing different field locations. For example, infield surface were softer than outfield surfaces, showing Gmax values of 69.554 and 63.111 respectively, when measured with a Clegg Soil Impact Tester (Table 8). Among outfield areas, the centerfield sampling zone tended to be softer than the left and right field zones, as measured with both the Clegg Soil Impact Tester and the F-355 apparatus (Table 8). The nature of the game of baseball lends itself to centerfielders being more mobile than the left and right fielders. Due to the fact that centerfielders are not stationary as much as the other outfielders the compaction of the infill material may be lessened enough to produce a softer surface.

Natural Turfgrass Surfaces

Significant differences in surface pace were observed across different natural turfgrass playing surfaces. The natural turfgrass surface with the fastest pace had a coefficient of restitution value of 53.339 %, the slowest surface had a coefficient of restitution of 42.853%, and the mean coefficient of restitution was 47.87% (Table 9). This difference between the fastest and slowest surfaces translates into the ball reaching the player at approximately a 9% slower velocity, thus allowing the player additional time to field and approaching ground ball. This small difference can drastically affect a game’s outcome. Baseballs striking natural turfgrass surfaces lost approximately 53% (Table 9) of their initial velocity upon impact at a twenty five degree angle of inclination. This is significantly more than infill and skinned surfaces at the same angle of inclination. Balls striking infill systems lost approximately 48% of their initial velocity (Table 7) and those striking skinned surfaces lost approximately 43 % (Table 1)

These observed differences in surface pace were associated with certain surface characteristics including surface hardness (Gmax), moisture content, and the thickness of the thatch layer As with both skinned and infilled synthetic surfaces, a harder surface will absorb less energy, thus returning more energy to the ball after impact. This will potentially allow for the ball’s velocity after impact to be greater, giving rise to a higher coefficient of restitution value.

The role the thatch layer played in determining the pace of a natural turfgrass playing surfaces was interesting. Thatch is a layer of organic material that sits above the hard soil base layer (Beard, 1973). The ball needs to travel through this layer to contact the base layer below. Yet unlike skinned soil and infill turf surfaces, increases in the thickness of the impeding layer were associated with increased surface pace. Organic layers, unlike the loose material associated with skinned and infilled surfaces, are a cohesive unit of connected materials. This gives the layer elasticity that may be allowing a springboard effect to occur, generating a faster velocity after impact. More research is needed to explore this issue.

Differences were found in surface hardness across each natural turfgrass field. Infield surfaces were found to be significantly harder than outfield surfaces, 69.26 compared to 59.54, respectively (Table 10). This difference in surface hardness could potentially be due to a number of factors. Infields are often topdressed with sand and rolled in an effort to smooth the surface in order to achieve a consistent ball response. Topdressing with sand and subsequent rolling is commonly associated with increasing the surface hardness of golf course putting greens (Beard, 1973). Traffic patterns could be another factor, along with repeated ball to surface impacts from batting practice session. As with infill systems, the centerfield area of the outfield was softer than both left and right field, 57.883 compared to 59.954 and 62.024, respectively (Table 10). Again, this is likely because left and right fielders traditionally are stationary for longer periods of time during a game than centerfielders.

Applications of water will serve to lower surface hardness and thus reduce the velocity of the ball after impact. Outfield surfaces were found to have significantly higher volumetric moisture contents than infield surfaces, 25.10% compared to 24.24%, respectively (Table 10). This could potentially be due to the fact the infield turfgrass is covered by a tarp during periods of rain while the outfield is left exposed. Within the infield, the sampling zone in front of home plate had the highest moisture content, 25.970% (Table 10). This is likely due to the fact that field managers often water down this area, as well as the home plate skinned cutout, to reduce the velocity of the baseball after impact.

Conclusion

Surface characteristics were found to have a significant effect on the safety and quality of baseball fields. The hardness of the playing surface, particularly the skinned soil areas, often reached unsafe levels, to that point that increases in the frequency of injuries may be likely. A key component of playing quality is consistent playing surface pace. Variation in maintenance procedures likely resulted in differences in playing surface pace observed in this evaluation. More research is being conducted at the Joseph Valentine Turfgrass Research Center, University Park, PA to explore these issues in detail.

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Nitrogen Fertilization of Putting Greens Cohabited by Penn 'A-4' Creeping Bentgrass and Annual Bluegrass

Max Schlossberg, Center for Turfgrass Science—Penn State University

Introduction

Of all the managed turfgrass areas comprising a golf course, none are more valued or intensively maintained than the putting greens. Putting green square footage may represent <2% of the total managed golf course turf, yet putting green quality can make or break a golfer's perception of playing conditions, and quite possibly their entire golfing experience.

Nitrogen (N) fertilization is an important component of putting green management. Under optimal growth conditions and intermediate nutrient sufficiency, no other plant essential nutrient has as powerful an influence on turfgrass canopy color and vigor, root-to-shoot growth relations, and disease susceptibility. Likewise, when applied at rates commensurate with turfgrass requirements, traditional fertilizer sources providing any/all plant essential nutrient(s) besides N (excepting acids or liming agents) do not have the profound effect on soil biochemical activity that N fertilizers do.

Nitrogen fertilizers include numerous quick-release (QR; e.g. salts, urea) and slow-release forms (SR; e.g. natural organics, synthetic organics, coated prills), each having their pros and cons. The advent of SR technologies may be the most notable advance in recorded fertilizer history. However, because the most effective SR fertilizers are water-insoluble, coated, or both; most are only available in granular or sprayable-powder forms. Low-SGN, SR granulars are effective putting green fertilizers that minimize nutrient leaching loss and osmotic tissue desiccation, while steadily supplying available nutrients to turfgrass. Nevertheless, the persistent nature of granular SR fertilizers requires them to either be watered through the canopy, stabilized in the upper soil profile (i.e. applied following aerification or verticutting procedures) or free to persist on the putting surface, potentially redirecting golfer's putts before being carried away in the mower clippings. This is one of several justifications for liquid/spray fertilizer application to putting greens during periods of peak golfing activity. Further supports of this application method are:

- Frequent/light fertilizer applications optimize plant health and nutrient recovery (Bowman, 2003)
- Regular spray applications are already being made to putting greens during the peak season

These things considered, independent field studies were initiated on two putting greens, purposefully co-habited by creeping bentgrass (*Agrostis palustris* L. 'Penn A4') and annual bluegrass (*Poa annua* L.). These experiments were facilitated in 2003 and 2004 at the PSU Valentine Turfgrass Research Center (University Park, PA) for the purpose of identifying:

– Annual N fertilization rate effect on color and health of putting greens cohabited by creeping bentgrass and *Poa annua*; and

– The potential interactive effects of QR-N form and/or systematic growth regulation on the first objective parameters.

Methods

Though creeping bentgrass/annual bluegrass mixtures covered both experimental putting greens, their underlying root zones possessed dramatically different physical and chemical properties (Table 1). Likewise, the topdressed pushup green (TDPU) was over 20 years old at experiment initiation, while the sand-based green (SB) was constructed only 2 years prior. In both studies, fertilizer treatments (each comprising 1/13 of the annual rate) were applied April to October with a CO_2-powered hand sprayer in a volume of 2.2 gal./1000 ft^2 (95 GPA), every 15 ± 4 days. The 2-year experiment on the TDPU green evaluated a wide array of annual N rates (1.5-8 lbs N/1000 ft^2•year) and ammonium to nitrate ratios (NH_4^+ as ammonium sulfate vs. NO_3^- as calcium nitrate) to determine their influence on color, health, and nutrient content of the putting surface. In 2004, the SB green experiment evaluated a narrow range of treatments that showed most positive responses on the TDPU green the previous year. These treatments were; 3 or 5-lbs N/1000 ft^2•year in one of four QR-N forms: ammonium nitrate, ammonium sulfate, 9 parts NH_4-N:1 part NO_3-N, or 9 parts NH_4-N:1 part dicyandiamide-N (DCD; an organic nitrification-inhibitor containing 67% N by mass), with or without bi-monthly Primo MAXX (trinexapac-ethyl, 0.125 oz./1000 ft^2) growth regulator applications, for the same TDPU-green study purposes listed above.

Soil Properties	Experimental Green TDPU	SB
Soil pH (1:1 H_2O)	7.0	7.5
*CEC (meq / 100 g soil)	8.1	4.7
†Soil Organic Matter (% mass)	4.0	1.3
$CaCO_3$ equivalency (% mass)	2.0	3.3
	—*lbs nutrient / acre—	
P_2O_5	293	67
K	141	31
Mg	365	134
Ca	2,512	1,624

* Determined using Mehlich 3 extractant
† Determined by loss on ignition (LOI)

Table 1. Preliminary soil fertility/chemical properties of experimental putting green root zones (composite samples of upper 3", thatch removed).

As mentioned, these sites were maintained as golf course putting greens throughout the experimental periods. Corrective P_2O_5 and K_2O fertilizer applications were made prior to each experimental season. All plots were equally mowed (0.125" height; 6-7 days a week), irrigated, and treated with plant protectants when necessary. Outside of the described treatments, no systemic fungicides, growth regulators, fertilizers, or wetting agents were applied to either study. Measurements collected for evaluative purpose were: turfgrass shoot growth/vigor (clipping yield, in lbs dry clippings/1000 ft^2•day), canopy dark green color index (DGCI)(Karcher & Richardson, 2003), and tissue nutritional status (nutrient concentration in dry clippings). These data were collected 2-5 times per study•year, within 4 to 12 days of treatment application, and analyzed by regression and/or analysis of variance statistical procedures.

Results

Statistically, shoot growth/vigor response was better correlated to rate of N fertilizer application than to form of the QR N (data not shown). Expectedly, growth response to N was direct. However, clipping yield measured on the SB green lagged behind yields measured on the identically N-fertilized TDPU green (Fig. 1). Further, Primo MAXX (GR) application to the SB green depressed growth rate to 74% of the control plot growth rate, independent of N rate or form.

Canopy color, measured by dark green color index (DGCI), was significantly affected by both N rate and form on the TDPU green. Though not shown here due to space constraints, a significant effect of fertilizer ammonium content on DGCI was observed over 2 years on the TDPU green. At annual N rates exceeding 5 lbs N/1000 ft^2, canopy DGCI levels significantly increased when ammonium comprised half (4% increase) or >80% (6% increase) of the fertilizer N. Conversely, canopy color on the SB green was affected most by N rate or GR (Fig. 2), with GR treatment increasing DGCI values 5%, regardless of N rate or form.

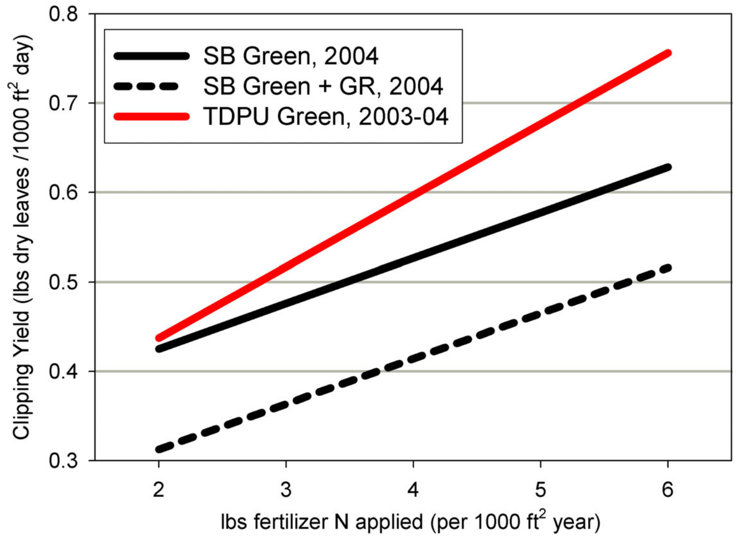

Fig. 1. Average daily clipping yield (shoot biomass production); by experimental putting green, annual nitrogen fertilizer rate, and trinexapac-ethyl (GR) application (sand-based green [SB] only).

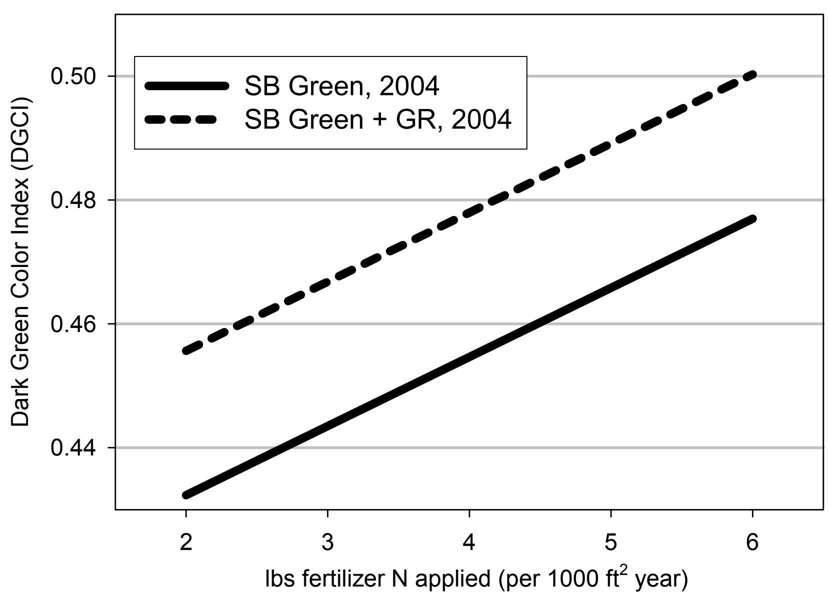

Fig. 2. Average dark green coloration (by DGCI) of sand-based putting green, by annual nitrogen fertilizer rate and trinexapac-ethyl application.

Shoot tissue nutrient concentration data, an integral requirement in the comprehensive evaluation of turfgrass health, provided valuable information. In both greens, N fertilization rate directly affected N, K, Cu, and Zn levels in tissue. However, the more interesting nutrient level responses to N-fertilizer applications were observed on the TDPU green, particularly the direct relation of tissue P and Mn levels to increasing ammonium content at every N-rate (Fig. 3).

Of the treatments applied to the SB green, GR application decreased K and Mn concentration in shoots by 5 and 15% respectively. As with the TDPU green, N rate and N form interacted to affect shoot Mn levels significantly (Fig. 4).

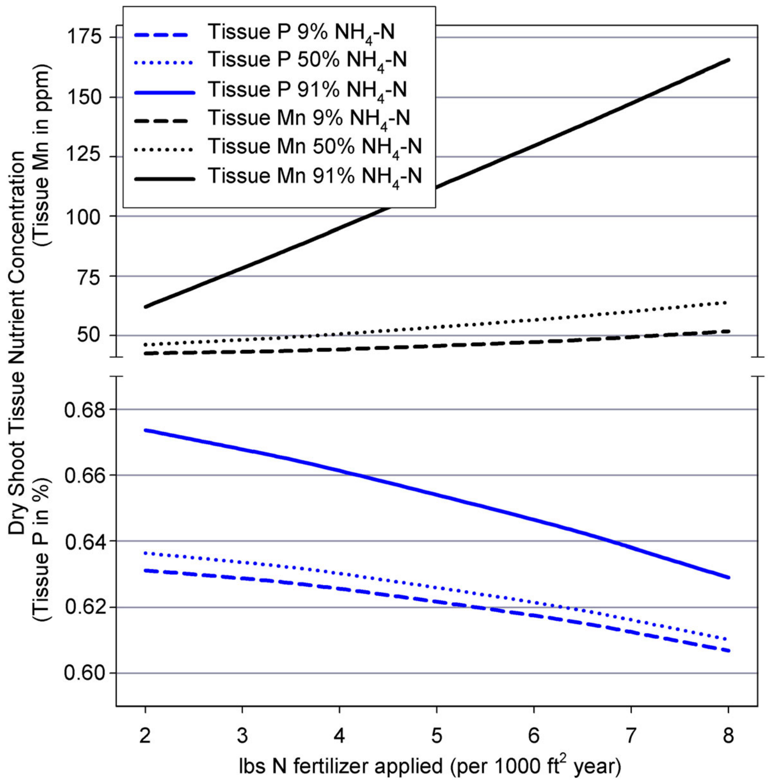

Fig. 3. Average leaf tissue P or Mn concentration from topdressed-pushup (TDPU) green, by ammonium content of quick-release N fertilizer and annual nitrogen fertilizer rate.

Summary

These data support previous research results and provide new insight into putting green turfgrass nutritional response to N. The difference observed in shoot growth between the 2 greens was not expected; considering similar conditions of light, temperature, and N fertilizer reapplication frequency. The lesser growth rate of the SB green, when compared to the TDPU green, illustrates the limited nutrient sequestering-capacity and nutrient mineralization activity associated with young, low-OM, sand-based root media. Moreover, University Park received 29" of rain between May and October in 2004, and the relatively-limited nutrient uptake in the SB green may have resulted from nutrient leaching. Thus, root zone soil OM and percolation rate are traits that should be factored into decisions regarding N fertilizer type, rate, and frequency of reapplication.

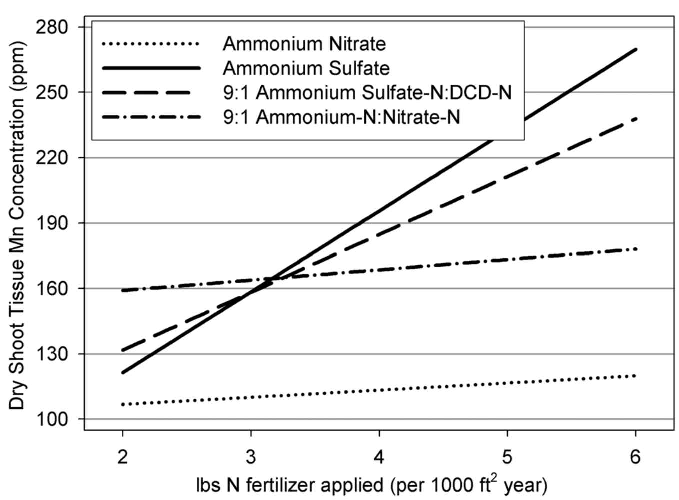

Fig. 4. Average leaf tissue Mn concentration from sand-based (SB) green, by quick-release N fertilizer formulation and annual nitrogen fertilizer rate.

Nitrogen form played a significant role in canopy color and tissue P on the TDPU green, and affected Mn tissue levels of both greens. The N form associated with these enhancements was ammonium. Exclusive use of ammonium sulfate for N fertilization is a well-recognized soil-acidifying strategy. In both greens, ammonium sulfate fertilization resulted in significant tissue Mn increases, regardless of soil chemical properties (Table 1) or historical micronutrient fertilizer applications.

The observed effects of Primo MAXX GR on putting green growth and color are in agreement with recent research (McCullough et al., 2005). Use of the GR did not interact with N rate or form, but consistently increased canopy color (%5) while suppressing shoot growth (26%), tissue K (5%), and tissue Mn (15%) in the 4-12 day period following GR application. Ideally, these results will be considered by golf course superintendents who have not adopted GR use as a maintenance practice, yet fervently withhold nitrogen fertilizer from their bentgrass/*Poa* cohabited putting greens for the purpose of enhancing ball roll distance. An important message that can be derived from these results is this: Suitable green speed can be mutually excluded from suboptimal leaf N and disease susceptibility. Increase your N fertilization frequency and rate to satisfy the N requirements of healthy turfgrass (>4% tissue N). This action, coupled with initiation of GR applications, is an effective and widely-used method to significantly enhance plant health and canopy color (Fig. 2) without an undesired concomitant increase in shoot growth (Fig. 1).

Acknowledgements
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2005 Progress Report for 2 Year Golf Course Turfgrass Management Program, Research Facilities, and Media Relation Activities

2005 was a transitional year for us here at Penn State. However, it did not hinder our progress in any way. I encourage you to view all of the research reports from our faculty which are posted at www.paturf.org. I would like to thank the Pennsylvania Turfgrass Council for their cooperation in helping us educate the industry and provide reports for our ongoing progress.

As you can see, all of our faculty engaged in very useful research that will further help us understand and implement better management practices. From my own perspective, it was a tremendously busy year for all of us. Taking on the role of directing the Golf Course Turfgrass Management Program as well as coordinating our research and facility activities certainly is an ongoing challenge that I'm sure will remain extremely comprehensive. It is something I am enjoying tremendously. I am working with professionals that are leaders in their specific studies…and I get to help coordinate all of our work into efforts that will best help you in the industry.

We made some changes in the Two year program. You may not be aware of this but as of July 1, 2005, any graduate, past or present of the Golf Course Turfgrass Management Program will receive thirty Baccalaureate credits that can be applied toward a B.S. Turfgrass Science degree which can be completed on campus or by distant education through Penn State's World Campus. World Campus is not a replacement for the hands on training and continuous faculty contact you receive in the Two year program. We don't expect it ever to be.

PSU vs. MSU in Cutter Cup event held at Merion Golf Club East. PSU won 3 ½ to 1 ½ in stroke play!!

PSU World Campus is certainly a very good supplement to the training that one receives through our resident program. Thus, graduates learn the communication, technical, networking, and overall life skills, along with the fundamental and detailed management techniques needed to succeed in our industry of turfgrass management by attending the

Two year program. They can then go into the industry for an extended working season making them valuable assets to any facility. Furthermore, they can continue their studies online while gaining valuable work experience simultaneously. The reputation of our Two year technical program speaks for itself. Most importantly, we teach the students to think so that they are prepared to work through the infinite challenges they will encounter in their careers. I am committed to securing that reputation always, and I am always working to improve the value of our education. By having consistency in our faculty…those that teach the B.S. program also teach the Two year program which is truly unique and extremely valuable…we continue to have sound education while producing fine individuals continuing to be successful in the industry. We employed 100% of our graduates this past March while producing multiple Golf Course Superintendents, Assistant GC Superintendents and Sports Turf managers. At the conclusion of this academic year, we will have graduated more than 1,500 students from the Two year program. We are all certainly proud of that fact and are committed to producing many to follow.

Our facilities for research include the Joseph Valentine Turfgrass Research Center and the Landscape Management Resource Center which comprise seventeen and twenty-four acres of research plots and breeding grounds respectively. In 2005, I supervised the installation of a sub-ground irrigation system through 10 acres of ground to enhance our turfgrass breeding efforts so that we can continue our work in developing improved turfgrass varieties well into the future. Also constructed was a 14,000 square foot USGA specification putting green. Students from our 2006 graduating class of the Two year program participated in this work. We will use this facility for further research and recommendations for improved management of fine putting green surfaces. The green is being grown in this spring. As you can see from the research reports linked with this report, the facilities are being utilized very effectively and continuously.

With regard to our media relation efforts, I am proud to say that I have traveled the state, the country and beyond all in an effort to improve our understanding of the needs of the industry, to recruit students into our program, and to assist any way I can with the issues being faced day to day. I have taken some of our research efforts into the field and hope to continue to do so. I visited more than six dozen golf courses last season and I hope to achieve that level this year as well. Please do not hesitate to contact me should there be anything I can help you or your club with throughout the season.

I have been asked if I miss being a superintendent. Truly, I feel like I still am a superintendent. I can’t allow myself to be detached from the industry…and I find myself volunteering to assist operations near and far…I think this would be my “fix.” Training what will be the future leaders of our industry has satisfaction that I can’t explain. As those of you who have gone through the program know, it is not until the end that you realize the value of what we put you through during the thirty-two weeks of training. For me, it is continued education. And this is most true when you consider that I am continuing with graduate studies. But the day you stop feeling like a student of this industry is the day you should retire…no matter what age that may be. This is a message that I try to instill in students from day one…and I hope they will never forget it. I will always be a superintendent at heart and will continue to assist any way I can with improving facilities, operations, and the industry. Turfgrass Management and the Science that fuels it is an infectious passion…I'm proud to have it and happy to share it. Good luck with your 2006 season!

Please make an effort to attend this year's PSU Field Days being held Wednesday and Thursday August 9th and 10th. The Bar-B-Que event will be held at Beaver Stadium on Wednesday evening, August 9th with fun activities and tours taking place. Please bring your family along. Please visit the PTC website at www.paturf.org for further details. Thank you! cmagro@psu.edu

Turfgrass Online Educational Program Developments

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Professor of Turfgrass Management

By the end of 2005, we completed the eighth year of online certificate programs in Turfgrass Management, including a total of eight courses (Table 1) and more than 2700 enrollments, including students from North and South America, Europe, Asia, ad Africa. This year also saw the initiation of the online Bachelor of Science (B.S.) Degree Program in Turfgrass Science and preliminary development of a ninth course (TURF 435, Turfgrass Nutrition, 4 credits, Schlossberg) to expand the program's offerings. Initial response to the online B.S. Degree Program has been tremendous, with special interest shown by graduates of the two-year Golf Turf Management Program who are granted 30 credits (for successful completion of that program) toward meeting the 120-credit requirement for the degree.

Table 1. Turfgrass Courses Currently Offered through the Penn State World Campus.

Course #	Course Title	Credits	Instructor(s)
TURF 230	Turfgrass Pesticides	1	Watschke
TURF 235	The Turfgrasses	3	Turgeon
TURF/HORT 238	Weed Control in Turf and Ornamentals	3	Watschke & Kuhns
ENT 317	Turfgrass Insects	3	Heller
PPATH 412	Turfgrass Diseases	3	Uddin
TURF 425	Turfgrass Cultural Systems	3	Watschke
TURF 434	Turfgrass Edaphology	3	McNitt
TURF 436W	Case Studies in Turfgrass Management	3	Turgeon

The methods employed in teaching online turfgrass courses were initially developed by the instructors, and then refined during successive offerings based on feedback from students. Cooperative research with faculty and students from the Instructional Systems Program in the College of Education at Penn State have resulted in some of the advanced instructional techniques employed in these courses. The courses tend to be highly interactive, requiring regular (almost daily) participation in lessons and practical exercises by both students and instructors. Response to the courses and to the programs (basic and advanced certificates, B.S. degree) has been overwhelmingly positive.

In the future, we hope to be able to offer an online Master of Turfgrass Management (M.T.M.) degree for recipients of the B.S. degree who wish to expand their knowledge and skills in the management of turfgrass systems.