2011 Purdue University Turfgrass Research Summary

Acknowledgements
This publication was designed and prepared by Jennifer Biehl, Turf Program Secretary and Executive Secretary of the Midwest Regional Turf Foundation.

Disclaimer
Some of the information presented in this guide, especially pesticide recommendations, may be specific to Indiana. Readers outside Indiana should check with their own cooperative extension services for state-specific information.

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On the cover: Crabgrass (*Digitaria* spp.) control research at Purdue University. Photo by Aaron Patton.

2011 Purdue University Turfgrass Research Summary

Table of Contents Page

Turfgrass Industry:

As the green industry continues to have a large impact on Indiana and the nation, Purdue University has assembled an outstanding team of researchers, extension personnel, and educators that are dedicated to solving problems and helping meet the needs of Indiana residents. One segment of the Indiana green industry that continues to provide a significant impact on the state's economy is the turfgrass industry, which includes residential and commercial lawn care, sports turf, cemeteries, sod production, golf course maintenance, and more. Indiana's professional turfgrass industry is estimated by some to generate in excess of $1.4 billion in annual expenditures and provide over 11,500 jobs.

The Annual Report of the Purdue University Turf Program is published each year by the Purdue Turf Team and features significant findings made by turfgrass scientists over the past year. It is our desire that this publication will keep our stakeholders up-to-date on significant changes and advancements that affect our industry.

This 2011 Annual Report includes 21 papers from faculty, staff, and graduate students. We hope that these findings will enhance your ability to conduct business in an efficient and productive manner.

We would also like to recognize the many organizations, companies, and individuals who have contributed their time, talent and resources to help make our program successful. We are forever indebted to the many people who contribute to this program. Special recognition goes to the Midwest Regional Turf Foundation which supports the research and extension programs of each member of the Turf Team and also provides substantial support towards the operating and capital expenses of the W.H. Daniel Turfgrass Research and Diagnostic Center.

We hope that this publication will be of value to all persons with an interest in the Indiana green industry.

Cale Bigelow
Associate Professor

Tim Gibb
Insect Diagnostician

Yiwei Jiang
Associate Professor

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Professor

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Supporters of the Purdue University Turf Program in 2011

The Turfgrass Program at Purdue University relies on the support of the Midwest Regional Turf Foundation and gifts from the turfgrass industry for a large portion of its operating budget. We would like to extend our thanks to the members of the Midwest Regional Turf Foundation for their loyal support of turfgrass research and education at Purdue.

In addition, various individuals, organizations, and businesses have provided grants, products, or equipment to support our efforts throughout the year. Without this support, we would be unable to conduct many of the research projects included in this report.

Individuals

Al Capitos, Purdue Athletic Department
Greg Shaffer, Elcona Country Club
Jim Scott, Purdue Univ. Athletic Dept.
Brian Bornino, Purdue Univ. Athletic Dept.
Scott Helkamp, Purdue Univ. Grounds Dept

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Turfgrass, Inc
United States Department of Agriculture NC-RIPM
United States Golf Association
Valent USA

We regret that some individuals or companies may have inadvertently been left off of this list. If your company has provided financial or material support for the program and is not mentioned above, please contact us so that your company's name can be added in future reports.

Evaluation of Putting Green Bentgrass Cultivars and Blends

PURDUE UNIVERSITY
TURFGRASS SCIENCE

Cale A. Bigelow and W. Tracy Tudor, Department of Agronomy, Purdue University

SUMMARY: To evaluate the adaptation of various commercial and experimental bentgrass cultivars and blends to research putting green conditions in a cool-humid climate located in West Lafayette, IN.

MATERIALS AND METHODS

This field study was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN on a calcareous sand-based research putting green with a soil pH of 7.9 and 2.4% organic matter on a site with full sun exposure. This test was planted in participation with the National Turfgrass Evaluation Program (NTEP) 2008 putting green evaluation test (17 creeping bentgrass and 2 velvet bentgrass cultivars). In addition, 31 commercially available creeping bentgrass cultivars or blends were also planted. The blends were created from the commercially supplied seed in order to observe the performance of potentially compatible cultivars, Declaration + 007, or potentially incompatible cultivars, Penncross/Penn A-4/L-93, which would be potentially undesirable primarily due to contrasting shoot densities and leaf textures. A complete list of cultivars, blends and the source of seed is contained in Table 1. All cultivars except LS-44 were originally planted on 8 Sept., 2008 at 1 # seed/1000 ft^2, LS-44 was seeded on 4 Oct., 2008. At planting Milorganite (6-2-0) was surface applied with the seed at the rate of ½ lb. of N 1000 ft^2 and the entire area received 1.0 lb. P2O5 from triple super phosphate fertilizer.

Bigelow, C., and W.T. Tudor. 2012. Evaluation of Putting Green Bentgrass Cultivars and Blends. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 1-9.

Throughout the growing season the study site received approximately 4 lbs. of nitrogen (N) per 1000 ft^2 yr-1. Granular applications, ½ lb. of N 1000 ft^2, were applied mid-April and 5 days prior to September core cultivation. Granular applications were supplemented by liquid urea 0.2 lbs. N 1000 ft^2 applications applied approximately every 10-14 days from June through early September. Liquid applications also included trinexapac-ethyl (Primo Maxx) at 6 fl. oz/Acre alternated with trinexapac-ethyl +flurprimidol (Legacy) at 10 fl. oz/A and a commercially available liquid chelated iron product. The study area was mowed daily mid-April - Oct. with a triplex mower set to 0.140 inches. The study area was irrigated to promote growth via an overhead irrigation system to supplement natural rainfall. Sand topdressing was applied five times during the growing season, approximately 0.5 cu. ft. 1000 ft^2 and core cultivation occurred in September with cores removed. Fungicides were applied primarily to control dollar spot on a curative basis using chlorothalonil alone or a propiconazole+chlorothalonil tank-mix.

Data collected included visual ratings, approximately twice monthly during active growth, for putting green quality on a 1-9 scale where; 1=poor, 9=optimum greenness, density and uniformity and 6=acceptable putting surface. Genetic color, shoot density and leaf texture were also rated on a 1-9 scale where 9=best. Additionally, disease incidence and severity was periodically evaluated. Two diseases were rated in 2011, pink snow mold (Microdochium spp. patch) and dollar spot. Pink snow mold was evaluated on a 1-9 scale where 9=no disease present and 1=severe plot blight and percentage plot affected. Dollar spot was assessed by counting the number of infection centers per plot.

Each cultivar was replicated three times in 4 x 6 plots arranged in a randomized complete block design. Data was subjected to analysis of variance using the SAS (Statistical Analysis Systems, SAS Institute, Cary, NC) and treatment means separated using Fisher's protected LSD at p=0.05.

Results and Discussion

Visual turfgrass quality: (Tables 2 and 3)

- After three consecutive seasons of ratings eight cultivars ranked in the top statistical category for visual appearance or turfgrass quality. These include: V8, PST-OJO, MacKenzie/Tyee blend, T-1, A08-TDN2, Tyee/007 blend, 007 and MVS-AP-101.
- When evaluating quality for only the summer period (mid-June through mid-Sept.) 14 cultivars were in the top statistical category. These include: V8, PST-OJO, A08-TDN2, T-1, MVS-AP-101, MacKenzie/Tyee blend, Tyee/007 blend, 007, SR1150, SRP-1WM, Declaration/007 blend, Tyee, Declaration and LTP-FEC

Disease incidence: (Table 4):

- These cultivars were most susceptible to dollar spot: T-1, PST-OJO, Cato/Backspin/Mariner/96-2, Cato/Backspin, Penncross/A-4 SRP-1BLTR3, 96-2, and Backspin
- These cultivars were most susceptible to pink snow mold: Penn A-4 and Penn G-2

Figure 1. Overview of the bentgrass putting green cultivars and cultivar response to disease. Photo: 16 March, 2011

Table 1. Overview of the bentgrass cultivars, species and seed sources.

Entry	Cultivar†	Species‡	Seed Source¶	Entry	Cultivar	Species	Source
1	Penncross	CBG	Standard entry	26	Southshore	CBG	Jacklin Seed (Simplot)
2	Penn A-1	CBG	Standard entry	27	LS-44	CBG	Virginia Lehman
3	SR7200	VLT	Standard entry	28	Tyee	CBG	Seed Research
4	Declaration	CBG	Standard entry	29	007	CBG	Seed Research
5	Proclamation (LTP-FEC)	CBG	Lebanon Seabord Corp.	30	MacKenzie	CBG	Seed Research
6	L-93	CBG	Standard entry	31	Cato	CBG	Pickseed
7	T-1	CBG	Jacklin Seed (Simplot)	32	Mariner	CBG	Pickseed
8	Alpha	CBG	Jacklin Seed (Simplot)	33	96-2	CBG	Pickseed
9	Penn A-2	CBG	John Deere Landscapes	34	Backspin	CBG	Turf Merchants
10	MVS-AP-101	CBG	Mountain View Seeds	35	SR1150	CBG	Seed Research
11	A08-TDN2	CBG	The Scotts Co.	36	SRP-1WM	CBG	Seed Research
12	AFM	CBG	John Deere Landscapes	37	Dominant X-treme	CBG	Seed Research
13	Authority	CBG	John Deere Landscapes	38	MacKenzie/Tyee	CBG	Seed Research
14	SRP-1GMC	CBG	Seed Research	39	Tyee/007	CBG	Seed Research
15	SRP-1BLTR3	CBG	Seed Research	40	Penn A-1/A-4	CBG	Tee-2-Green
16	PST-OJO	CBG	Penncross Bentgrass Assoc.	41	Southshore/L-93	CBG	Jacklin (Simplot)
17	V8	CBG	Jacklin Seed (Simplot)	42	A-4/Declaration	CBG	---
18	Pin-up (HTM)	CBG	ProSeeds Marketing	43	Backspin/Declaration	CBG	---
19	Villa	VLT	NTEP Standard entry	44	Penncross/A-4	CBG	---
20	PennG-2	CBG	Tee-2-Green	45	Penncross/A-4/L-93	CBG	---
21	PennA-4	CBG	Tee-2-Green	46	Cato/Backspin	CBG	---
22	Pennlinks II	CBG	Tee-2-Green	47	Cato/Backspin/Mariner/96-2	CBG	---
23	Penneagle II	CBG	Tee-2-Green	48	Southshore/L-93/Declaration	CBG	---
24	Crystal Blue Links	CBG	Tee-2-Green	49	Declaration/007	CBG	---
25	Putter	CBG	Jacklin Seed (Simplot)	50	Declaration/A-4/Alpha/T-1	CBG	---

Entries 1-19 are all part of the National Turfgrass Evaluation Program (NTEP) official putting green trial.

† All cultivars except LS-44 were originally planted on 8 Sept., 2008 at 1 # seed/1000 ft^2, LS-44 was seeded on 4 Oct., 2008.

‡CBG=Creeping bentgrass, VLT=velvet bentgrass

¶ Seed sources were a combination of the National Turfgrass Evaluation Program 2008 putting green trial, individual seed companies and blends of cultivars of personal interest. All cultivar blends were assembled using equal amounts of each cultivar on a per weight basis.

Table 2. Mean annual visual turfgrass quality ratings for bentgrass cultivars and cultivar blends grown on a sand-based research putting green. Purdue University, 2011.

		Rating period			
		----------- Putting green quality (1-9 scale) ¶ ----------			
V8	CBG	8.4	7.3	8.2	8.0
PST-OJO	CBG	8.2	7.5	7.9	7.9
MacKenzie/Tyee	CBG	7.6	7.9	7.9	7.8
T-1	CBG	7.9	7.2	8.0	7.7
A08-TDN2	CBG	7.9	7.6	7.6	7.7
Tyee/007	CBG	7.5	7.6	7.7	7.6
007	CBG	7.8	7.3	7.8	7.6
MVS-AP-101	CBG	8.0	7.0	7.7	7.6
SRP-1WM	CBG	8.0	6.8	7.8	7.5
SR1150	CBG	7.7	7.4	7.5	7.5
Declaration/007	CBG	7.8	7.2	7.6	7.5
Declaration	CBG	7.9	6.8	7.8	7.5
Proclamation (LTP-FEC)	CBG	7.8	7.2	7.4	7.5
Tyee	CBG	7.4	7.3	7.6	7.5
HTM	CBG	7.4	7.2	7.7	7.4
Authority	CBG	7.4	6.9	8.0	7.4
Dominant X-treme	CBG	7.4	7.1	7.6	7.4
SRP-1GMC	CBG	7.4	6.9	7.8	7.3
Crystal Blue Links	CBG	7.3	6.9	7.6	7.2
A-4/Declaration	CBG	7.5	6.7	7.4	7.2
Backspin/Declaration	CBG	7.4	6.7	7.5	7.2
Alpha	CBG	7.1	7.0	7.4	7.2
AFM	CBG	6.9	6.9	7.7	7.2
Declaration/A-4/Alpha/T-1	CBG	7.3	6.8	7.4	7.2
Penneagle II	CBG	6.9	6.9	7.5	7.1
SRP-1BLTR3	CBG	6.9	6.8	7.6	7.1
Penn A-1/A-4	CBG	7.2	6.5	7.5	7.1
Penn A-4	CBG	6.9	6.6	7.6	7.0
Penn A-1	CBG	7.0	6.4	7.5	7.0
Backspin	CBG	6.8	6.7	7.3	6.9
MacKenzie	CBG	7.0	6.7	7.1	6.9
L-93	CBG	6.7	6.5	7.3	6.9
96-2	CBG	6.6	6.7	7.2	6.8
Southshore/L-93/Declaration	CBG	6.8	6.4	7.1	6.8
Cato/Backspin	CBG	6.4	6.3	7.5	6.7
PennG-2	CBG	6.5	6.2	7.4	6.7
LS-44	CBG	6.7	5.8	7.1	6.7
Penn A-2	CBG	6.3	6.2	7.2	6.6
Penncross/A-4/L-93	CBG	6.5	6.1	7.2	6.6
Penncross/A-4	CBG	6.4	5.7	7.3	6.5
Cato	CBG	6.4	5.8	7.0	6.4

Southshore/L-93	CBG	6.3	5.8	7.0	6.4
Cato/Backspin/Mariner/96-2	CBG	6.2	6.0	6.8	6.3
Putter	CBG	6.0	6.0	6.7	6.2
Villa	VLT	6.7	5.9	5.8	6.1
Pennlinks II	CBG	6.0	5.7	6.5	6.1
Southshore	CBG	5.8	5.6	6.4	5.9
SR7200	VLT	6.5	5.4	5.8	5.9
Mariner	CBG	5.2	5.3	6.1	5.6
Penncross	CBG	5.2	4.8	6.0	5.3
LSD (0.05)		0.4	0.6	0.5	0.4

† All cultivars were originally planted on 8 Sept., 2008 at 1 # seed/1000 ft^2. LS-44 was not include in analysis due to the substantially slower establishment of this late-seeded cultivar.
‡CBG=Creeping bentgrass, VLT=velvet bentgrass
¶ Visual putting green quality was rated on a 1-9 scale where; 1=poor, 9=optimum greenness, density and uniformity and 6=acceptable putting surface.
*Means in the same column followed by the same letter are not significantly different according the LSD t-test (p=0.05).
Cultivars surrounded by the red box are in the highest statistical category for turfgrass quality. Those surrounded by the yellow box are all similar to Declaration, those surrounded by the blue box are all similar to Penn A-4 and those surrounded by the green box are similar to L-93.

Table 3. Mean summer visual turfgrass quality ratings for bentgrass cultivars and cultivar blends grown on a sand-based research putting green. Purdue University, 2011.

		Summer Rating period			
Cultivar†	Species‡	2009	2010	2011	3-yr Mean
		----------- Putting green quality (1-9 scale) ¶ ----------			
V8	CBG	8.6	7.1	8.2	7.9
PST-OJO	CBG	8.2	7.5	7.8	7.8
A08-TDN2	CBG	8.0	7.4	7.8	7.7
T-1	CBG	8.0	7.1	8.1	7.7
MVS-AP-101	CBG	8.1	7.0	8.0	7.7
MacKenzie/Tyee	CBG	7.6	7.9	7.7	7.7
Tyee/007	CBG	7.7	7.5	7.8	7.7
007	CBG	7.9	7.1	8.0	7.7
SR1150	CBG	7.8	7.3	7.8	7.6
SRP-1WM	CBG	8.2	6.4	8.2	7.6
Declaration/007	CBG	7.8	7.0	8.0	7.6
Tyee	CBG	7.4	7.4	7.8	7.5
Declaration	CBG	8.0	6.6	8.0	7.5
LTP-FEC	CBG	7.9	7.0	7.6	7.5
HTM	CBG	7.5	7.0	7.8	7.4
Authority	CBG	7.5	6.6	8.0	7.4
Dominant X-treme	CBG	7.5	6.9	7.7	7.3
A-4/Declaration	CBG	7.6	6.6	7.8	7.3
Crystal Blue Links	CBG	7.4	6.6	7.7	7.2
Alpha	CBG	7.3	6.9	7.5	7.2
Backspin/Declaration	CBG	7.5	6.5	7.7	7.2
SRP-1GMC	CBG	7.4	6.4	7.8	7.2
Penn A-1/A-4	CBG	7.4	6.4	7.8	7.2
SRP-1BLTR3	CBG	7.0	6.7	7.8	7.2
AFM	CBG	6.9	6.9	7.8	7.2
Declaration/A-4/Alpha/T-1	CBG	7.3	6.7	7.5	7.2
Penn A-4	CBG	7.0	6.5	7.8	7.1
Penneagle II	CBG	7.0	6.8	7.5	7.1
Backspin	CBG	7.0	6.8	7.4	7.1
MacKenzie	CBG	7.0	6.7	7.3	7.0
Penn A-1	CBG	7.0	6.3	7.7	7.0
L-93	CBG	6.9	6.3	7.6	6.9
96-2	CBG	6.8	6.5	7.4	6.9
Cato/Backspin	CBG	6.7	6.1	7.7	6.8
Southshore/L-93/Declaration	CBG	6.9	6.1	7.2	6.7
Penncross/A-4/L-93	CBG	6.6	6.0	7.6	6.7
Penn A-2	CBG	6.6	6.1	7.4	6.7
PennG-2	CBG	6.6	5.9	7.7	6.7
LS-44	CBG	6.9	5.5	7.4	6.6
Cato/Backspin/Mariner/96-2	CBG	6.4	6.1	6.9	6.5
Southshore/L-93	CBG	6.5	5.7	7.1	6.4

Penncross/A-4	CBG	6.4	5.6	7.2	6.4
Cato	CBG	6.5	5.5	7.0	6.3
Putter	CBG	6.1	5.9	6.8	6.3
Villa	VLT	6.9	5.8	5.8	6.2
Pennlinks II	CBG	6.0	5.4	6.7	6.0
Southshore	CBG	5.9	5.5	6.5	6.0
SR7200	VLT	6.6	5.1	5.9	5.9
Mariner	CBG	5.4	5.1	6.1	5.5
Penncross	CBG	5.3	4.7	6.0	5.3
LSD (0.05)		0.4	0.6	0.5	0.4

† All cultivars were originally planted on 8 Sept., 2008 at 1 # seed/1000 ft^2. LS-44 was not include in analysis due to the substantially slower establishment of this late-seeded cultivar.
‡CBG=Creeping bentgrass, VLT=velvet bentgrass
¶ Visual putting green quality was rated on a 1-9 scale where; 1=poor, 9=optimum greenness, density and uniformity and 6=acceptable putting surface. ***Summer*** *ratings were from mid-June through mid-September.*
*Means in the same column followed by the same letter are not significantly different according the LSD t-test (p=0.05).
Cultivars surrounded by the red box are in the highest statistical category for turfgrass quality. Those surrounded by the yellow box are all similar to Declaration, those surrounded by the blue box are all similar to Penn A-4 and those surrounded by the green box are similar to L-93.

Table 4. Visual disease ratings for bentgrass cultivars and cultivar blends grown on a sand-based research putting green. Purdue University, 2011.

		Disease rating¶		
		Michrodochium patch		Dollar spot
Cultivar†	Species‡	2010	2011	3-yr Mean
		% plot	1-9 scale	centers plot^{-1}
Pennlinks II	CBG	5.0	7.3	0.0
Declaration/A-4/Alpha/T-1	CBG	0.3	8.3	0.0
LTP-FEC	CBG	0.2	8.7	0.0
L-93	CBG	0.3	8.7	0.0
MVS-AP-101	CBG	0.0	9.0	0.0
SRP-1WM	CBG	0.0	9.0	0.0
Declaration/007	CBG	0.0	9.0	0.0
HTM	CBG	0.0	9.0	0.0
A-4/Declaration	CBG	0.0	9.0	0.0
LS-44	CBG	0.0	9.0	0.0
Villa	VLT	0.0	9.0	0.0
PennG-2	CBG	7.5	6.3	0.3
V8	CBG	1.7	8.0	0.3
MacKenzie/Tyee	CBG	0.4	8.0	0.3
Authority	CBG	0.8	8.0	0.3
A08-TDN2	CBG	0.2	8.7	0.3
007	CBG	0.1	8.7	0.3
Declaration	CBG	0.0	9.0	0.3
SRP-1GMC	CBG	0.0	9.0	0.3
Backspin/Declaration	CBG	0.0	9.0	0.3
Crystal Blue Links	CBG	0.7	8.3	0.7
AFM	CBG	0.0	9.0	0.7
Penncross	CBG	0.1	9.0	0.7
Penn A-1/A-4	CBG	0.1	8.7	1.0
Tyee	CBG	0.0	9.0	1.0
Southshore/L-93/Declaration	CBG	0.0	9.0	1.0
Southshore/L-93	CBG	0.0	9.0	1.0
Penneagle II	CBG	3.2	7.3	1.3
SR1150	CBG	0.8	8.3	1.3
SR7200	VLT	0.0	8.7	1.3
Dominant X-treme	CBG	0.2	8.7	2.0
Penn A-2	CBG	0.1	8.7	2.3
Putter	CBG	0.1	8.7	2.3
Southshore	CBG	0.0	9.0	2.3
Tyee/007	CBG	0.1	8.7	3.0
MacKenzie	CBG	0.0	9.0	3.0
Penn A-1	CBG	0.8	8.3	3.3
Penn A-4	CBG	25.3	5.7	4.3
Penncross/A-4/L-93	CBG	0.0	9.0	4.3
Cato	CBG	0.0	9.0	5.0

Mariner	CBG	1.0	8.3	5.3
Alpha	CBG	0.7	8.0	6.3
T-1	CBG	3.4	7.0	6.7
PST-OJO	CBG	0.2	8.7	7.0
Cato/Backspin/Mariner/96-2	CBG	0.0	9.0	8.3
Cato/Backspin	CBG	0.0	9.0	8.7
Penncross/A-4	CBG	0.1	8.7	9.0
SRP-1BLTR3	CBG	0.0	9.0	11.7
96-2	CBG	0.3	8.3	16.0
Backspin	CBG	0.0	9.0	17.0
LSD (0.05)		10.5	1.7	6.3

† All cultivars were originally planted on 8 Sept., 2008 at 1 # seed/1000 ft^2. LS-44 was not include in analysis due to the substantially slower establishment of this late-seeded cultivar.
‡CBG=Creeping bentgrass, VLT=velvet bentgrass
¶ Disease was visually rated for *Michrodochium* patch and dollar spot. *Michrodochium* patch was rated on a 1-9=no disease scale and also for percentage plot affected. Dollar spot was rated on the number of infection centers per plot..
*Means in the same column followed by the same letter are not significantly different according the LSD t-test (p=0.05).

Diverse Responses of Perennial Ryegrass Accessions to Submergence Stress

PURDUE
UNIVERSITY
TURFGRASS SCIENCE

Xiaoqing Yu and Yiwei Jiang, Department of Agronomy, Purdue University

SUMMARY: Submergence can severely affect the growth of perennial grasses. The objective of this study was to characterize the responses of perennial ryegrass (*Lolium perenne* L.) accessions to submergence and its recovery following de-submergence. One hundred globally collected perennial ryegrass accessions were submerged for 7 d followed by 7 d of recovery, respectively. The accessions were generally grouped into three types: fast growth with maintenance of color (escape), slow growth with maintenance of color (quiescence), and slow growth with loss of color (susceptible). Diverse responses of perennial ryegrass accessions to submergence are useful in creating more tolerant materials and in further characterizing physiological and molecular mechanisms of submergence tolerance.

Turfgrass management and production is largely influenced by climate variability and weather extremes. The increased frequency of flooding negatively affects grass quality. Grass plants can be exposed to either waterlogged or submerged conditions after a flooding event. Submergence describes the condition in which the whole plant is completely covered by water after a flooding event. Plants can die more quickly under submergence due to a lack of oxygen. Submergence stress either inhibits or enhances plant growth, depending on type of species and survival strategies on growth characteristics under water (Bailey-Serres and Voesenek, 2008). The variable growth and physiological responses of different perennial grass species and ecotypes to submergence stress provide an important basis for identifying molecular mechanisms of submergence tolerance and molecular markers linked to stress tolerance.

Grass species, water depth, light levels, and temperature may all have an impact on plant survival under excess water conditions. A few reports have illustrated the effects of various flooding stresses on perennial grass physiology. Water levels occurring at 15-, 5-, and 1-cm below the soil surface all significantly decreased turf quality, chlorophyll concentration, root water-soluble carbohydrate, and soluble protein concentrations in five creeping bentgrass (*Agrostis palustris* L.) cultivars, but to a lesser extent in tolerant cultivars (Jiang and Wang, 2006). Ten Kentucky bluegrass (*Poa pratensis* L.) cultivars varied largely in shoot dry weight, chlorophyll concentration, and cell membrane leakage under flooding stress occurring at the soil surface (Wang and Jiang, 2007). These results demonstrate the differential responses of perennial grass species and cultivars to various flooding stresses. Further research is needed to explore phenotypic responses of diverse ecotypes within a perennial grass species to submerged conditions and recovery following stress.

ADDITIONAL INDEX WORDS:
Flooding, Growth, Physiology, Tolerance

Yu, X., and Y. Jiang. 2012. Diverse Responses of Perennial Ryegrass Accessions to Submergence Stress. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 10-13.

Perennial ryegrass is one of the most important cool-season turf grasses. This grass has world-wide distribution, diverse germplasm, diploid genetics, and available genomic resources, thus providing a good model for further study of the genetic basis of flooding tolerance. The objective of this study was to characterize the responses of perennial ryegrass germplasm to submergence and its recovery following de-submergence. The results will be valuable for identifying the molecular mechanisms of submergence tolerance

Materials and Methods

One hundred accessions of perennial ryegrass were initially planted in a greenhouse at Purdue University, West Lafayette, IN, USA. Ninety-nine accessions were finally used for the analysis including 32 wild, 36 cultivated, and 31 uncertain materials from 41 countries. The seeds were sown in plastic pots (4-cm diameter, 9-cm deep) containing a sandy-loam soil with a pH of 6.9 in a greenhouse, and each accession was propagated through multiple times. Plants were watered daily and fertilized once a week with a soluble fertilizer (N- P2O5-K2O, 24-8-16) (Scotts Inc., Marysville, OH, USA) to provide 240 kg N ha^{-1}, 33 kg P ha^{-1}, 132 kg K ha^{-1} and micronutrients. During the growing periods, the average day air temperatures and photosynthetic photon flux density (PPFD) in the greenhouse were 19.3 ± 1.5 ºC and 200 µmol m^{-2} s^{-1}, respectively. Experiment lasted from Oct. 6 to Nov. 28 of 2009.

Submergence stress was imposed by submerging the grass pots in (86 cm length × 38cm width × 30 cm height) plastic containers with tap water. The water level was kept at 5 cm below the top of the container. The control pots were placed in the same size containers without water. The stress treatments began on Nov. 14 of 2009. No nutrients were supplied to the plants during the treatment. The water was not changed but algae were removed if they accumulated. After 7 d of stress, the submerged plants were taken out for recovery for 7 d. Upon recovery, water and nutrients were then applied to both the control and the stressed plants at the rate described previously. To identify growth exclusively achieved under submergence or after recovery, all plants were cut to 5-6 cm prior to stress or before recovery to obtain a uniform height. Plant height in each pot was recorded. During the periods of submergence stress, the average air and water temperatures and PPFD were 19.8 ± 1.0 °C, 17.5 ± 0.8 °C, and 113 µmol m^{-2} s^{-1}. During recovery, the average air temperatures and PPFD were 20.5 ± 0.6 °C and 100 µmol m^{-2} s^{-1}.

At the end of the 7 d treatments, plant height (HT) was measured by recording the longest leaf blade. At 7 d, the leaves corresponding to this HT were cut and the tissues were dried in an oven at 80°C for 3 d. The absolute growth rate (GR) was calculated as dry weight per day during a 7-d period for all treatments. The total water-soluble carbohydrate (WSC) was measured in the selected accessions that represented different types of tolerant and susceptible groups of perennial ryegrass accessions under submergence condition. The WSC was measured using the anthrone method (Koehler, 1952) with some modifications. The WSC was extracted from 20-50 mg of leaf power with 1 mL double distilled water. The extract was shaken for 10 min and centrifuged at 11,000 × g for 10 min, and the supernatant was collected. The extraction was repeated two more times and the supernatant was pooled. A 1 mL of extract was mixed with 7 mL freshly prepared anthrone [200 mg anthrone + 100 mL 72% (w/w) H_2SO_4] and placed in a boiling water bath for 8 min. After cooling, the absorbance at 625 nm was read. The standard curve was made using glucose in a range of 5 to 300 µg mL^{-1}.

The experiment was a split plot design in two treatments (control and submergence) by 100 accessions of factorial arrangements. One accession had been dropped during statistical analysis because too many numbers were missing. Each accession and treatment was replicated three times and three benches represented three replicates for each accession. The pots were completely randomly assigned into five containers within the control or submerged regime for each bench, respectively. During the recovery period, both the control and submerged grasses were also arranged in the same way as described previously. Statistical analysis was performed using SAS (SAS Institute Inc., Cary, NC, USA).

Results and Discussion

Large variations in HT and GR of perennial ryegrass were observed under the control and submergence stress. Compared to the pattern of the controls, the overall distribution in HT and GR shifted towards a high frequency of lower values across accessions under submergence stress (Fig. 1). For example, approximately 20 % of the accessions had an HT of 9 to 10 cm under the control condition, while approximately 25 % of the accessions had an HT of 7 to 8 cm under the submergence stress. The decreased leaf elongation in perennial ryegrass was consistent with other reports demonstrated in common reed [(*Phragmites australis* (Cav.) Trin. ex Steud.] seedlings (Mauchamp et al., 2001) and bermudagrass (*Cynodon dactylon* L.) (Tan et al., 2010). After 7 d re-submergence, the overall distribution in HT and GR shifted towards a high frequency of higher values (Fig. 1).

Escape (T1), quiescence tolerance (T2), and susceptible types (ST) of perennial ryegrass accessions were generally identified under the submergence conditions. An increased 0.37 cm of HT was observed for T1 under stress, indicating submergence-induced elongation. T1 had higher HT and GR than T2 and ST under stress (Fig. 2). Compared to the control, a 49 % reduction in GR was observed in ST (Fig. 2). The plants with an escape strategy respond to submergence by enhanced shoot elongation. This escape strategy is advantageous in shallow floodwaters in which the shoot elongation allows plants to re-establish air contact (Luo et al., 2011). In contrast, when submerged, the shoots of quiescence type (T2) do not elongate to conserve energy, which could positively affect the survival rate and generation of new tissues after de-submergence (Panda et al., 2008; Colmer and Voesenek, 2009).

Relative to their respective controls, submergence significantly decreased WSC concentration by 57 %, 64 %, and 66 % for T1, T2, and ST, respectively. The relatively higher levels of WSC observed in T1 could be beneficial for submergence tolerance. In Kentucky bluegrass, shoot WSC concentration was reduced in some cultivars under soil waterlogging conditions along with a decline in grass quality (Wang and Jiang, 2007). The levels of non-structure carbohydrates after submergence are strongly associated with seedling survival in other species such as rice (*Oryza sativa* L.) (Das et al., 2005).

In summary, large phenotypic variations in HT, GR and WSC were found in diverse perennial ryegrass accessions in response to submergence. The escape and quiescence types of submergence responses were identified within perennial ryegrasses. The escape type generally had faster growth than the quiescence- and- susceptible types of plants under stress. The escape type had higher WSC concentration than the susceptible plants. The results can be used to further study physiological and molecular mechanisms contributing to submergence tolerance.

References

Bailey-Serres, J., and L.A.C.J. Voesenek. 2008. Flooding stress: Acclimations and genetic diversity. Ann. Rev. Plant Biol. 59:313-319.

Colmer, T.D., and L.A.C.J. Voesenek. 2009. Flooding tolerance: Suites of plant traits in variable environmental. Func. Plant Biol. 36:665-681.

Das, K. K., R.K. Sarkar, and A.M. Ismail. 2005. Elongation ability and non-structural carbohydrate levels in relation to submergence tolerance in rice. Plant Sci. 168:131-136.

Jiang Y, and K. Wang. 2006. Growth, physiological, and anatomical responses of creeping Bentgrass cultivars to different depths of waterlogging. Crop Sci. 46:2420-2426.

Koehler, L.H. 1952. Differentiation of carbohydrates by anthrone reaction rate and color intensity. Anal. Chem. 24:1576-1579.

Luo, F., K.A. Nagel, H. Scharr, B. Zeng, U. Schurr, and S. Matsubara. 2011. Recovery dynamics of growth, photosynthesis and carbohydrate accumulation after de-submergence: A comparison between two wetland plants showing escape and quiescence strategies. Ann. Bot. 07:49-63.

Mauchamp, A., S. Blanch, and P. Grillas. 2001. Effects of submergence on the growth of Phragmites australis seedlings. Aquat. Bot. 69:147–164.

Panda, D., S.G. Sharma, R.K. Sarkar. 2008. Chlorophyll fluorescence parameters, CO2 photosynthetic rate and regeneration capacity as a result of complete submergence and subsequent re-emergence in rice (*Oryza sativa* L.). Aquat Bot. 88:127-133.

Tan, S., M. Zhu, and Q. Zhang. 2010. Physiological responses of bermudagrass (*Cynodon dactylon*) to submergence. Acta Physiol Plant. 133-140.

Wang, K, and Y. Jiang. 2007. Waterlogging tolerance of Kentucky bluegrass cultivars. HortScience 43:386-390.

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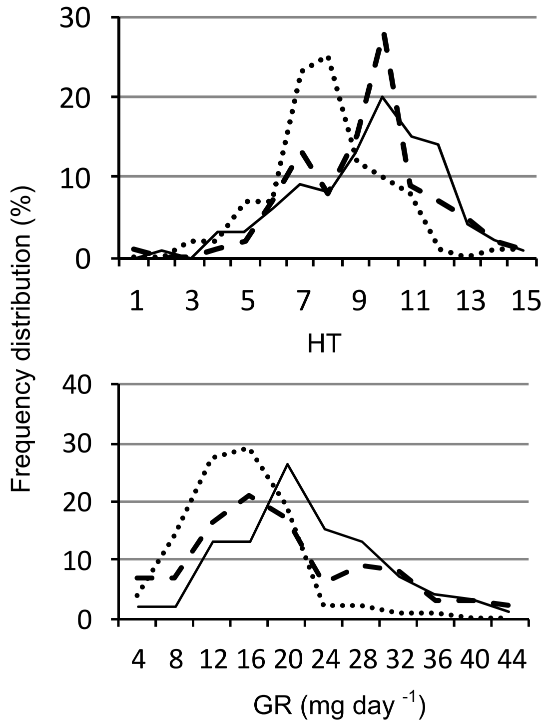

Fig. 1. Frequency distributions in maximum plant height (HT) and growth rate (GR) of 99 accessions of perennial ryegrass under the control (solid line), submergence (dots), and recovery (dash line) conditions.

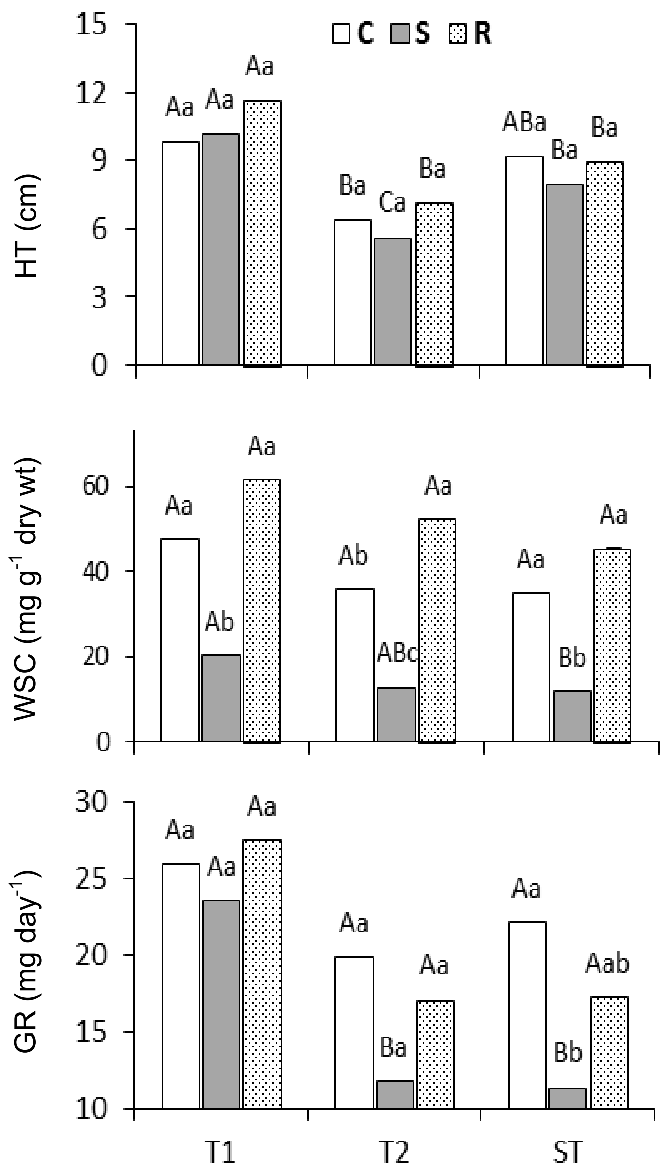

Fig. 2. Effects of submergence and recovery on plant height (HT), total water-soluble carbohydrate (WSC), and growth rate (GR) in perennial ryegrasses. C, S, and R represent the control, submergence and recovery, respectively. T1, T2, and ST represent escape tolerant, quiescence tolerant, and susceptible type, respectively. Data were averaged by four accessions for T1 and T2 and five accessions for ST, respectively. Means followed by same small letter are not significantly different at $P < 0.05$ within treatments for a given type of plant. Means followed by the same capital letter are not significantly different at $P < 0.05$ among type of plants for a given treatment.

Controlling *Poa annua* on putting green height turf in Indiana, Michigan, and Nebraska: 2011 Research Update

Purdue University
Turfgrass Science

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Summary: Annual bluegrass (*Poa annua*) is the most troublesome and probably the most studied weed on golf courses throughout the United States. A number of herbicides and growth regulators are labeled and effective for *Poa annua* control on fairway height turf including bispyribac-sodium (Velocity), ethofumesate (Prograss), flurprimidol (Cutless) and paclobutrazol (Trimmit). As turfgrass extension specialists, we often enter discussions about how to limit or control annual bluegrass on putting greens and how control varies from one location to another. We are evaluating seven season-long treatments of growth regulators or herbicides to control annual bluegrass on putting greens. By completing identical studies at multiple locations that differ widely geographically, we are able to extrapolate our results to a large portion of the United States. The three best treatments improved annual bluegrass control vs. the untreated check on 36% of the rating dates over multiple locations and three years. Velocity at 2 oz/A applied 4 times, Trimmit, and Cutless were the best performers across all years and locations; however, the results are variable by location. This may help explain the highly variable anecdotal results from superintendents across the country and support the fact that a superintendent may have to experiment to find the best treatment for controlling annual bluegrass at their location.

Annual bluegrass (*Poa annua*) is the most troublesome and probably the most studied weed on golf courses throughout the United States. A number of herbicides and growth regulators are labeled and effective for *Poa annua* control on fairway height turf including bispyribac-sodium (Velocity), ethofumesate (Prograss), flurprimidol (Cutless) and paclobutrazol (Trimmit, TGR). As turfgrass extension specialists, we often enter discussions about how to limit or control annual bluegrass on putting greens. Outside of the typical cultural methods for exclusion on new putting greens, we have little confidence in using growth regulators or herbicides on greens north of the transition zone because of labeling issues and the following three reasons:

Additional index words:
bispyribac; cumyluron; Cutless; ethofumesate; flurprimidol; paclobutrazol; Primo; Prograss; Trimmit; trinexapac-ethyl; Velocity.

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1. Most of the previous research was done on fairway height bentgrass which is more competitive with annual bluegrass and more tolerant of herbicides or growth regulators (Bigelow et al., 2007; Woosley et al., 2003).
2. Most of the previous plant growth regulator research was done with monthly applications and/or either summer or fall applications, unlike applications made every two weeks with today's standards (Isgrigg et al., 1999a, 1999b; Johnson and Murphy, 1995, 1996).
3. Most of the putting greens-height research was done in the southeast United States where annual bluegrass is likely more susceptible to control during the warmer summers (Isgrigg et al., 1999a, 1999b; Johnson and Murphy, 1995, 1996; Teuton et al., 2007).

Because of these issues, we are evaluating seven season-long treatments of growth regulators or herbicides to control annual bluegrass on putting greens. By completing identical studies at four locations that differ widely geographically, we are able to extrapolate our results to a large portion of the United States.

Materials and Methods

Plots of green-height annual bluegrass/creeping bentgrass were already established on putting greens that are mowed daily at 0.125" and sand-topdressed regularly. The areas receive 2.5 to 3.0 lbs N/1000 ft^2/yr. Treatments are applied in 2 gals water/1000 ft^2 and are listed in Table 1. Most of these treatments are within label limits with the exception of Velocity, and are based on superintendents and label recommendations as well as previous research experience. Treatment 3 is an experimental herbicide with potential for *Poa annua* control (Askew et al., 2009). Visual quality and percent cover of creeping bentgrass and annual bluegrass are recorded monthly and transect counts are taken in mid-May and mid-August, the expected high and low points for annual bluegrass populations, respectively. The transect counts minimize subjectiveness between rates and will allow reliable comparisons between years within locations and across locations. This study has been done on the same plots in West Lafayette, IN, and East Lansing, MI, in 2009-2011, Lexington, KY, in 2009-2010, and Lincoln, NE, in 2010-2011. We expect this study to continue one more year in IN, MI, and NE.

Results and Discussion

Annual bluegrass populations are naturally at a seasonal high in April or May, drop to a seasonal low in August and then return to a seasonal high the following spring. Our data show that regardless of treatment, annual bluegrass cover dropped dramatically over the summer to almost insignificant populations (Fig. 1). Therefore, one could deduce incorrectly that their control strategy is working if no untreated area for comparison is included on their golf course. Annual bluegrass control was highly variable from location to location and among years. Though data were recorded on 72 dates over the four locations and three years, treatment differences were only evident on 44 of the dates. This suggests that regardless of the control regime attempted, the superintendent will not see any detectable differences on 40% of the days the greens are examined. Therefore if an annual bluegrass control program is attempted, it is critical to manage expectations of the staff and other decision makers who might expect dramatic results.

The three best treatments improved annual bluegrass control vs. the untreated check on 36% of the rating dates over the four locations and three years (Table 1). Velocity at 2 oz/A applied 4 times, Trimmit, and Cutless were the best performers across all years and locations. Within locations, Trimmit has been the best performer at Purdue (Fig. 2), Trimmit and Cutless at Michigan State (Fig. 3), HM9530 and Velocity at 1 oz/ A at University of Kentucky, and Velocity at 2 oz/A at University of Nebraska (Fig. 4). These results not only help explain the highly variable anecdotal results from superintendents across the country, but also suggest that a superintendent may have to experiment to find the best treatment for controlling annual bluegrass at their location.

References

Askew, S. D., J. B. Willis, M. J. Goddard, and T. L. Mittlestead. 2009. Controlling Annual Bluegrass on Greens and Fairways with HM9930. WSSA Abstracts: 380.

Bigelow, C. A., G. A. Hardebeck, and B. T. Bunnell. 2007. Monthly flurprimidol applications reduce annual bluegrass populations in a creeping bentgrass fairway. Online. Applied Turfgrass Science doi:10.1094/ATS-2007-0508-02-RS.

Isgrigg, J. III, and F. H. Yelverton. 1999. New approaches to management of annual bluegrass in bentgrass putting greens. Proc Southern Weed Sci. Soc. 52:72.

Isgrigg, J. III, and F. H. Yelverton. 1999. Transition of *Poa annua* spp *reptans* infested bentgrass putting greens to monoculture bentgrass using plant growth regulators. Proc. Southern Weed Sci. Soc. 52:76-77.

Johnson, B. J. and T. R. Murphy. 1995. Effect of paclobutrazol and flurprimidol on suppression of *Poa annua* spp *reptans* in creeping bentgrass (*Agrositis stolonifera*) greens. Weed Tech. 10:705-709.

Johnson, B. J. and T. R. Murphy. 1996. Suppression of a perennial subspecies of annual bluegrass (*Poa annua* spp *reptans*) in a creeping bentgrass (*Agrositis stolonifera*) green with plant growth regulators. Weed Tech. 10:705-709.

Teuton, T. C., C. L. Main, J. C. Sorochan, J. S. McElroy, and T. C. Mueller. 2007. Annual bluegrass (*Poa annua*) control in creeping bentgrass (*Agrostis stolonifera*) putting greens with bispyribac-sodium. Weed Tech. 21:426-430.

Woosley, P. B., D. W. Williams, and A. J. Powell. 2003. Postemergence control of annual bluegrass (*Poa annua* spp. *reptans*) in creeping bentgrass (*Agrostis stolonifera*) turf. Weed Tech. 17:770-776.

Acknowledgements

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Table 1. Treatments used to control annual bluegrass in identical experiments in four states over 2009-2011. Out of the total 72 rating dates across all locations and years, the best performing treatments reduced annual bluegrass cover in 36% of the ratings.

Trt	Product	Rate	Application frequency	Application dates	Total applications per year	Percent of 2009-2011 dates where Poa cover < untreated check (72 total ratings in 4 states & 3 years)
1	Velocity WSP	1 oz/A	2 wks	May-Sep	8	26%
2	Velocity WSP	2 oz/A	2 wks	Aug-Sep	4	36%
3	HM9530	130 oz/A	5 mo	Apr, Aug	2	21%
4	Trimmit	8 oz/A 16 oz/A	2 wks 2 wks	Apr-May, Aug-Sep June-July	8 4	36%
5	Cutless	8 oz/A 16 oz/A	2 wks 2 wks	Apr-May May-Aug	5 7	36%
6	Legacy	10 oz/A	2 wks	Apr-Sep	12	21%
7	Primo	11 oz/A	2 wks	Apr-Sep	12	14%
8	Check	-	-	-	-	0%

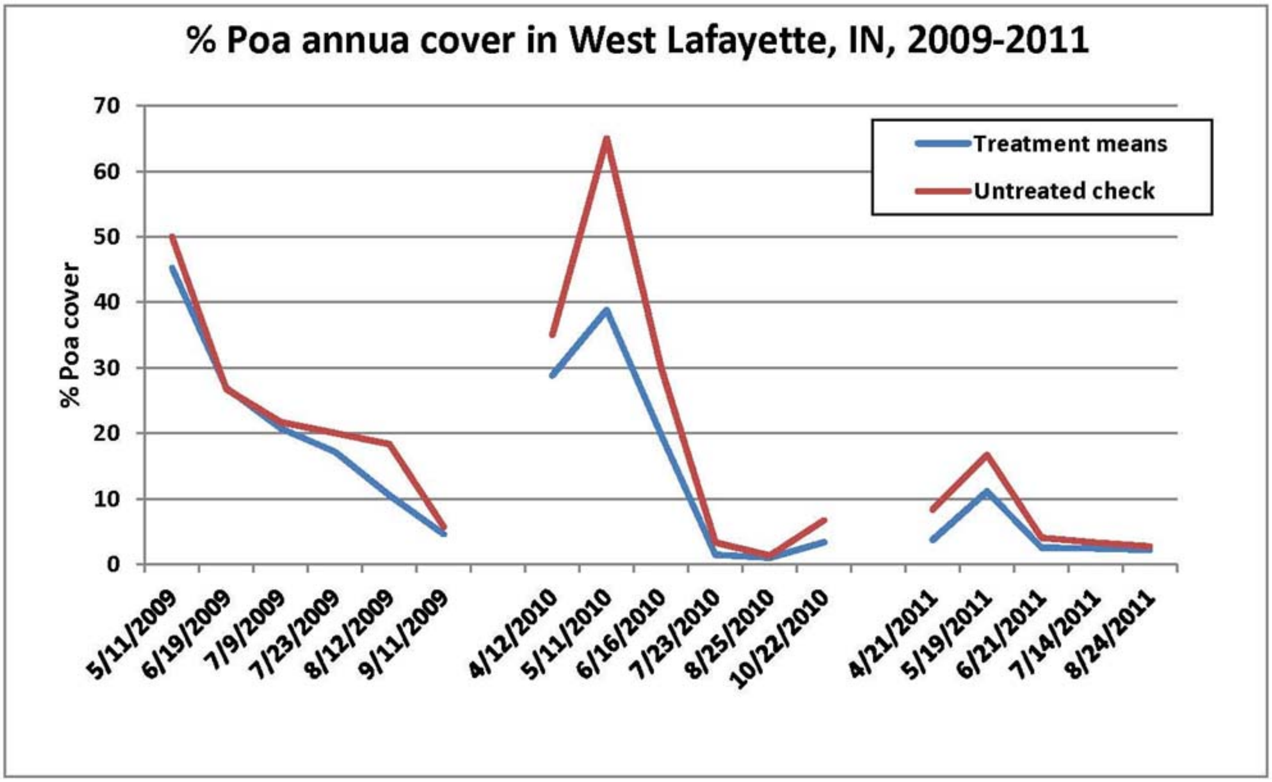

Figure 1. Percent cover of *Poa annua* visually rated in 2009-2011 in Indiana. Cover of the treatments was averaged over the 7 treatments. Regardless of treatment, *Poa annua* cover decreases naturally in August. This suggests that success of *Poa annua* control strategies could be misinterpreted as successful if untreated areas are not included for comparison.

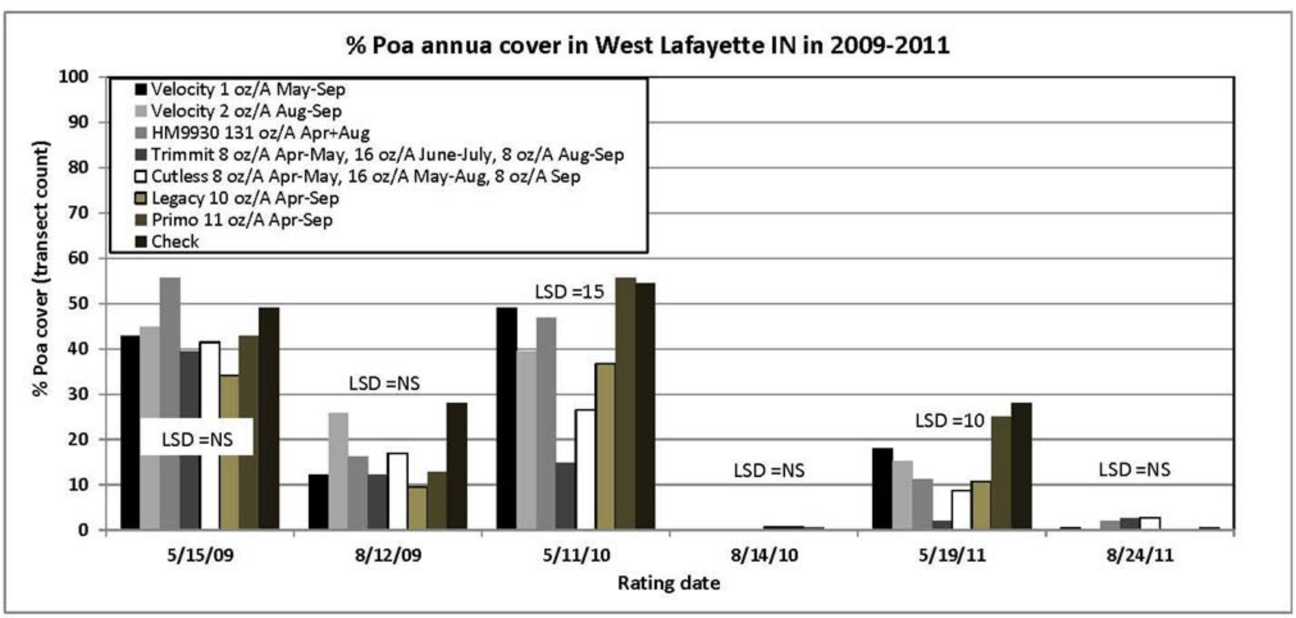

Figure 2. Percent *Poa annua* cover in Indiana 2009-2011. *Poa annua* cover was counted using a transect and then converted to percent cover. Trimmit was the best performing treatment in Indiana.

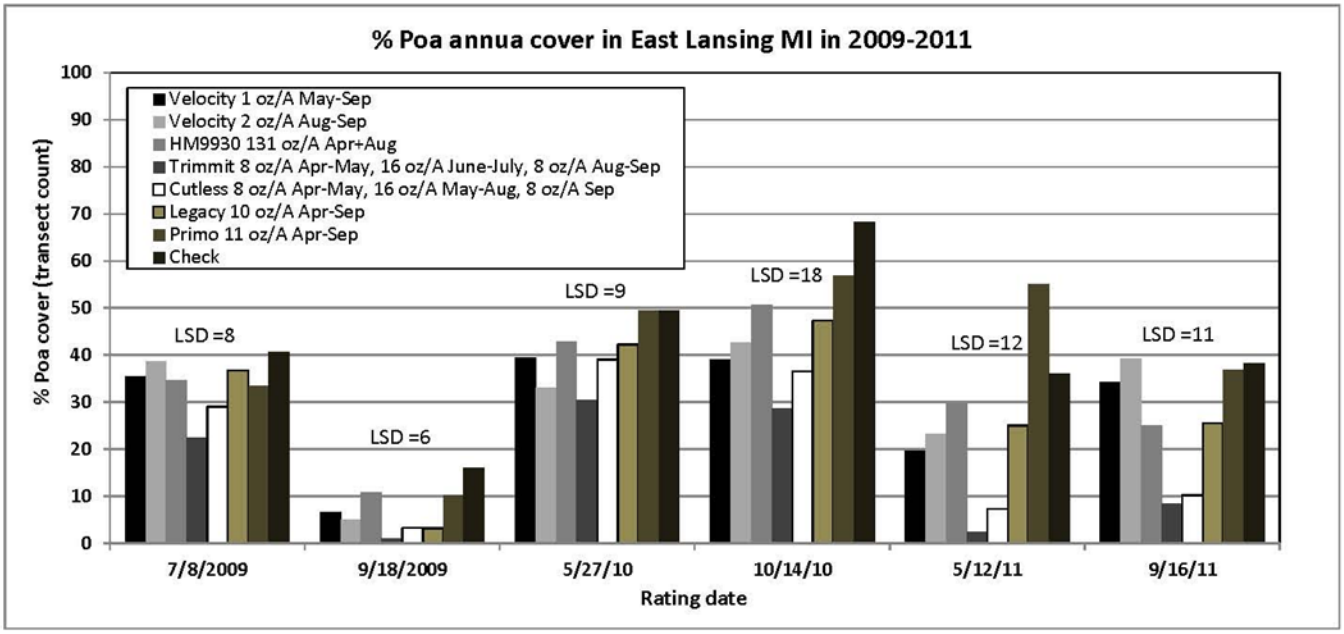

Figure 3. Percent *Poa annua* cover in Michigan 2009-2011. *Poa annua* cover was counted using a transect and then converted to percent cover. Trimmit and Cutless were the best performing treatments in Michigan to date.

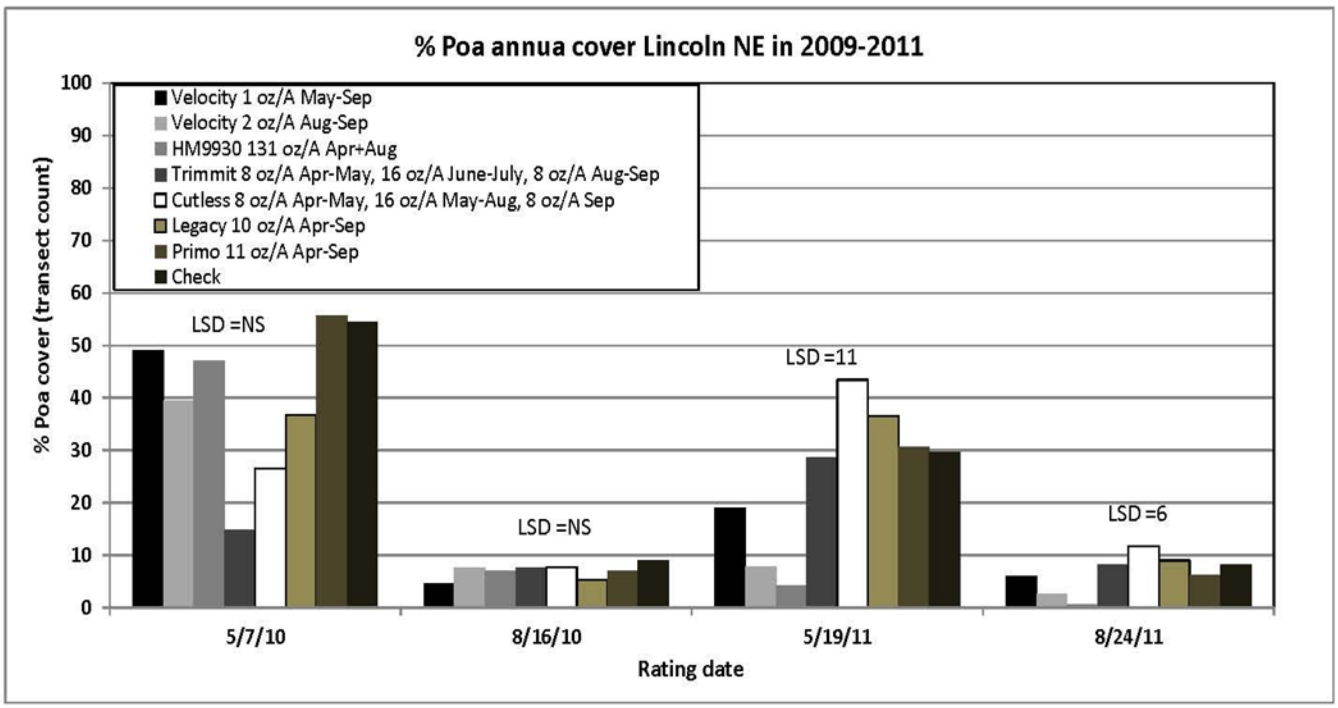

Figure 4. Percent *Poa annua* cover in Nebraska 2010-2011. *Poa annua* cover was counted using a transect and then converted to percent cover. Velocity applied four times at 2 oz/Acre was the best performing treatment to date.

Controlling Yellow Nutsedge With Sedgehammer+

PURDUE UNIVERSITY
TURFGRASS SCIENCE

Aaron Patton and Dan Weisenberger, Department of Agronomy, Purdue University

SUMMARY: Yellow nutsedge (*Cyperus esculentus*) is the primary sedge species found in Indiana and it is a tough to control perennial weed in turf. Yellow nutsedge is especially problematic in wet, poorly drained areas. Unfortunately, there are no cultural controls (mowing, fertilizer, etc.) effective at combating this weed other than efforts to reduce soil moisture, thus herbicides are required for control. Regardless of herbicide selection, yellow nutsedge will require multiple applications for control. SedgeHammer (halosulfuron) is an effective yellow nutsedge herbicide that is safe on all turf species but requires the addition of a non-ionic surfactant for best results. The objective of this experiment was to evaluate a new formulation of Sedgehammer+ (halosulfuron + surfactant), which contains a surfactant, for control of yellow nutsedge. SedgeHammer+ provided control higher than Dismiss (sulfentrazone) at 8 oz/A after a single application, but following the sequential application of both herbicides on 12 July their control was equivalent for the remainder of the growing season. These results confirm the efficacy of a new halosulfuron formulation (SedgeHammer+) is effective for controlling yellow nutsedge. The product became available in 2011 and is sold in prepackaged sizes for treating 1,000 ft^2 of turf.

Yellow nutsedge (*Cyperus esculentus*) is the primary sedge species found in Indiana and it is a tough to control perennial weed in turf. Yellow nutsedge is especially problematic in wet, poorly drained areas. Therefore, reducing irrigation and promoting drainage will help reduce yellow nutsedge, but it will survive in areas not overwatered or wet.

Different than broadleaf weeds and grasses, sedges have a triangular shaped stem and have leaves arranged in groups of three. Yellow nutsedge has shiny, green leaves, a finely-pointed leaf tip, and no ligule or collar (unlike grasses). The seedhead for yellow nutsedge is not often visible in mown areas, but when produced in unmown areas can be easily identified by its yellow or golden color.

Yellow nutsedge emerges in Indiana in late April to early May but often does not become visible in turf until late May. Most often, yellow nutsedge is identified in the summer months when the growth rate of its yellow-green leaves exceeds that of the surrounding turf areas making it easily visible.

ADDITIONAL INDEX WORDS:
Cyperus esculentus; Dismiss; halosulfuron; sulfentrazone.

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The survival structure from which yellow nutsedge germinates and emerges from annually each spring is a tuber (also called a nutlet). These tubers are produced by the plant in the soil about 4-8 inches deep at the end of each summer. Weed control programs with herbicide applications before mid-summer (July) are most effective. Unfortunately, there are no cultural controls (mowing, fertilizer, etc.) effective at combating this weed other than efforts to reduce soil moisture, thus herbicides are required for control. Mechanical or hand removal of sedges can be effective but only if the underground tubers are removed along with the above ground foliage.

Regardless of herbicide selection, yellow nutsedge will require multiple applications for control. SedgeHammer (halosulfuron) is an effective yellow nutsedge herbicide that is safe on all turf species but requires the addition of a non-ionic surfactant for best results. The objective of this experiment was to evaluate a new formulation of Sedgehammer+ (halosulfuron + surfactant), which contains a surfactant, for control of yellow nutsedge.

Materials and Methods

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The area was an established perennial ryegrass blend with a history of yellow nutsedge pressure. Experimental design was randomized complete block with four replications and an individual plot size of 25 ft^2. Plots were mown three time per week at 2 inches. Plots were treated with herbicides on 2 June and 12 July. Herbicides were applied in 87 gpa water with a CO_2-pressurized sprayer at 30 psi. Yellow nutsedge was visually rated. Injury to ryegrass was rated on a 9 to 1 scale with 9 = no injury, 7 = acceptable injury, and 1 = totally brown turf. All data were analyzed using SAS (SAS Institute, Inc). Means separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Results and Discussion

SedgeHammer+ provided effective control of yellow nutsedge throughout this experiment (Table 1). Although EdgeHammer+ was not compared to SedgeHammer 75DF in this experiment, others have confirmed these products provide similar efficacy (personal communication, Michigan State University). SedgeHammer+ provided control greater than Dismiss (sulfentrazone) at 8 oz/A after a single application, but following the sequential application of both herbicides on 12 July their control was equivalent for the remainder of the growing season (Table 1). Some injury was observed on 16 June (two weeks after the first application) from SedgeHammer+ (Table 2) although this injury was acceptable and short-lived. These results confirm the efficacy of a new halosulfuron formulation (SedgeHammer+) is effective for controlling yellow nutsedge. The product became available in 2011 and is sold in prepackaged sizes for treating 1,000 ft^2 of turf.

Table 1. Herbicide effect on yellow nutsedge coverage.

		Yellow Nutsedge Coverage					
Treatment[a]	rate	16 June	30 June	12 July	27 July	11 Aug	24 Aug
		%					
SedgeHammer+	19.84 oz/A	0 b[b]	2 b	6 b	2 b	1 b	1 b
Dismiss	8 oz/A	18 a	25 a	23 a	0 b	0 b	1 b
+NIS	0.25 % v/v						
Untreated		19 a	27 a	28 a	30 a	48 a	46 a
P-value		0.0339	0.0123	0.0246	<0.0001	0.0013	0.0009

[a] Treatments were applied 2 June and 12 July over the same plots.
[b] Within columns, means followed by the same letter are similar.

Table 2. Herbicide effect on injury to perennial ryegrass.

		Injury	
Treatment[a]	rate	16 June	30 June
SedgeHammer+	19.84 oz/A	8 b[b]	9
Dismiss	8 oz/A	9 a	9
+NIS	0.25 % v/v		
Untreated		9 a	9
P-value		<0.0001	NS

[a] Treatments were applied 2 June and 12 July over the same plots.
[b] Within columns, means followed by the same letter are similar.

Do Granular Herbicide Applications Effectively Control Broadleaf Weeds in Turf?

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Turfgrass Science

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Summary: Postemergence herbicides such as 2,4-D, MCPP and others are generally much more effective at controlling weeds when sprayed on the foliage than when applied as a granular herbicide/fertilizer combination product. Furthermore, when applied as a granule, these broadleaf herbicides more effectively control weeds when applied to moist foliage rather than dry turf. The reason for this is that most postemergence herbicides require foliar uptake. However, new herbicides that can be taken up through plant root systems may provide improved weed control as granules but this has not been sufficiently explored. The objectives of this experiment were to 1) determine which herbicides most effectively control ground ivy and white clover, 2) determine the best method of herbicide application, and 3) determine if any herbicide by application method interactions exist. Data from both weed species support that 1) when using traditional broadleaf herbicides that liquid applications are better than granular applications for controlling weeds, 2) granular applications to moist turf are more effective than granular applications to dry turf, and 3) new herbicides with root activity can control susceptible weeds equally well as liquid or granular applications. NOTE: State registration for Imprelis was cancelled and federal registration was later cancelled by the U.S. Environmental Protection Agency. This cancellation does not allow the continued use of Imprelis herbicide in the U.S. Any such applications are illegal.

Postemergence herbicides such as 2,4-D, MCPP and others are useful for weed control when sprayed on the foliage or when applied as a granular herbicide/ fertilizer combination product (Neal, 1993). When applied as a granule, these broadleaf herbicides more effectively control weeds when applied to moist foliage rather than dry turf (Jagschitz et al., 1983; Scott, 1995; Loughner and Nolting, 2012). The reason for this is that most postemergence herbicides require foliar uptake. Uptake of granular combination products can be improved if weed foliage is wet at the time of application such as in the early morning when dew is present or following an irrigation application as this helps the granules to stick to the weed foliage allowing the herbicide to enter the leaf tissue. Even when granular herbicides are applied to wet foliage, these products are still generally less effective than sprays (Neal, 1993). However, new herbicides that can be taken up through plant root systems may provide improved weed control when applied as granules but this has not been sufficiently explored. Ground ivy (Glechoma hederacea) and white clover (Trifolium repens) are problematic weeds in lawns and these species were selected for this experiment to 1) determine which herbicides (penoxsulam, aminocyclopyrachlor, and a mixture of 2,4-D + MCPP + dicamba) most effectively control ground ivy and white clover, 2) determine the best method (granules on wet turf, granules on dry turf, and liquid on dry turf) of herbicide application, and 3) determine if any herbicide by application method interactions exist.

Additional index words:
2,4-D; aminocyclopyrachlor; dicamba; Imprelis; Lockup; mecoprop; penoxsulam; Trimec; Sapphire.

Patton, A., and D. Weisenberger. 2012. Do Granular Herbicide Applications Effectively Control Broadleaf Weeds in Turf? 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 22-25.

Materials and Methods

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The first area was a Kentucky bluegrass (*Poa pratensis*) blend with a history of ground ivy pressure and the second area was a perennial ryegrass (*Lolium perenne*) blend with a history of white clover pressure. Experimental design was a 3 (herbicides) × 3 (turf wetness) factorial randomized complete block with three replications and an individual plot size of 25 ft^2. The three herbicides were Lockup (granular penoxsulam), Sapphire (liquid penoxsulam), Imprelis (aminocyclopyraclor granular and liquid), and Trimec (2,4-D + MCPP + dicamba, granular and liquid). The three application strategies were granules on wet turf, granules on dry turf, and liquid spray on dry turf. Plots were treated with herbicides on 12 October 2010. Herbicides were applied in 80 gpa water with a CO_2-pressurized sprayer at 30 psi. Plots were visually rated for ground ivy and clover coverage respectively. All data were analyzed using SAS (SAS Institute, Inc). Means separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Results and Discussion

For the majority of rating dates, ground ivy coverage was affected only by herbicide treatments (Table 1) with Imprelis. On 5 May 2011, following the 12 October 2010 applications a herbicide by application strategy interaction did exist due to difference in control from Trimec formulations where the liquid spray applications reduced ground ivy coverage most, followed by the granular Trimec application to wet turf, followed by granular Trimec application to dry turf (Table 2). This is consistent with our current understanding of how foliar uptake herbicides work and is consistent with previous research (Jagschitz et al., 1983; Neal, 1993; Scott, 1995; Loughner and Nolting, 2012).

Some difference within treatment were observed on the control of white clover on 5 May and 7 June, but all treatments reduced white clover to <4% compared to the untreated check (20%) when evaluated on 7 June (Table 3). On 15 April 2011 a herbicide by application strategy interaction did exist due to difference in control from Trimec formulations where the foliar spray provided better control than the granular applications (Table 4). On 7 July 2011, following the 12 October 2010 applications a herbicide by application strategy interaction did exist due to difference in control from Trimec formulations where the liquid spray applications reduced white clover coverage most, followed by the granular Trimec application to wet turf, followed by granular Trimec application to dry turf (Table 4). Data collected on white clover control is consistent with previous work (Loughner and Nolting, 2012) documenting the efficacy of moist vs. dry and liquid vs. granular. Imprelis and penoxsulam both can be taken up by plant roots which allow them to work effectively as granular applications.

Data from both weed species support that 1) when using traditional broadleaf herbicides that liquid applications are better than granular applications for controlling weeds, 2) granular applications to moist turf are more effective than granular applications to dry turf, and 3) new herbicides with root activity can control susceptible weeds equally well as liquid or granular applications.

Following the initiation of this experiment, the Office of Indiana State Chemist issued a stop sale, use, or removal order (SSURO) for the herbicide Imprelis due to injury to non-target vegetation (Patton et al., 2011). The herbicide was deemed to be MISBRANDED. This SSURO requires DuPont Professional Products to cease all sale, distribution and use of DuPont Imprelis herbicide in the State of Indiana, effective August 1, 2011. As a result, Imprelis may no longer be used in Indiana and product should be returned to DuPont via their recall and refund program. The objectives of this research were to evaluate the efficacy of Imprelis for weed control and these authors did not evaluate the safety of this herbicide on trees or shrubs.

References

Jagschitz, J. A., Ebdon, J. S., Erlandsen, T., and Bylterud, A. 1983. Broadleaf weed control trials in turf in USA and Norway. Proc. Northeast Weed Sci. Soc. 37 (supplement):65-70.

Loughner, D. L., and Nolting, S. P. 2010. Influence of foliar moisture on postemergent granule herbicide control of white clover and dandelion in cool-season turf. Online. Applied Turfgrass Science doi:10.1094/ATS-2010-0713-01-RS.

Neal, J. 1993. Granular herbicides for post-emergent broadleaf weed control in cool-season turfgrass without 2, 4-D. Int. Turfgrass Soc. Res. J. 7:238-245.

Patton, A., T. Creswell, G. Ruhl, and S. Weller. 2011. A Turf Professionals Guide to Suspected Imprelis® Herbicide Injury in the Landscape. Purdue University Plant & Pest Diagnostic Laboratory publication. Available at: http://www.ppdl.purdue.edu/PPDL/pubs/briefs/ImprelisLCO.pdf

Scott, D. T. 1995. Postemergent broadleaf weed control with Confront granule fertilizer formulations. Proc. Northeast Weed Sci. Soc. 49:105-106.

Table 1. Herbicide effects on ground ivy coverage across application strategy (granular or spray applications).

Treatment [a]	rate	Ground ivy 12 Oct	25 Oct	11 Nov	15 April	7 June	7 July
		%					
penoxsulam	0.03875 lb ai/A	84 b [b]	79	61 a	6 a	55 a	78 a
aminocyclopyraclor	0.07 lb ai/A	92 a	77	26 b	0 b	1 b	2 b
2,4-D, MCPP, and Dicamba	180 lb/A	87 ab	76	67 a	3 ab	62 a	85 a
Untreated [c]		90	77	72	4	78	95
ANOVA							
Herbicide		0.0255	NS	<0.0001	0.0058	<0.0001	<0.0001
Application Strategy		NS	NS	NS	NS	NS	NS
Herbicide × Application Strategy		NS	NS	NS	NS	NS	NS

[a] Means of three replications and three turf application strategies (granular to dry turf, granular to wet turf, and liquid to dry turf).
[b] Within columns, means followed by the same letter are similar.
[c] Presented for comparison only.

Table 2. Control of ground ivy as affected by herbicide and application strategy (granules on wet turf, granules on dry turf, and liquid spray on dry turf).

Treatment [a]	rate	Turf wetness	Ground ivy 5 May
			%
Lockup (granular penoxsulam)	0.03875 lb ai/A	wet	25 bc [a]
Lockup (granular penoxsulam)	0.03875 lb ai/A	dry	27 b
Sapphire (liquid penoxsulam)	0.03875 lb ai/A	dry	27 b
Imprelis (granular)	0.07 lb ai/A	wet	1 d
Imprelis (granular)	0.07 lb ai/A	dry	1 d
Imprelis (liquid)	0.07 lb ai/A	dry	0 d
Trimec (granular)	180 lb/A	wet	27 b
Trimec (granular)	180 lb/A	dry	40 a
Trimec (liquid)	4 pt/A	dry	13 c
Untreated [b]			35
ANOVA			
Herbicide			<0.0001
Application Strategy			0.0485
Herbicide × Application Strategy			0.0332

[a] Within columns, means followed by the same letter are similar.
[b] Presented for comparison only.

Table 3. Herbicide effects on white clover coverage across application strategy (granular or spray applications).

Treatment [a]	rate	White clover 12 Oct	25 Oct	11 Nov	5 May	7 June
		%				
penoxsulam	0.03875 lb ai/A	29	21	10	1 ab [b]	3 a
aminocyclopyraclor	0.07 lb ai/A	33	19	5	0 b	0 b
2,4-D, MCPP, and Dicamba	180 lb/A	29	19	9	2 a	3 a
Untreated [c]		37	37	30	15	20
ANOVA						
Herbicide		NS	NS	NS	0.0445	0.0055
Application Strategy		NS	NS	NS	0.0445	NS
Herbicide × Application Strategy		NS	NS	NS	NS	NS

[a] Means of three replications and three turf application strategies (granular to dry turf, granular to wet turf, and liquid to dry turf).
[b] Within columns, means followed by the same letter are similar.
[c] Presented for comparison only.

Table 4. Control of white clover as affected by herbicide and application strategy (granules on wet turf, granules on dry turf, and liquid spray on dry turf).

Treatment [a]	rate	Turf wetness	White clover 15 April	7 July
			%	
Lockup (granular penoxsulam)	0.03875 lb ai/A	wet	4 b [a]	3 bc
Lockup (granular penoxsulam)	0.03875 lb ai/A	dry	0 b	2 c
Sapphire (liquid penoxsulam)	0.03875 lb ai/A	dry	0 b	2 c
Imprelis (granular)	0.07 lb ai/A	wet	0 b	0 c
Imprelis (granular)	0.07 lb ai/A	dry	0 b	0 c
Imprelis (liquid)	0.07 lb ai/A	dry	0 b	0 c
Trimec (granular)	180 lb/A	wet	15 a	6 b
Trimec (granular)	180 lb/A	dry	20 a	10 a
Trimec (liquid)	4 pt/A	dry	0 b	2 c
Untreated [b]			37	20
ANOVA				
Herbicide			0.0007	0.0001
Application Strategy			0.0354	0.0387
Herbicide × Application Strategy			0.0311	0.0173

[a] Within columns, means followed by the same letter are similar.
[b] Presented for comparison only.

Efficacy of Current Organic Postemergent Weed Control Options in Turfgrass Systems

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SUMMARY: A common question from lawn care companies and homeowners is "What organic herbicides or non-pesticide products are available for weed control?" An organic herbicide is one that can be used in USDA Organic farming. There are few organic herbicides available in turf. The objectives of this experiment were to determine the efficacy of various organic control products on common weed species, and also to determine the herbicide injury caused by various organic control products on Kentucky bluegrass. Turf injury was highest for the flame thrower treatment applied on 20 Oct 2010 although turf had completely recovered by 15 April 2011 the following spring. Scythe, Organic Weed & Grass Killer, BurnOut Weed & Grass Killer, octanoic acid, octanoic acid + clove oil, and clove oil all also caused unacceptable injury to Kentucky bluegrass in the initial weeks after application. No product provided ground ivy control. Dandelion coverage varied by treatment (P=0.07) with the Ortho Weed-Be-Gon (RTU) reducing dandelion coverage to 1% the following spring with organic herbicides not providing any appreciable control. Weed control without pesticides remains difficult in turfgrass systems due to undesirable turf injury and low efficacy of organic products. Homeowners wishing to control weeds with organic products need to make multiple spot treatments for improved control and be accepting of some turf injury.

A common question from lawn care companies and homeowners is "What organic herbicides or non-pesticide products are available for weed control?" An organic herbicide is one that can be used in USDA Organic farming. There are few organic herbicides available in turf. Corn gluten meal is the predominant organic herbicide used in turfgrass systems for preemergence control of crabgrass. This product has shown to be effective in northern states in lawns due to improvements in turf density from the nitrogen fertilization provided from this product although testing in Indiana and states south of Indiana often show limited or no efficacy of this product for preemergence crabgrass control.

ADDITIONAL INDEX WORDS:
2-phenethyl propionate; Caprylic acid; cinnamon bark; citrus oil; d-limonene; eugenol; Iron HEDTA; octanoic acid; Pelargonic acid; potassium salts of fatty acids; sodium lauryl sulfate; vinegar..

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Among the postemergence organic herbicides, Scythe (pelargonic acid) and acetic acid (5% or greater solutions) are the most common. Other medium-length fatty acids and clove oil (eugenol) show some promise; however, these organic postemergence herbicides are non-selective and injurious to actively growing turfgrasses in any method other than for directed spot treatments to weeds. Thus, these organic postemergence herbicides often have limited use in turf other than for weed control in parking lots, fence rows, and other bare ground applications or they require applications as spot treatments to the weed to limit injury to the turf. Despite some information on the efficacy of organic weed control options, there are very few published research studies on their efficacy, especially on some over-the-counter products and homeowner "concoctions". The objectives of this experiment were to determine the efficacy of various organic control products on common weed species, and also to determine the herbicide injury caused by various organic control products on Kentucky bluegrass.

Materials and Methods

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The area was a Kentucky bluegrass blend and had a history of ground ivy and dandelion pressure. Experimental design was a randomized complete block with three replications and an individual plot size of 11 ft^2. Plots were treated with herbicides (Table 1) on 20 Oct 2010. Herbicides were applied in 75 gpa water with a CO_2-pressurized sprayer at 30 psi. Plots were visually rated for ground ivy and dandelion coverage, and injury to Kentucky bluegrass. Injury was rated on a 9 to 1 scale with 9 = no injury, 7 = acceptable injury, and 1 = totally brown turf. All data were analyzed using SAS (SAS Institute, Inc). Means separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Results and Discussion

Turf injury was highest for the flame thrower treatment applied on 20 Oct 2010 although turf had completely recovered by 15 April 2011 the following spring (Table 2). Scythe, Organic Weed & Grass Killer, BurnOut Weed & Grass Killer, octanoic acid, octanoic acid + clove oil, and clove oil all also caused unacceptable injury to Kentucky bluegrass in the initial weeks after application (Table 2).

Ground ivy coverage was reduced initially by Scythe, EcoSmart, Organic Weed & Grass Killer, BurnOut Weed & Grass Killer, clove oil, octanoic acid + clove oil, flame thrower, and the mechanical weed control treatments (Table 3). However, this control was short lived as all treatments were similar to the untreated control in the spring following fall applications including the Ortho Weed-B-Gon treatment which served as the homeowner standard in this experiment. It is worth noting that herbicides containing triclopyr such as Ortho Weed-B-Gon Chickweed, Clover, Oxalis Killer would be a better choice for ground ivy control. Dandelion coverage varied by treatment (P=0.07) with the Ortho Weed-Be-Gon (RTU) providing the most dandelion control the following spring.

Weed control without pesticides remains difficult in turfgrass systems due to undesirable turf injury and low efficacy of organic products. Homeowners wishing to control weeds with "organic" products need to make multiple spot treatments for improved control and be accepting of some turf injury. In this experiment, we made only one application but control would be improved with repeated applications (two in fall at a one-month interval and as needed in the spring). Ortho Ecosense Lawn Weed Killer and other herbicides containing FeHEDTA have received the most attention recently because they are less injurious than other organic herbicides, but FeHEDTA did not provide any weed control in this experiment. Ideally, an organic herbicide would provide effective control of weed species without being harmful to the desirable turfgrass species. Unfortunately, this research did not identify such a product.

Table 1. Product description of organic weed control options used in this experiment.

Product	Rate	Information
Scythe	7% v/v	Pelargonic acid
Ortho Ecosense Lawn Weed Killer	RTU	Iron HEDTA (FeHEDTA)
EcoSmart 64oz	RTU	Contains 2-phenethyl propionate, eugenol, and sodium lauryl sulfate as active ingredients
Fast Acting Weed and Grass Killer	RTU	Contains potassium salts of fatty acids as active ingredient. www.planetnatural.com
Organic Crabgrass Killer	2 lb/100 ft^2	Contains cinnamon bark as active ingredient. www.planetnatural.com
Organic Weed & Grass Killer	1:4 Prod:H_2O	Contains citrus oil (d-limonene) as active ingredient. www.planetnatural.com
BurnOut Weed & Grass Killer	1:2 Prod:H_2O	Contains citric acid, clove oil, and sodium lauryl sulfate as active ingredients. www.planetnatural.com
Octanoic acid	1.8 gal/A	Caprylic acid, eight-carbon saturated fatty acid, also known as octanoic acid
Clove Oil	3.21 gal/A	100% pure purchased from NOW Foods, Item# NWF467, 4 fl oz. Eugenol is the main component in the essential oil extracted from cloves, comprising 72–90% of the total.
Octanoic Acid + Clove Oil	1.8 gal/A + 1.07 gal/A	Description above
Vinegar Cocktail	RTU	To 1 gallon of 10% vinegar, add 1 ounce of orange/citrus oil (d-limonene), 1 teaspoon of liquid soap, 1 tablespoon of molasses. This was a home remedy recommended by some. Although there are many variations of this, these components are recommended in many home weed killer concoctions. Orange oil purchased from citrusdepot.net.
Flame Thrower		Weed dragon home and garden torch kit.
Mechanical weed Control		Weeds removed by pulling and cutting with a knife.
Ortho Weed-Be-Gon	RTU	2,4-D + mecoprop (MCPP) + dicamba
Untreated check		

Table 2. Herbicide injury to Kentucky bluegrass from organic weed control options.

		Injury				
Treatment	rate	22 Oct	25 Oct	5 Nov	17 Nov	15 April
Scythe	7% v/v	6.3 b[a]	4.0 f	4.6 e	6.6 d	9
Ortho Ecosense Lawn Weed Killer	RTU	9.0 a	9.0 a	9.0 a	9.0 a	9
EcoSmart 64oz	RTU	8.7 a	7.0 bcd	7.3 bc	8.3 abc	9
Fast Acting Weed and Grass Killer	RTU	8.3 a	8.3 ab	7.3 bc	8.7 ab	9
Organic Crabgrass Killer	2 lb/100 ft^2	9.0 a	9.0 a	8.3 ab	9.0 a	9
Organic Weed & Grass Killer	1:4 Prod:H_2O	8.0 a	4.7 ef	5.3 de	7.0 cd	9
BurnOut Weed & Grass Killer	1:2 Prod:H_2O	8.3 a	6.3 d	6.3 cd	8.3 abc	9
Octanoic acid	1.8 gal/A	8.0 a	5.6 de	5.7 de	7.7 abcd	9
Clove Oil	3.21 gal/A	9.0 a	8.0 abc	6.3 cd	8.3 abc	9
Octanoic Acid	1.8 gal/A	8.0 a	4.3 ef	5.3 de	7.3 bcd	9
+ Clove Oil	1.07 gal/A					
Vinegar Cocktail	RTU	8.0 a	6.7 cd	6.7 cd	7.7 abcd	9
Flame Thrower		1.0 c	1.0 g	2.3 f	3.3 e	9
Mechanical weed Control		9.0 a	9.0 a	8.7 ab	8.7 ab	9
Ortho Weed-Be-Gone	RTU	9.0 a	8.7 a	8.7 ab	8.7 ab	9
Untreated		9.0 a	8.7 a	8.7 ab	9.0 a	9
P-value		<0.0001	<0.0001	<0.0001	<0.0001	NS

[a] Within columns, means followed by the same letter are similar.

Table 3. Organic herbicide effects on ground ivy coverage.

		Ground ivy coverage			
Treatment	rate	17 Nov	15 April	29 April	3 June
		%			
Scythe	7% v/v	18 fg	12	25	68
Ortho Ecosense Lawn Weed Killer	RTU	83 ab	11	32	72
EcoSmart 64oz	RTU	72 bc	20	37	70
Fast Acting Weed and Grass Killer	RTU	90 ab	7	32	77
Organic Crabgrass Killer	2 lb/100 ft^2	78 ab	18	43	63
Organic Weed & Grass Killer	1:4 Prod:H_2O	58 cd	4	30	73
BurnOut Weed & Grass Killer	1:2 Prod:H_2O	38 e	9	20	65
Octanoic acid	1.8 gal/A	77 ab	6	28	77
Clove Oil	3.21 gal/A	43 de	14	35	67
Octanoic Acid	1.8 gal/A	33 ef	4	13	62
+ Clove Oil	1.07 gal/A				
Vinegar Cocktail	RTU	83 ab	12	32	77
Flame Thrower		1 g	5	23	70
Mechanical weed Control		13 g	9	30	68
Ortho Weed-Be-Gon	RTU	92 a	9	33	67
Untreated		93 a	20	38	70
P-value		<0.0001	NS	NS	NS

Table 4. Organic herbicide effects on dandelion coverage.

Treatment	rate	Dandelion coverage 15 April
		%
Scythe	7% v/v	8
Ortho Ecosense Lawn Weed Killer	RTU	14
EcoSmart 64oz	RTU	18
Fast Acting Weed and Grass Killer	RTU	20
Organic Crabgrass Killer	2 lb/100 ft^2	18
Organic Weed & Grass Killer	1:4 Prod:H_2O	7
BurnOut Weed & Grass Killer	1:2 Prod:H_2O	23
Octanoic acid	1.8 gal/A	10
Clove Oil	3.21 gal/A	23
Octanoic Acid	1.8 gal/A	28
+ Clove Oil	1.07 gal/A	
Vinegar Cocktail	RTU	13
Flame Thrower		30
Mechanical weed Control		18
Ortho Weed-Be-Gon	RTU	1
Untreated		10
P-value		0.07

Evaluation of Crabgrass Control with Various Dimension Formulations and Corn Gluten Meal

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TURFGRASS SCIENCE

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SUMMARY: Crabgrass (*Digitaria* spp.) is often considered to be the most problematic weed in lawns. Crabgrass is a summer annual grassy weed that typically germinates in April in the Midwest (early April in southern areas and late-April in northern areas). The best approach to controlling crabgrass is using a preemergence herbicide such as dithiopyr (Dimension), pendimethalin (Pendulum), prodiamine (Barricade), sulfentrazone + prodiamine (Echelon), and others. The objective of this experiment was to evaluate how Dimension 2EW compares to Dimension granular formulations (Dimension on a fertilizer carrier) for crabgrass control in northern turfgrass and to evaluate the efficacy of corn gluten meal compared to commercial herbicides. All Dimension treatments had less crabgrass coverage than the untreated check and corn gluten meal on all rating dates (Table 1). All rates of Dimension on fertilizer and Dimension 2EW at 0.5 and 0.25 + 0.25 (spilt application) lbs ai per acre provided the same results on all rating dates. Plots treated with Dimension 2EW at 0.38 lbs ai/A had more crabgrass when rated 5 August than plots treated at 0.38 lbs ai/A with Dimension 0.21G. Although some have reported crabgrass control with corn gluten meal, our study in 2011 is consistent with our previous work with corn gluten meal in Indiana that shows little to no efficacy for preemergence crabgrass control.

Large crabgrass (*Digitaria sanguinalis*) and smooth crabgrass (*Digitaria ischaemum*) are both species of crabgrass found in the Midwest that are collectively referred to as crabgrass. Crabgrass is often considered to be the most problematic weed in lawns. Crabgrass is a summer annual grassy weed that typically germinates in April in the Midwest (early April in southern areas and late-April in northern areas). Proper mowing (higher mowing heights), proper fertilization (some rather than none to improve turf density), irrigation to prevent summer dormancy during drought, and aerification of compacted areas to improve turf health are all cultural practices that can be used to reduce crabgrass. Despite proper cultural practices, crabgrass may still remain problematic in certain "hot spots" such as next to sidewalks and driveways as well as sunny turf areas. The best approach to controlling crabgrass is using a preemergence herbicide such as dithiopyr (Dimension), pendimethalin (Pendulum), prodiamine (Barricade), sulfentrazone + prodiamine (Echelon), and others. These herbicides inhibit cell division and prevent crabgrass seeds from properly emerging. Since these herbicides work on germinating seeds, they must be applied prior to germination with the exception of dithiopyr which controls crabgrass after germination until it reaches one tiller.

ADDITIONAL INDEX WORDS:
dithiopyr, preemergence.

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An increased demand for organic lawn care products has also increased the use of organic alternatives to traditional pesticides. The predominant organic herbicide used in turfgrass systems is corn gluten meal for preemergence control of crabgrass. This product has shown to be effective in northern states in Kentucky bluegrass lawns as an organic solution to weed control (Christians, 1993). The objective of this experiment was to evaluate how Dimension 2EW compares to Dimension granular formulations (Dimension on a fertilizer carrier) for crabgrass control in northern turfgrass and to evaluate the efficacy of corn gluten meal compared to commercial herbicides.

Materials and Methods

The experiment was conducted at the W.H. Daniel Research and Diagnostic Center in West Lafayette, IN. The site was a Kentucky bluegrass blend with a uniform cover by crabgrass. Experimental design was randomized complete block with three replications and an individual plot size of 25 ft^2. Plots were mown at 2 inches as needed. Plots were treated with herbicides 13 April and 13 June (table 1). Herbicides were applied in 87 gpa water with a CO_2-pressurized sprayer at 30 psi. An untreated check was included for comparison. Crabgrass coverage was visually rated. All data were analyzed using SAS (SAS Institute, Inc). Means were separated using Fisher's protected least significant difference when F tests were significant at $\alpha=0.05$.

Results and Discussion

All Dimension treatments had less crabgrass coverage than the untreated check and corn gluten meal on all rating dates (Table 1). Statistically, all rates of Dimension on fertilizer and Dimension 2EW at 0.5 and 0.25 + 0.25 lbs ai per acre provided the same results on all rating dates. Plots treated with Dimension 2EW at 0.38 lbs ai/A had more crabgrass when rated 5 August than plots treated at 0.38 lbs ai/A with Dimension 0.21G. Although some have reported crabgrass control with corn gluten meal (Christians, 1993), our study in 2011 is consistent with our previous work with corn gluten meal in Indiana that shows little to no efficacy for preemergence crabgrass control (Reicher and Weisenberger, 1994).

References

Christians, N. E. 1993. The use of corn gluten meal as a natural preemergence weed control in turf. Int. Turfgrass Soc. Res. J. 7:284-290.

Reicher, Z., and D. Weisenberger. 2004. Annual grass control with experimental and commercially available products. Annu. Rep. Purdue Univ. Turfgrass Sci. Program. p.121-122.

Table 1. Herbicide effects on crabgrass coverage

Treatment	Rate	Application date	Crabgrass coverage 9 June	8 July	5 August
	lbs ai/A		%		
Dimension 2EW	0.38	13 April	0 b[a]	6 b	33 b
Dimension 2EW	0.5	13 April	0 b	3 b	23 bc
Dimension 2EW	0.25	13 April	0 b	2 b	18 c
Dimension 2EW	0.25	13 June			
Dimension on fert 0.21G[b]	0.38	13 April	0 b	2 b	15 c
Dimension on fert 0.21G[b]	0.5	13 April	0 b	2 b	11 c
Dimension on fert 0.10G[b]	0.25	13 April	0 b	2 b	12 c
Dimension on fert 0.10G[b]	0.25	13 June			
Corn Gluten Meal	20[c]	13 April	5 a	58 a	98 a
Untreated		13 April	8 a	68 a	98 a
P-value			0.003	<0.0001	<0.0001

[a] Means followed by the sample letter are not significantly different.
[b] 0-0-7 was the fertilizer carrier used for Dimension granular applications.
[c] Rate of application was lbs product per 1000 ft^2.

Herbicide Safety and Weed Control Comparison in Spring Seeded Kentucky Bluegrass

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: Early spring preemergence herbicides are often necessary in Indiana to prevent troublesome annual grassy weeds such as crabgrass and goosegrass. However, all preemergence herbicides (except Tupersan) work to prevent the emergence of turfgrass seeds as well as weed seeds, so a turf manager cannot use a preemergence herbicide if they plan on seeding in the spring. Postemergence herbicides can also be used to control crabgrass and other weeds in spring when seeding turf. The objective of this experiment was to evaluate six products at three different application timings for use in establishing Kentucky bluegrass from seed in the spring. Kentucky bluegrass coverage was highest (38%) for Tupersan applied at seeding followed by Tenacity applied at seeding or at emergence (17 and 19%, respectively). Crabgrass coverage on 12 August was lowest for Tenacity applied at emergence. Two applications of post crabgrass products are needed for complete control when Kentucky bluegrass is spring seeded. These results support that 1) late summer and early fall is a better seeding date than the spring due to reduced weed pressure, and 2) two applications of a postemergence herbicide will be needed in spring seeded Kentucky bluegrass areas.

Early spring preemergence herbicides are often necessary in Indiana to prevent troublesome annual grassy weeds such as crabgrass and goosegrass. Additionally, these applications help to prevent the emergence of some broadleaf weeds. Most preemergence herbicides work to kill weeds by preventing cell division causing death to weed seedlings shortly after they germinate. All preemergence herbicides (except Tupersan) work to prevent the emergence of turfgrass seeds as well as weed seeds, so a turf manager cannot use a preemergence herbicide if they plan on seeding in the spring. As mentioned, Tupersan (siduron) may be used for preemergence control of annual grassy weeds in newly seeded cool-season turf. This herbicide is more expensive and short-lived, but it is the only safe preemergence herbicide to apply at the time of seeding.

ADDITIONAL INDEX WORDS:
aminocyclopyrachlor; carfentrazone; Drive XLR8; Imprelis; mesotrione; *Poa pratensis*; QuickSilver; quinclorac; siduron; SquareOne; Tenacity; Tupersan.

Patton, A., and D. Weisenberger. 2012. Herbicide Safety and Weed Control Comparison in Spring Seeded Kentucky Bluegrass. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 33-39.

Another strategy is to use a postemergence herbicide instead of a preemergence herbicide to control crabgrass and other weeds in late May and June that is safe to use on seedling turf. Options include Drive XLR8 (quinclorac), Quicksilver (carfentrazone), Tenacity (mesotrione), and SquareOne (quinclorac + carfentrazone). These products can be most safely used very soon after seeding to control crabgrass (see label for exact details on each turf species). If the seedlings are more mature (have been mown 2-3 times following their emergence) then other products such as Q4 Plus (quinclorac + sulfentrazone + 2,4-D + dicamba), Onetime (quinclorac + MCPP + dicamba), or Solitare (quinclorac + sulfentrazone) can also be used. The objective of this experiment was to evaluate herbicides at three different application timings for use in establishing Kentucky bluegrass from seed in the spring.

MATERIALS AND METHODS

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The area had been fallow for a year and had a history of weed pressure. Kentucky bluegrass was seeded on 19 May 2011 at 2 lbs/1000 ft^2 and plots were covered initial with a seed germination blanket to reduce seed movement prior to germination. The cover was removed prior to emergence following germination. Plots were also overseeded with large crabgrass, yellow nutsedge (tubers), ragweed, and purslane at the same time Kentucky bluegrass was seeded. Yellow nutsedge tubers, 10 per plot, were inserted 1 inch deep on a grid so plants could be counted.

Experimental design was a 7 (herbicides) × 3 (timings) factorial in a randomized complete block with three replications and an individual plot size of 25 ft^2. The seven herbicide treatments were Tenacity at 8 fl oz/A, Tupersan at 12 lb/A, Drive XLR8 at 64 oz/A, SquareOne at 12 oz/A, Imprelis at 4.5 fl oz/A, QuickSilver at 2.1 oz/A, and the untreated check. The three timings were day of seeding (19 May), at emergence (3 June), and 2 weeks after emergence (17 June). Plots were mown as needed at 3 inches. Plots were treated with herbicides on 19 May, 3 June, and 17 June. Herbicides were applied in 80 gpa water with a CO_2-pressurized sprayer at 30 psi. A non-ionic surfactant at the rate of 0.25 % v/v was included with the Tenacity treatments applied 3 June and 17 June. Plots were visually rated. All data were analyzed using SAS (SAS Institute, Inc). Means were separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

.Results and Discussion

Kentucky bluegrass coverage was highest for Tupersan (38%) applied at seeding followed by Tenacity applied at seeding or at emergence (17 and 19%, respectively) (Table 1; Fig. 1). Although statistical comparisons cannot be made, Kentucky bluegrass establishment was poor compared to tall fescue (separate but adjacent experiment; Patton and Weisenberger, 2012) which highlights their differences in seedling vigor and establishment rate. Similar to results on tall fescue, purslane coverage in Kentucky bluegrass was generally highest among Drive XLR8 and Tenacity treatments (Table 2). Ragweed coverage was sporadic, but all treatments seemed to reduce ragweed coverage except Tupersan and the untreated check (Table 3). Crabgrass coverage on 12 August was lowest for Tenacity applied at emergence (Table 4). This highlights that two applications of post crabgrass products are needed for more effective control when Kentucky bluegrass is spring seeded. Prostrate spurge was present in Tenacity treated plots more than the other treatments on 12 August (Table 5). These results support that 1) late summer and early fall is a better seeding date than the spring due to reduced weed pressure, and 2) two applications of a postemergence herbicide will be needed in spring seeded Kentucky bluegrass areas.

The purpose of this experiment was to test the efficacy of a single application of specific products at a specific timing. However, as mentioned previously many of the product labels recommend more than a single application for best results and this is especially important with Kentucky bluegrass since it is slower to establish. Turf managers should use this research to help choose the optimum product and timing for an application with the intention to scout the location and make a follow-up application for weed control at a later date for best results and optimum establishment. In this experiment Tupersan applied at seeding provided best results followed by Tenacity when applied at seeding and emergence.

References

Patton, A. and D. Weisenberger. 2012. Herbicide Safety and Weed Control Comparison in Spring Seeded Tall Fescue. 2011 Annual Report - Purdue University Turfgrass Science Program.

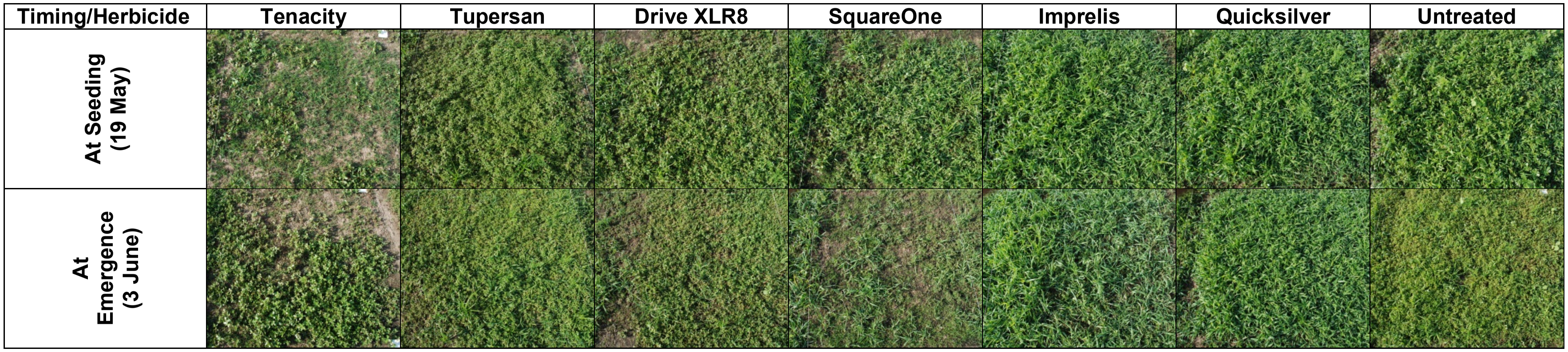

Fig. 1. Turf and weed coverage on 13 June 2011 for the first two application timings and the seven herbicide treatments. These photos provide evidence of the effectiveness of the applications at seeding as well as some treatments at emergence. However, since only a single application was used in this experiment, final Kentucky bluegrass coverage was low except for Tupersan applied at seeding or Tenacity applied at seeding or at emergence.

Table 1. Herbicide effects on Kentucky bluegrass coverage.

Treatments Herbicide	timing	Kentucky bluegrass coverage 6 July	3 Aug	12 Aug
		%		
Tenacity	DOS [a]	17	12 b [b]	17 bc
Tupersan	DOS	20	25 a	38 a
Drive XLR8	DOS	33	2 c	1 d
SquareOne	DOS	12	0 c	0 d
Imprelis	DOS	15	0 c	0 d
QuickSilver	DOS	13	0 c	0 d
Untreated	DOS	17	0 c	0 d
Tenacity	AE	42	8 b	19 b
Tupersan	AE	43	0 c	0 d
Drive XLR8	AE	9	0 c	2 d
SquareOne	AE	35	0 c	0 d
Imprelis	AE	52	0 c	0 d
QuickSilver	AE	15	0 c	0 d
Untreated	AE	42	0 c	0 d
Tenacity	2WAE	20	1 c	7 cd
Tupersan	2WAE	47	0 c	0 d
Drive XLR8	2WAE	52	0 c	2 d
SquareOne	2WAE	17	0 c	0 d
Imprelis	2WAE	60	1 c	0 d
QuickSilver	2WAE	18	0 c	0 d
Untreated	2WAE	45	0 c	0 d
ANOVA				
Herbicide		NS	<0.0001	<0.0001
Time		NS	<0.0001	0.0039
Herbicide × Time		NS	<0.0001	<0.0001

[a] DOS = day of seeding; AE = at emergence; 2WAE = two weeks after emergence.
[b] Within columns, means followed by the same letter are similar.

Table 2. Herbicide effects on purslane coverage.

Treatments Herbicide	timing	Purslane coverage 6 July	3 Aug	12 Aug
		%		
Tenacity	DOS [a]	28 d [b]	23 c	13 de
Tupersan	DOS	0 h	7 de	6 ef
Drive XLR8	DOS	72 bc	20 cd	23 cd
SquareOne	DOS	17 defgh	2 e	2 ef
Imprelis	DOS	8 fgh	2 e	2 ef
QuickSilver	DOS	3 gh	1 e	0 f
Untreated	DOS	18 defg	7 de	2 ef
Tenacity	AE	90 a	73 a	63 a
Tupersan	AE	20 defg	6 de	2 ef
Drive XLR8	AE	87 ab	55 b	32 bc
SquareOne	AE	1 h	1 e	0 ef
Imprelis	AE	8 fgh	0 e	1 ef
QuickSilver	AE	0 h	1 e	0 f
Untreated	AE	22 def	6 de	3 ef
Tenacity	2WAE	75 abc	58 ab	42 b
Tupersan	2WAE	12 defgh	4 e	1 ef
Drive XLR8	2WAE	60 c	13 cde	6 ef
SquareOne	2WAE	22 def	3 e	1 ef
Imprelis	2WAE	28 d	0 e	0 ef
QuickSilver	2WAE	10 efgh	2 e	2 ef
Untreated	2WAE	27 de	6 de	3 ef
ANOVA				
Herbicide		<0.0001	<0.0001	<0.0001
Time		0.0003	0.0018	0.0082
Herbicide × Time		<0.0001	<0.0001	<0.0001

[a] DOS = day of seeding; AE = at emergence; 2WAE = two weeks after emergence.
[b] Within columns, means followed by the same letter are similar.

Table 3. Herbicide effects on ragweed coverage.

Treatments Herbicide	timing	Ragweed coverage 6 July	3 Aug	12 Aug
		%		
Tenacity	DOS [a]	4	0 c [b]	0 b
Tupersan	DOS	11	7 a	9 a
Drive XLR8	DOS	1	1 b	0 b
SquareOne	DOS	2	0 c	0 b
Imprelis	DOS	4	0 c	0 b
QuickSilver	DOS	6	1 bc	0 b
Untreated	DOS	10	0 bc	1 b
Tenacity	AE	0	0 c	0 b
Tupersan	AE	9	1 bc	0 b
Drive XLR8	AE	0	0 c	0 b
SquareOne	AE	0	0 c	0 b
Imprelis	AE	0	0 c	0 b
QuickSilver	AE	4	1 bc	0 b
Untreated	AE	4	1 bc	0 b
Tenacity	2WAE	0	0 c	0 b
Tupersan	2WAE	7	1 bc	1 b
Drive XLR8	2WAE	0	0 c	0 b
SquareOne	2WAE	0	0 c	0 b
Imprelis	2WAE	0	0 c	0 b
QuickSilver	2WAE	4	0 c	0 b
Untreated	2WAE	7	1 bc	1 b
ANOVA				
Herbicide		<0.0001	<0.0001	<0.0001
Time		0.0018	<0.0001	<0.0001
Herbicide X Time		NS	<0.0001	<0.0001

[a] DOS = day of seeding; AE = at emergence; 2WAE = two weeks after emergence.
[b] Within columns, means followed by the same letter are similar.

Table 4. Herbicide effects on crabgrass, and clover coverage.

Treatments Herbicide	timing	Coverage on 12 Aug Crabgrass	Clover
		%	
Tenacity	DOS [a]	48 c [b]	0 b
Tupersan	DOS	33 c	7 a
Drive XLR8	DOS	73 b	0 b
SquareOne	DOS	97 a	0 b
Imprelis	DOS	92 ab	0 b
QuickSilver	DOS	98 a	0 b
Untreated	DOS	97 a	1 b
Tenacity	AE	2 d	0 b
Tupersan	AE	97 a	0 b
Drive XLR8	AE	47 c	0 b
SquareOne	AE	90 ab	0 b
Imprelis	AE	96 a	0 b
QuickSilver	AE	98 a	0 b
Untreated	AE	97 a	0 b
Tenacity	2WAE	35 c	0 b
Tupersan	2WAE	96 a	0 b
Drive XLR8	2WAE	85 ab	0 b
SquareOne	2WAE	93 ab	0 b
Imprelis	2WAE	88 ab	0 b
QuickSilver	2WAE	84 ab	0 b
Untreated	2WAE	97 a	0 b
ANOVA			
Herbicide		<0.0001	<0.0001
Time		NS	<0.0001
Herbicide X Time		<0.0001	<0.0001

[a] DOS = day of seeding; AE = at emergence; 2WAE = two weeks after emergence.
[b] Within columns, means followed by the same letter are similar.

Table 5. Herbicide effects on prostrate spurge coverage.

Treatments Herbicide	Coverage on 12 Aug Spurge
	%
Tenacity	7 a [a]
Tupersan	1 bc
Drive XLR8	4 b
SquareOne	1 bc
Imprelis	0 c
QuickSilver	1 c
Untreated	1 bc
ANOVA	
Herbicide	0.0004
Time	NS
Herbicide X Time	NS

[a] Within columns, means followed by the same letter are similar.

Herbicide Safety and Weed Control Comparison in Spring Seeded Tall Fescue

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Turfgrass Science

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SUMMARY: Early spring preemergence herbicides are often necessary in Indiana to prevent troublesome annual grassy weeds such as crabgrass and goosegrass. However, all preemergence herbicides (except Tupersan) work to prevent the emergence of turfgrass seeds as well as weed seeds, so a turf manager cannot use a preemergence herbicide if they plan on seeding in the spring. Postemergence herbicides can also be used to control crabgrass and other weeds in spring when seeding turf. The objective of this experiment was to evaluate six products at three different application timings for use in establishing tall fescue from seed in the spring. Tall fescue coverage was highest (>55%) when Tenacity was applied at 8 oz/A on the day of seeding or the day of emergence, and when Tupersan was applied at seeding at 12 lb/A. Crabgrass coverage when rated on 11 August was lowest for Tenacity, Tupersan and Drive XLR8 applied at seeding; Tenacity, Drive and SquareOne applied at emergence; and Tenacity applied at 2WAE. The purpose of this experiment was to test the efficacy of a single application of specific products at a specific timing. However, many of the product labels recommend more than a single application for best results. Turf managers should use this research to help choose the optimum product and timing for an application with the intention to scout the location and make a follow-up application for weed control at a later date for best results and optimum establishment.

Early spring preemergence herbicides are often necessary in Indiana to prevent troublesome annual grassy weeds such as crabgrass and goosegrass. Additionally, these applications help to prevent the emergence of some broadleaf weeds. Most preemergence herbicides work to kill weeds by preventing cell division causing death to weed seedlings shortly after they germinate. All preemergence herbicides (except Tupersan) work to prevent the emergence of turfgrass seeds as well as weed seeds, so a turf manager cannot use a preemergence herbicide if they plan on seeding in the spring. As mentioned, Tupersan (siduron) may be used for preemergence control of annual grassy weeds in newly seeded cool-season turf. This herbicide is more expensive and short-lived, but it is the only safe preemergence herbicide to apply at the time of seeding.

ADDITIONAL INDEX WORDS:
aminocyclopyrachlor; carfentrazone; Drive XLR8; *Festuca arundinacea*; Imprelis; mesotrione; QuickSilver; quinclorac; siduron; SquareOne; Tenacity; Tupersan.

Patton, A., and D. Weisenberger. 2012. Herbicide Safety and Weed Control Comparison in Spring Seeded Tall Fescue. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 40-44

Another strategy is to use a postemergence herbicide instead of a preemergence herbicide to control crabgrass and other weeds in late May and June that is safe to use on seedling turf. Options include Drive XLR8 (quinclorac), Quicksilver (carfentrazone), Tenacity (mesotrione), and SquareOne (quinclorac + carfentrazone). These products can be most safely used very soon after seeding to control crabgrass (see label for exact details on each turf species). If the seedlings are more mature (have been mown 2-3 times following their emergence) then other products such as Q4 Plus (quinclorac + sulfentrazone + 2,4-D + dicamba), Onetime (quinclorac + MCPP + dicamba), or Solitare (quinclorac + sulfentrazone) can also be used. The objective of this experiment was to evaluate six products at three different application timings for use in establishing tall fescue from seed in the spring.

Materials and Methods

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The area had been fallow for a year and had a history of weed pressure. Tall fescue was seeded on 19 May 2011 at 7 lbs/1000 ft^2 and plots were covered initially with a seed germination blanket to reduce seed movement prior to germination. The cover was removed prior to emergence following germination. Plots were also overseeded with large crabgrass, yellow nutsedge (tubers), ragweed, and purslane at the same time as the tall fescue. Yellow nutsedge tubers, 10 per plot, were inserted 1 inch deep on a grid so plants could be counted.

Experimental design was a 7 (herbicides) × 3 (timings) factorial in a randomized complete block with three replications and an individual plot size of 25 ft^2. The seven herbicide treatments were Tenacity at 8 fl oz/A, Tupersan at 12 lb/A, Drive XLR8 at 64 oz/A, SquareOne at 12 oz/A, Imprelis at 4.5 fl oz/A, QuickSilver at 2.1 oz/A, and the Untreated check. The three timings were day of seeding (19 May), at emergence (30 May), and 2 weeks after emergence (13 June). Plots were mown as needed at 3 inches. Plots were treated with herbicides on 19 May, 30 May, and 13 June. Herbicides were applied in 80 gpa water with a CO_2-pressurized sprayer at 30 psi. A non-ionic surfactant at the rate of 0.25 % v/v was included with the Tenacity treatments applied 30 May and 13 June. Plots were visually rated for percent weed and turf coverage. All data were analyzed using SAS (SAS Institute, Inc). Means were separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Results and Discussion

Tall fescue coverage was highest (>55%) when Tenacity was applied at 8 oz/A on the day of seeding or the day of emergence, and when Tupersan was applied at seeding at 12 lb/A (Fig. 1; Table 1). Goosegrass coverage at the end of the study on 11 August was inconsistent across treatments and not likely reliable do to inconsistent distribution as the untreated check was among the treatments with the lowest coverage (Table 2). Purslane coverage was generally highest among Tenacity and Drive XLR8 treatments (Table 2). Crabgrass coverage when rated on 11 August was lowest for Tenacity, Tupersan and Drive XLR8 applied at seeding; Tenacity, Drive and SquareOne applied at emergence; and Tenacity applied at 2WAE (Table 2).

The purpose of this experiment was to test the efficacy of a single application of specific products at a specific timing. However, many of the product labels recommend more than a single application for best results. Turf managers should use this research to help choose the optimum product and timing for an application with the intention to scout the location and make a follow-up application for weed control at a later date for best results and optimum establishment. In this experiment Tenacity provided the best results at seeding and emergence, but Tupersan also produced good results when applied at seeding.

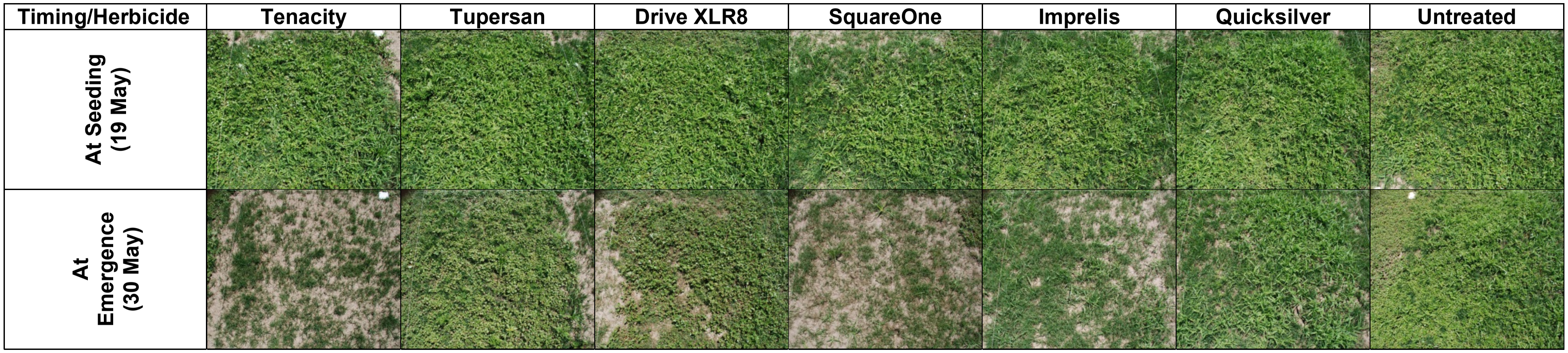

Fig. 1. Turf and weed coverage on 13 June 2011 for the first two application timings and the seven herbicide treatments. These photos provide evidence of the effectiveness of the applications at emergence, but Tenacity and Tupersan applied at seeding also proved to be successful treatments in the final analysis despite their appearance in these photos.

Table 1. Herbicide effects on tall fescue coverage.

Treatments Herbicide	timing	Tall fescue coverage 6 July	3 Aug	11 Aug
		%		
Tenacity	DOS [a]	17	58 ab [b]	58 a
Tupersan	DOS	11	57 ab	56 a
Drive XLR8	DOS	4	3 c	8 b
SquareOne	DOS	4	3 c	5 b
Imprelis	DOS	1	1 c	2 b
QuickSilver	DOS	0	0 c	2 b
Untreated	DOS	2	1 c	2 b
Tenacity	AE	7	88 a	80 a
Tupersan	AE	7	28 bc	22 b
Drive XLR8	AE	6	0 c	2 b
SquareOne	AE	27	12 c	17 b
Imprelis	AE	13	25 bc	17 b
QuickSilver	AE	17	2 c	3 b
Untreated	AE	1	1 c	2 b
Tenacity	2WAE	5	10 c	22 b
Tupersan	2WAE	1	0 c	2 b
Drive XLR8	2WAE	17	3 c	6 b
SquareOne	2WAE	7	0 c	0 b
Imprelis	2WAE	8	7 c	5 b
QuickSilver	2WAE	11	6 c	5 b
Untreated	2WAE	2	1 c	1 b
ANOVA				
Herbicide		NS	<0.0001	<0.0001
Time		NS	0.0184	0.0227
Herbicide × Time		NS	0.0302	0.0461

[a] DOS = day of seeding; AE = at emergence; 2WAE = two weeks after emergence.
[b] Within columns, means followed by the same letter are similar.

Table 2. Herbicide effects on goosegrass, crabgrass, and purslane coverage.

Treatments Herbicide	timing	Coverage on 11 Aug Goosegrass	Crabgrass	Purslane
		%		
Tenacity	DOS [a]	1 d [b]	38 cde	7 de
Tupersan	DOS	2 d	35 cde	1 e
Drive XLR8	DOS	18 bcd	43 bcde	29 bc
SquareOne	DOS	5 d	88 ab	1 e
Imprelis	DOS	2 d	91 a	1 e
QuickSilver	DOS	1 d	96 a	1 e
Untreated	DOS	1 d	92 a	8 de
Tenacity	AE	0 d	0 e	18 cd
Tupersan	AE	7 d	64 abcd	1 e
Drive XLR8	AE	43 b	0 e	55 a
SquareOne	AE	72 a	0 e	4 de
Imprelis	AE	11 cd	57 abcd	0 e
QuickSilver	AE	4 d	91 a	0 e
Untreated	AE	0 d	89 a	5 de
Tenacity	2WAE	5 d	27 de	35 b
Tupersan	2WAE	7 d	90 a	2 e
Drive XLR8	2WAE	5 d	68 abcd	15 cde
SquareOne	2WAE	23 bcd	73 abc	0 e
Imprelis	2WAE	35 bc	57 abcd	0 e
QuickSilver	2WAE	16 bcd	74 abc	0 e
Untreated	2WAE	9 cd	88 ab	7 de
ANOVA				
Herbicide		0.0017	<0.0001	<0.0001
Time		0.0179	0.0043	NS
Herbicide × Time		0.0091	0.0180	0.0018

[a] DOS = day of seeding; AE = at emergence; 2WAE = two weeks after emergence.
[b] Within columns, means followed by the same letter are similar.

Herbicide Selection and Timing Influences Ground Ivy Control

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SUMMARY: Ground ivy (*Glechoma hederacea*), sometimes referred to as creeping Charlie, is a creeping perennial broadleaf weed that is a common weed in turf and difficult to control once established. Previous reports have documented the efficacy of fall applications for ground ivy control. The objectives of this experiment were to 1) determine which herbicides most effectively control ground ivy, 2) determine which application timing (fall vs. spring) is most effective, and 3) determine if any herbicide by application timing interactions exist. Herbicides containing 2,4-D, fluroxypyr, triclopyr, and aminocyclopyrachlor or mixtures of these ingredients provided the best ground ivy control. Fluroxypyr and metsulfuron provided better ground ivy control with fall applications than spring applications, but this is consistent with recommendations and previous research that suggest that fall applications of broadleaf herbicides are more efficacious when applied in the fall compared to the spring. However, most of the products used in the experiment provided similar levels of ground ivy control when used in either the spring or the fall. Thus, although timing is critical, proper herbicide selection is more critical for weed control. NOTE: State registration for Imprelis was cancelled and federal registration was later cancelled by the U.S. Environmental Protection Agency. This cancellation does not allow the continued use of Imprelis herbicide in the U.S. Any such applications are illegal.

Ground ivy (*Glechoma hederacea*), sometimes referred to as creeping Charlie, is a creeping perennial broadleaf weed that is a common weed in turfgrass and difficult to control once established. Among the cultural practices that typically control weeds, implementing recommended nitrogen fertilization practices (≥4 lbs N/1000 ft^2) are known to reduce ground ivy coverage compared to non-fertilized turf (Kohler et al., 2004) but it is unknown how mowing, irrigation, drainage, and soil compaction influence ground ivy populations. Despite a beneficial reduction in ground ivy from fertilization, herbicides are needed for effective control. Multiple experiments have revealed that triclopyr provides effective and consistent control of ground ivy (Kohler et al., 2004; Reicher and Weisenberger., 2007). Fluroxypyr has also been described as effective, though slightly less effective and consistent than triclopyr (Reicher and Weisenberger., 2007). Additionally, 2,4-D also effectively controls ground ivy when applied alone (Kohler et al., 2004) or when it mixed with 2,4-DP (dichlorprop) or MCPP (Vrabel et al., 1987; Borger et al., 2002). Tank-mixes with 2,4-D and triclopyr also increase control of ground ivy when tank-mixed with other herbicides (Olson and Wright, 1988; Vrabel et al, 1987). The activity of other herbicides is not fully known.

ADDITIONAL INDEX WORDS:
2,4-D; aminocyclopyrachlor; Banvel; Blade; clopyralid; dicamba; Dismiss; Escalade 2; fluroxypyr; Imprelis; Lontrel; MCPP (mecoprop); Mecomec 4; mesotrione; metsulfuron; Spotlight; sulfentrazone; Tenacity; triclopyr; Trimec Classic; Turflon Ester Ultra, TZONE.

Patton, A., and D. Weisenberger. 2012. Herbicide Selection and Timing Influences Ground Ivy Control. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 45-48.

Fall applications are typically recommended for perennial broadleaf weed control with applications at or near the first frost are considered most effective. Previous reports have documented the efficacy of fall applications for ground ivy control (Reicher and Weisenberger, 2007). Efficacy was reported for applications of herbicide for ground ivy control anytime from 1 September to 1 November in West Lafayette, IN with some reduction in control from a late fall application on

15 November (Reicher and Weisenberger., 2007). Thus, a wide window of dates can be used in the fall to control ground ivy but little is known about how the efficacy of spring applications compares to fall applications. Many lawn care companies and home owners also treat weeds in the spring, including ground ivy, as this is when these weeds are more noticeable and homeowners generally have more interest and energy for yard work. The objectives of this experiment were to 1) determine which herbicides most effectively control ground ivy, 2) determine which application timing (fall vs. spring) is most effective, and 3) determine if any herbicide by application timing interactions exist.

Materials and Methods

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The site was a Kentucky bluegrass blend with a uniform cover by ground ivy. Plots were mown at 2 inches. Experimental design was 2 × 14 factorial with three replications and an individual plot size of 25 ft^2. The two application timings were fall and the following spring. The fifteen herbicide treatments were 2,4-D ester, Banvel (dicamba), Blade (metsulfuron), Dismiss (sulfentrazone), Escalade 2 (2,4-D + fluroxypyr + dicamba), Imprelis (aminocyclopyrachlor), Lontrel (clopyralid), Mecomec 4 (mecoprop), Spotlight (fluroxypyr),Tenacity (mesotrione), Trimec Classic (2,4-D + mecoprop + dicamba), Turflon Ester Ultra (triclopyr), TZONE (triclopyr + sulfentrazone + 2,4-D + dicamba), and the untreated check.

Plots were treated with herbicide on 8 October 2010 (fall) or 13 April 2011 (spring). Herbicides were applied in 87 gpa water with a CO_2-pressurized sprayer at 30 psi. Ground ivy percent coverage was visually rated. All data were analyzed using SAS (SAS Institute, Inc). Means were separated using Fisher's protected least significant difference when F tests were significant at $\alpha=0.05$.

Results and Discussion

The main effect of herbicide was significant on all fall rating dates (Table 1). When treatment effects were evaluated on 11 November – 1 month after herbicide application – ground ivy coverage was reduced more than 50% by 2,4-D ester, Escalade 2, Imprelis, Spotlight, and TZONE. This was consistent with our previous observations that herbicides containing 2,4-D, fluroxypyr, triclopyr, and aminocyclopyrachlor or mixtures of these ingredients provide the best ground ivy control.

When treatment effects were analyzed in the spring, there was a timing by herbicide interaction on 2 of the 3 rating dates and the main effect of herbicide was significant on all spring rating dates (Table 1). 2,4-D ester (fall), Imprelis (spring and fall) and Spotlight (fall) reduced ground ivy coverage most when rated on 8 July 2011 (2 months after application)(Figs. 1-6). The timing by herbicide interaction was present due to an inconsistent response from Blade, Spotlight, and Tenacity across seasons. Both Blade and Spotlight provided much better ground ivy control when applied in the fall rather than the spring. Tenacity did not provide acceptable control with either application timing but did appear to reduce ground ivy coverage most when applied in the spring. Tenacity is a product designed to control weeds best with sequential applications and two applications spaced 2 weeks apart at 8 oz/A should provide better ground ivy control than from the single application reported in this experiment.

It is not clear why Spotlight and Blade provided better ground ivy control with fall applications than spring applications, but this is consistent with recommendations and previous research that suggest fall applications of broadleaf herbicides are more efficacious when applied in the fall compared to the spring. However, most of the products used in the experiment provided similar levels of ground ivy control when used in either the spring or the fall. Thus, although timing is critical, proper herbicide selection is more critical for weed control.

Following the initiation of this experiment, the Office of Indiana State Chemist issued a stop sale, use, or removal order (SSURO) for the herbicide Imprelis due to injury to non-target vegetation (Patton et al., 2011). The herbicide was deemed to be MISBRANDED. This SSURO requires DuPont Professional Products to cease all sale, distribution and use of DuPont Imprelis herbicide in the State of Indiana, effective August 1, 2011. As a result, Imprelis may no longer be used in Indiana and product should be returned to DuPont via their recall and refund program. The objectives of this research were to evaluate the efficacy of Imprelis for weed control and these authors did not evaluate the safety of this herbicide on trees or shrubs.

References

Borger, J.A., T.L. Watschke, and J.T. Brosnan. 2002. Broadleaf weed control in 2002. In the 57th Annual Meeting of the Northeastern Weed Science Society. Vol.57, 2003, p.105

Kohler, E.A., C.S. Throssell, and Z.J. Reicher. 2004. Cultural and chemical control of ground ivy (*Glechoma hederacea*). HortScience 39(5): 1148-1152.

Olson, B.D. and W.G. Wright. 1988. Postemergence broadleaf weed control in turf with triclopyr and phenoxy herbicide. Proceedings of the 42nd Annual Meeting of the Northeastern Weed Science Society. Vol.42, January 1988, p.177

Reicher, Z.J. and D.V. Weisenberger. 2007. Herbicide selection and application timing in the fall affects control of ground ivy. Online. Applied Turfgrass Science doi:10.1094/ATS-2007-0831-01-RS.

Vrabel, T.E. 1987. Wild violet control in cool season turf. Proceeding of 41st Annual Meeting of the Northeastern Weed Science Society. Vol.41, January 1987, p.237.

Table 1. Herbicide and timing effects on coverage of ground ivy.

Herbicide	rate	timing[a]	Ground Ivy Coverage 22 Oct 2010	11 Nov 2010	5 May 2011	7 June 2011	8 July 2011
			%				
2,4-D ester[b]	3 qt/A	fall	75 ab[c]	17 ef	2 ij	4 f	8 hi
2,4-D ester[b]	3 qt/A	spring			12 fghij		18 fgh
Banvel	1 pt/A	fall	80 ab	78 ab	43 abc	64 ab	88 ab
Banvel	1 pt/A	spring			32 bcde		87 ab
Blade	0.5 oz/A	fall	80 ab	68 ab	2 ij	7 f	17 ghi
Blade	0.5 oz/A	spring			18 efghij		80 abcd
Dismiss	8 oz/A	fall	28 d	23 de	27 cdef	69 ab	78 abcd
Dismiss	8 oz/A	spring			17 efghij		87 ab
Escalade 2	3 pt/A	fall	75 ab	20 def	4 hij	7 f	18 fgh
Escalade 2	3 pt/A	spring			20 efghi		18 fgh
Imprelis	4.5 oz/A	fall	32 d	9 ef	0 j	0 f	1 i
Imprelis	4.5 oz/A	spring			7 ghij		1 i
Lontrel	1.33 pt/A	fall	87 a	82 a	55 a	74 a	87 ab
Lontrel	1.33 pt/A	spring			40 abcd		83 abc
Mecomec	4 pt/A	fall	87 a	83 a	53 a	75 a	92 a
Mecomec	4 pt/A	spring			48 ab		87 ab
Spotlight	1.33 pt/A	fall	68 b	15 ef	1 ij	27 de	13 ghi
Spotlight	1.33 pt/A	spring			28 cdef		73 bcde
Tenacity	8 oz/A	fall	77 ab	63 b	28 cdef	54 bc	88 ab
Tenacity	8 oz/A	spring			45 abc		60 e
Trimec Classic	4 pt/A	fall	77 ab	42 c	19 efghi	38 cd	67 de
Trimec Classic	4 pt/A	spring			22 defgh		80 abcd
Turflon Ester Ultra	1 pt/A	fall	72 ab	35 cd	3 ij	14 ef	27 fg
Turflon Ester Ultra	1 pt/A	spring			23 defg		28 fg
TZONE	4 pt/A	fall	77 ab	22 def	4 hij	11 ef	28 fg
TZONE	4 pt/A	spring			17 efghij		33 f
Untreated Check		fall	78 ab	75 ab	28 cdef	77 a	70 cde
Untreated Check		spring			43 abc		75 bcde
ANOVA							
Timing					0.0046	NS	0.0001
Herbicide			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Timing × Herbicide					0.0545	NS	<0.0001

[a] Plots were treated with herbicide on 8 October 2010 (fall) or 13 April 2011 (spring).
[b] 2,4-D ester was mistakenly applied at above label rates at 2.85 lbs a.i./acre or 3 quarts/acre. The label allows for up to 2 lbs a.i./acre or 4.2 pints/acre. NOTE: Each 2,4-D product has unique labeling so refer to your label for specific use instructions.
[c] Within columns, means followed by the same letter are similar.


Fig. 1. Spotlight applied at 1.33 pt/A on 8 October 2010. Photo taken on 5 May 2011.


Fig. 2. Spotlight applied at 1.33 pt/A on 13 April 2011. Photo taken on 5 May 2011.


Fig. 3. Imprelis applied at 4.5 oz /A on 8 October 2010. Photo taken on 5 May 2011.


Fig. 4. Imprelis applied at 4.5 oz /A on 13 April 2011. Photo taken on 5 May 2011.


Fig. 5. 2,4-D ester applied at 3 qt/A on 8 October 2010. Photo taken on 5 May 2011.


Fig. 6. Untreated check plot. Photo taken on 5 May 2011.

Mowing and Herbicide Effects on Ground Ivy Control in Turf

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: Ground ivy (*Glechoma hederacea*), sometimes referred to as creeping Charlie, is a tough-to-control broadleaf weed in the mint family usually found growing in the shade. When attempting to control weeds, Extension bulletins and many herbicide labels recommend not to mow turf 1-2 days before or after application of a herbicide to maximize control. However, the effect of mowing on herbicide efficacy has not been sufficiently explored. The objectives of this experiment were to 1) determine which herbicides most effectively control ground ivy, 2) determine the optimum mowing schedule for weed control, and 3) determine if any herbicide by mowing timing interactions exist. The herbicide treatments were 2,4-D ester, Blade, Imprelis, Trimec Classic, Turflon Ester Ultra, and the untreated check at various timings before or after mowing. At no point in the experiment did the main effect of mowing have a significant impact on ground ivy coverage nor was there a significant mowing by herbicide interaction. Thus, this preliminary data suggests that whether or not turf is mown before or after an application may not be as important as previously thought. Imprelis, a herbicide no longer registered for use, was the most effective at controlling ground ivy. This experiment will be repeated in 2011-2012.

Ground ivy (*Glechoma hederacea*), sometimes referred to as creeping Charlie, is a tough-to-control broadleaf weed in the mint family usually found growing in the shade. When controlling weeds Extension bulletins (Boyd, 2004; Reicher et al., 2006) and many herbicide labels (Anonymous, 2009, 2011) recommend not to mow turf 1 to 2 days before or after application of a herbicide to maximize control. However, the effect of mowing on herbicide efficacy has not been sufficiently explored. Technology exists that can apply a herbicide directly to freshly cut leaf tips immediately (during mowing) following cutting (Henson et al., 2003; Jester et al., 2009) and this research has demonstrated that it is equally effective at controlling weeds to traditional broadcast spray applications to unmown areas and the research also suggests that in some cases it can provide superior control (Jester et al., 2009). Thus, some research exists that contradicts the statements in Extension bulletins and herbicide labels. Therefore, we set out to determine whether or not mowing practices before or after mowing might affect the weed control with traditional broadcast herbicide applications. The objectives of this experiment were to 1) determine which herbicides most effectively control ground ivy, 2) determine the optimum mowing schedule for weed control, and 3) determine if any herbicide by mowing timing interactions exist.

ADDITIONAL INDEX WORDS:
2,4-D; aminocyclopyrachlor; Blade, Imprelis; metsulfuron; triclopyr; Trimec Classic; Turflon Ester.

Patton, A., and D. Weisenberger. 2012. Mowing and Herbicide Effects on Ground Ivy Control in Turf. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 49-52.

MATERIALS AND METHODS

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The site was a Kentucky bluegrass blend with a uniform cover by ground ivy.

Experimental design was 3 × 6 Factorial with four replications and an individual plot size of 25 ft^2. The three mowing timings were 1) mow 30 minutes prior to application, 2) mow 30 minutes after application, and 3) not mowed for 72 hours prior or 72 hours after application. These mowing treatments were designed to simulate a worst case scenario of mowing either immediately prior to or after a mowing. Plots were mown at 2 inches removing 0.5-1.5 inches of Kentucky bluegrass leaf tissue (Fig. 1). Ground ivy was dispersed throughout the turf canopy (Fig. 2) at heights of 0.5 to 3.0 inches prior to mowing and the mowing treatments removed approximately 30-40% of the ground ivy leaf tissue (Fig. 3). The herbicide treatments were 2,4-D ester, Blade, Imprelis, Trimec Classic, Turflon Ester Ultra, and the untreated check. The herbicide was mostly dry on the leaf surface when mowing 30 minutes following an application; however, the deck of the mower was cleaned with a blower to remove debris after each plot was mown to reduce the potential to track herbicide from one plot to another (Fig. 4).

Plots were treated with herbicide 29 October 2010. Herbicides were applied in 87 gpa water with a CO_2-pressurized sprayer at 30 psi. Ground ivy coverage was visually rated for percent cover. All data were analyzed using SAS (SAS Institute, Inc). The data were analyzed as a 3 × 5 Factorial without the untreated check and the coverage in the untreated check is shown in Table 1 for comparison purposes. Means were separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Results and Discussion

When rated 17 November (3 weeks after application) there were no immediate visible effects of the herbicide treatments. However, on each spring rating date herbicide affected ground ivy coverage. When rated on 8 July 2011, the 29 October application of Imprelis reduced ground ivy coverage most. In this experiment, 2,4-D provided fair ground ivy control, but the rate of 2,4-D used in this study were applied at 1.4 times (ester) the label recommended rate which restricts no more than 2.0 lbs a.i./acre of 2,4-D. Thus, the level of ground ivy control would be expected to be less when applied at label rates. The excellent control of ground ivy from Imprelis was consistent with other research done with this product at this location.

Following the initiation of this experiment, the Office of Indiana State Chemist issued a stop sale, use, or removal order (SSURO) for the herbicide Imprelis due to injury to non-target vegetation (Patton et al., 2011). The herbicide was deemed to be MISBRANDED. This SSURO requires DuPont Professional Products to cease all sale, distribution and use of DuPont Imprelis herbicide in the State of Indiana, effective August 1, 2011. As a result, Imprelis may no longer be used in Indiana and product should be returned to DuPont via their recall and refund program. The objectives of this research were to evaluate the efficacy of Imprelis for weed control and these authors did not evaluate the safety of this herbicide on trees or shrubs.

At no point in the experiment did the main effect of mowing have a significant impact on ground ivy coverage, nor was there a significant mowing by herbicide interaction. Thus, this preliminary data suggests that whether or not turf is mown before or after an application may not be as important as previously thought.

Thus far, our results with the products used in this experiment contradict statements in Extension bulletins (Boyd, 2004; Reicher et al., 2006) and herbicide labels that encourage mowing to be postponed before a herbicide application and agrees with research that documents good control of weeds when a herbicide is applied to a fresh wound (Henson et al., 2003; Jester et al., 2009). Despite this, we must caution that our results were obtained with the herbicides we selected on ground ivy with fall applications and that this experiment conducted on a different weed species, with different herbicides, or at a different timing could yield differing results. Our research on mowing after a herbicide application is novel and suggests that despite defoliation of a portion of the treated weed leaf by mowing, that enough treated leaf area remains for a herbicide to behave similarly to treatment of unmown areas. It is worth stating that not all Extension publications and herbicide labels recommend postponing mowing either before or after herbicide application as many do not mention any specific recommendations about mowing and the application. We will repeat experiment in 2011-2012.

References

Anonymous. 2009. Onetime herbicide label. BASF Corporation. Research Triangle Park, NC 27709. p.4

Anonymous. 2011. Trimec 992 herbicide label. PBI/Gordon Corporation. Kansas City, Missouri 64101. p.4

Boyd, J. 2004. Home lawn weed control. University of Arkansas Cooperative Extension Publication FSA-2109.

Henson, S.E., W.A. Skroch, J.D. Burton, and A.D. Worsham. 2003. Herbicide efficacy using a wet-blade application system. Weed Technol. 17:320-324.

Jester, J.L., S.D. Askew, and B.J. Brecke. 2009. Wet blade technology efficacy in controlling *Trifolium repens* and *Digitaria ischaemum* in turfgrass with herbicides. International turfgrass Society Research Journal 11:1199-1204.

Patton, A., T. Creswell, G. Ruhl, and S. Weller. 2011. A Turf Professionals Guide to Suspected Imprelis® Herbicide Injury in the Landscape. Purdue University Plant & Pest Diagnostic Laboratory publication. Available at: http://www.ppdl.purdue.edu/PPDL/pubs/briefs/ImprelisLCO.pdf.

Reicher, Z.J., C.A. Bigelow, A.J. Patton, and T. Voigt. 2006. Controlling broadleaf weeds in home lawns. Purdue Univ. and the Univ. of Illinois Cooperative Extension Publication. AY-9-W, IL-IN TW 31.

Fig. 1. Turf before mowing (left) and after mowing (right)

Fig. 2. Ground ivy appearance prior to mowing.

Fig. 3. Ground ivy appearance after mowing showing the full, partial, and lack of removal of ground ivy leaves following mowing. The mowing treatments removed approximately 30-40% of the ground ivy leaf tissue.

Fig. 4. The deck of the mower was cleaned with a blower to remove debris and reduce the potential to track herbicide from one plot to another.

Table 1. Herbicide effects on coverage of ground ivy. Means averaged over mowing and replication.

Herbicide	Product rate	Ingredient rate	Coverage 17 Nov 2010	29 April 2011	3 June 2011	8 July 2011
	oz/A	lbs a.i./A	%			
2,4-D ester [a]	96	2.9	87	4 b [b]	10 b	33 b
Blade	0.5	0.02	83	4 b	15 b	58 a
Imprelis	4.5	0.07	81	0 b	0 c	0 c
Trimec Classic	64	1.4	85	12 a	20 ab	55 a
Turflon ester ultra	32	1.0	82	14 a	29 a	56 a
ANOVA						
MOW			NS	NS	NS	NS
HERBICIDE			NS	<0.0001	<0.0001	<0.0001
MOW X HERBICIDE			NS	NS	NS	NS
Untreated check [c]			85	38	65	79

[a] 2,4-D ester was applied above label rates which allow up to 2.0 lbs a.i./acre. NOTE: Each 2,4-D product has unique labeling so refer to your label for specific use instructions.
[b] Within columns, means followed by the same letter are similar.
[c] Untreated check plots are shown for comparison purposes only and were not included in the analyses.

Preemergence Crabgrass Control with Various Herbicides

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TURFGRASS SCIENCE

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SUMMARY: Crabgrass (*Digitaria* spp.) is often considered to be the most problematic weed in lawns. Crabgrass is a summer annual grassy weed that typically germinates in April in the Midwest (early April in southern areas and late-April in northern areas). The best approach to controlling crabgrass is using a preemergence herbicide such as dithiopyr (Dimension), pendimethalin (Pendulum), prodiamine (Barricade), sulfentrazone + prodiamine (Echelon), and others. The objective of this experiment was to evaluate Quali-Pro's new prodiamine liquid formulation and compare to other preemergence herbicides for efficacy of crabgrass. All preemergence treatments performed better than the untreated check on all rating dates. Quali-Pro Prodiamine 65WDG and Barricade 65WDG performed the same on all rating dates and QP Dithiopyr 40WP and Dimension Ultra 40WP had equal control on all rating dates. QP Dithiopyr 40WP, Barricade 65WDG, and Dimension Ultra 40WP had lower percent coverage of crabgrass than QP Prodiamine 4L and Barricade 4L when rated on 1 September, and despite delivering the same amount of active ingredient, Quali-Pro Prodiamine 65 WDG and Barricade 65WDG reduced crabgrass coverage more than QP Prodiamine 4L and Barricade 4L, but it is not clear why these formulation differences occurred.

Large crabgrass (*Digitaria sanguinalis*) and smooth crabgrass (*Digitaria ischaemum*) are both species of crabgrass found in the Midwest that are collectively referred to as crabgrass. Crabgrass is often considered to be the most problematic weed in lawns. Crabgrass is a summer annual grassy weed that typically germinates in April in the Midwest (early April in southern areas and late-April in northern areas). Proper mowing (higher mowing heights), proper fertilization (some rather than none to improve turf density), irrigation to prevent summer dormancy during drought, and aerification of compacted areas to improve turf health are all cultural practices that can be used to reduce crabgrass. Despite proper cultural practices, crabgrass may still remain problematic in certain "hot spots" such as next to sidewalks and driveways as well as sunny areas. The best approach to controlling crabgrass is using a preemergence herbicide such as dithiopyr (Dimension), pendimethalin (Pendulum), prodiamine (Barricade), sulfentrazone + prodiamine (Echelon), and others. These herbicides inhibit cell division and prevent crabgrass seeds from properly emerging. Since these herbicides work on germinating seeds, they must be applied prior to germination with the exception of dithiopyr which controls crabgrass before and after germination until it reaches one tiller. The objective of this experiment was to evaluate Quali-Pro's new post-patent prodiamine liquid formulation and compare to other preemergence herbicides for efficacy of crabgrass.

ADDITIONAL INDEX WORDS:
Barricade, Dimension, dithiopyr, prodiamine, Quali-Pro.

Patton, A., and D. Weisenberger. 2012. Preemergence Crabgrass Control with Various Herbicides. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 53-54.

MATERIALS AND METHODS

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The area was an established Kentucky bluegrass blend with a history of crabgrass pressure. Experimental design was randomized complete block with three replications and an individual plot size of 25 ft^2. Plots were mown as needed at 2 inches. Plots were treated with herbicides on 26 April. Herbicides were applied in 30 gpa water with a CO_2-pressurized sprayer at 30 psi. Crabgrass coverage was visually rated. All data were analyzed using SAS (SAS Institute, Inc). Means separated using Fisher's protected least significant difference when F tests were significant at $\alpha=0.05$.

Results and Discussion

All treatments performed better than the check on all rating dates (Table 1). Quali-Pro Prodiamine 65WDG and Barricade 65WDG performed the same on all rating dates. QP Dithiopyr 40WP and Dimension Ultra 40WP had equal control on all rating dates. QP Prodiamine 4L was statistically better than Barricade 4L when rated on 1 September but neither were commercially acceptable. QP Dithiopyr 40WP, Barricade 65WDG, and Dimension Ultra 40WP had lower percent coverage of crabgrass than QP Prodiamine 4L and Barricade 4L when rated on 1 Sept. Despite delivering the same amount of active ingredient, Quali-Pro Prodiamine 65 WDG and Barricade 65WDG reduced crabgrass coverage more than QP Prodiamine 4L and Barricade 4L, but it is not clear why these formulation differences occurred..

Table 1. Preemergence herbicide effects on crabgrass coverage.

		Crabgrass coverage			
Herbicide	rate	9 June	28 June	5 Aug	1 Sept
		%			
Untreated	--	12 a[a]	62 a	99 a	98 a
QP Prodiamine 4L	24 fl oz/A	0 b	2 b	20 b	27 c
Quali-Pro Prodiamine 65WDG	1.15 lb/A	0 b	1 b	12 c	18 cd
QP Dithiopyr 40WP	1.25 lb/A	0 b	0 b	4 d	8 e
Barricade 4L	24 fl oz/A	0 b	1 b	25 b	37 b
Barricade 65WDG	1.15 lb/A	0 b	0 b	7 cd	12 de
Dimension Ultra 40WP	1.25 lb/A	0 b	0 b	8 cd	15 de
P-value		<0.0001	<0.0001	<0.0001	<0.0001

[a] Means followed by the sample letter are not significantly different.

Postemergence Broadleaf Herbicide Safety on Putting Greens

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Summary: Few broadleaf weeds can survive on putting greens with the exception of white clover, mouse-ear chickweed, and prostrate spurge. Despite a golf course superintendent's best efforts and even with the use of sound management practices, weeds other than annual bluegrass do occasionally occur on putting greens. However, many golf course superintendents are hesitant to use herbicides on their putting greens for fear that injury might occur. The objective of this experiment was to determine the safety of postemergence broadleaf herbicides on greens height creeping bentgrass and *Poa annua*. Some injury was observed from treatments on both annual bluegrass and creeping bentgrass putting greens but injury levels were acceptable (≥ 7) for all treatments including when herbicides were applied at a 2X rate. There were no differences in turf quality among treatments on either the annual bluegrass putting green or the creeping bentgrass putting green. These results suggest that broadleaf herbicides labeled for putting green use can be safely applied in the fall without fear of causing unacceptable injury.

Few herbicides or plant growth regulators are needed on golf course putting greens to control weeds with the exception of annual bluegrass (*Poa annua*). This is due to the fact that few broadleaf weeds can survive these low mowing heights with the exception of white clover, mouse-ear chickweed, and prostrate spurge. Crabgrass and goosegrass are problematic grassy weeds that can also occur in putting greens, especially in southern Indiana and the transition zone. Despite a golf course superintendent's best efforts and even with the use of sound management practices, weeds other than annual bluegrass do occasionally occur on putting greens. However, many golf course superintendents are hesitant to use herbicides on their putting greens for fear that injury might occur. The objective of this experiment was to determine the safety of postemergence broadleaf herbicides on greens height creeping bentgrass and annual bluegrass..

Additional index words:
2,4-D; 4-Speed; 4-Speed XT; Banvel; carfentrazone; dicamba; Mecomec 2.5; mecoprop (MCPP); pyraflufen-ethyl; Quicksilver T&O; triclopyr; Trimec Bentgrass; Trimec Classic; Trimec Encore; Trimec Southern.

Patton, A., and D. Weisenberger. 2012. Postemergence Broadleaf Herbicide Safety on Putting Greens. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 55-59.

Materials and Methods

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. One site was 'Pennlinks' creeping bentgrass (*Agrostis stolonifera*) grown on a USGA specification sand putting green and a second site was predominately annual bluegrass grown on a native soil putting green. Experimental design was randomized complete block with three replications and an individual plot size of 25 ft^2. Plots were mown at 0.135 inches daily. Herbicides included in this study are summarized in Table 1 and they were applied at the putting green label rate and at a rate 2× the label rate. Plots were treated with herbicide 24 Oct. 2011. Herbicides were applied in 40 gpa water with a CO_2-pressurized sprayer at 30 psi. An untreated check was included for comparison. Injury to creeping bentgrass was rated on a 9 to 1 scale with 9 = no injury, 7 = acceptable injury, and 1 = completely brown turf. Turf quality was visually rated using a scale of 9 to 1 with 9 = best quality, 7 = acceptable quality, and 1 = totally brown and/or bare plot. When visible injury was present, digital images were taken using a light box and then analyzed for color in SigmaScan Pro 5. A FieldScout CM 1000 Chlorophyll Meter was used when visible injury was present to gather three reading per plot and then averaged for analysis. All data were analyzed using SAS (SAS Institute, Inc). Means were separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Results and Discussion

Some injury was observed from treatments on both annual bluegrass and creeping bentgrass putting greens but injury levels were acceptable (≥ 7) for all treatments including when herbicides were applied at a 2X rate (Table 2). There were no differences in turf quality among treatments on either the annual bluegrass putting green or the creeping bentgrass putting green (Table 3). Results of turf color from digital image analysis were inconsistent with visual ratings (data not shown) likely due to the poor turf color on the plots as they entered winter dormancy. The CM1000 chlorophyll meter yielded results similar to visual ratings on the creeping bentgrass putting green with Banvel at 2 pt/A yielding the lowest mean chlorophyll index among plots on the annual bluegrass putting green (Table 4). These results suggest that broadleaf herbicides labeled for putting green use can be safely applied in the fall without fear of causing unacceptable injury. More injury might be expected from late spring and summer applications.

Table 2. Herbicide effect on injury to creeping *Poa annua* and creeping bentgrass.

		Injury					
Treatment	Rate	2 Nov	17 Nov	2 Dec	2 Nov	17 Nov	2 Dec
		Poa annua			creeping bentgrass		
4-Speed	1.8 pt/A [a]	9.0 a [b]	9	8 abc	9 a	9.0 a	9.0 a
4-Speed XT	1.8 pt/A [a]	9.0 a	9	9 ab	9 a	9.0 a	8.7 ab
Banvel	1 pt/A [a]	9.0 a	9	8 abc	9 a	8.7 b	8.3 bc
Mecomec 2.5	4 pt/A [a]	8.7 ab	9	9 a	8 b	9.0 a	8.7 ab
Quicksilver T&O	6.7 oz/A [a]	9.0 a	9	9 ab	9 a	9.0 a	9.0 a
+ NIS	0.25% v/v						
Trimec Bentgrass	2.7 pt/A [a]	9.0 a	9	8 abc	9 a	9.0 a	8.7 ab
Trimec Classic	1.8 pt/A [a]	9.0 a	9	9 ab	9 a	9.0 a	9.0 a
Trimec Encore	1.8 pt/A [a]	9.0 a	9	9 ab	9 a	9.0 a	9.0 a
Trimec Southern	2 pt/A [a]	9.0 a	9	8 bcd	9 a	9.0 a	9.0 a
4-Speed	3.6 pt/A [c]	9.0 a	9	8 abc	9 a	9.0 a	8.3 bc
4-Speed XT	3.6 pt/A [c]	8.7 ab	8	7 d	9 a	9.0 a	8.3 bc
Banvel	2 pt/A [c]	9.0 a	9	8 cd	9 a	8.0 c	7.3 d
Mecomec 2.5	8 pt/A [c]	8.0 c	9	9 ab	9 a	9.0 a	9.0 a
Quicksilver T&O	13.4 oz/A [c]	8.3 bc	9	9 ab	9 a	9.0 a	9.0 a
+ NIS	0.25% v/v						
Trimec Bentgrass	5.4 pt/A [c]	9.0 a	9	9 a	9 a	9.0 a	8.3 bc
Trimec Classic	3.6 pt/A [c]	9.0 a	9	9 a	9 a	9.0 a	8.3 bc
Trimec Encore	3.6 pt/A [c]	9.0 a	9	8 abc	9 a	9.0 a	8.0 c
Trimec Southern	4 pt/A [c]	8.6 ab	9	8 abc	9 a	9.0 a	8.0 c
Untreated		9.0 a	9	9 a	9 a	9.0 a	9.0 a
P-value		0.0007	NS	0.0111	0.0002	<0.0001	0.0001

[a] Label rate for putting green applications.
[b] Within columns, means followed by the same letter are similar.
[c] 2X putting green label rate.

Table 1. Broadleaf herbicides labeled for creeping bentgrass putting greens.

Trade Name (product/Acre)	Ingredients (amount of a.i. or a.e./A in parentheses)	Label rate/Acre	Label Language	Label Comments	Application Volume (gal/A)
4-Speed	2,4-D (0.5) + MCPP (0.13) + dicamba (0.05) + pyraflufen ethyl (0.001)	1.8 pint	Putting and Bowling Greens	Avoid applications during periods when turf is under stress due to high heat, humidity, and reduced moisture. Slight turf yellowing will disappear after about one week.	43 to 87
4-Speed XT	2,4-D (0.5) + triclopyr (0.06) + dicamba (0.06) + pyraflufen ethyl (0.001)	1.8 pint	Putting and Bowling Greens	Avoid applications during periods when turf is under stress due to high heat, humidity, and reduced moisture. Slight turf yellowing will disappear after about one week.	43 to 87
Banvel	dicamba (0.5)	1 pint	Bentgrass	Label neither allows nor restricts applications to putting greens. Use 1 pint or less of product per acre. Do not use on bentgrass unless possible crop injury can be tolerated. [Author note: weeds can be controlled with as little as 4 fl oz/acre with this herbicide]	3 to 50
Mecomec 2.5	mecoprop-p (MCPP) (1.25)	4 pint	Established Greens	Use only on actively growing turf that is not under stress. Do not apply to bentgrass in the heat of summer.	22 to 174
Quicksilver T&O	carfentrazone (0.1)	6.7 oz	Golf Course Greens	Quicksilver (carfentrazone) T&O 1.9EC at 2.0 to 6.7 oz per acre when temperatures are less than 85 °F provides excellent moss control. Apply as often as every two weeks to putting greens infested with silvery thread moss. Annual bluegrass can be damaged at rates greater than 2.0 oz Quicksilver T&O 1.9EC per acre. Use a non-ionic surfactant at 0.25% v/v. Do not apply to bentgrass when temperatures exceed 90 °F.	20 to 175
Trimec Bentgrass	mecoprop (0.24) + 2,4-D (0.15) + dicamba (0.06)	2.7 pint	Putting and Bowling Greens	Do not apply to bentgrass under stress. Do not apply when air temperatures exceed 85° F. May or fall application recommended.	high
Trimec Classic	2,4-D (0.45) + mecoprop (0.12) + Dicamba (0.05)	1.8 pint	Putting and Bowling Greens	Do not exceed 1.0 fl oz/1,000 ft^2 on creeping bentgrass putting greens using a spray volume of 5 gallons/1000 ft^2. Do not apply to bentgrass under stress. Do not apply when air temperatures exceed 85° F.	145
Trimec Encore	MCPA (0.67) + mecoprop (0.14) + dicamba (0.07)	1.8 pint	Putting and Bowling Greens	Do not exceed 1.0 fl oz/1,500 ft^2 on creeping bentgrass putting greens using a spray volume of 5 gallons/1000 ft^2. Do not apply to bentgrass under stress. Do not apply when air temperatures exceed 85° F. Slight yellowing will occur within a week.	145
Trimec Southern	mecoprop (0.33) + 2,4-D (0.36) + dicamba (0.07)	2.0 pint	Bentgrass	Use 2.0 pints of product per acre. Do not overdose closely-mowed bentgrass. Bermudagrass and bentgrass are moderately sensitive to 2,4-D.	2 to 300

Table 3. Herbicide effect on quality of *Poa annua* and creeping bentgrass.

		Quality	
Treatment	Rate	2 Nov	2 Nov
		Poa annua	creeping bentgrass
4-Speed	1.8 pt/A [a]	5.3	7.0
4-Speed XT	1.8 pt/A [a]	5.0	7.0
Banvel	1 pt/A [a]	5.7	7.0
Mecomec 2.5	4 pt/A [a]	5.0	6.7
Quicksilver T&O	6.7 oz/A [a]	5.0	7.0
+ NIS	0.25% v/v		
Trimec Bentgrass	2.7 pt/A [a]	5.0	7.0
Trimec Classic	1.8 pt/A [a]	5.0	7.0
Trimec Encore	1.8 pt/A [a]	5.0	6.7
Trimec Southern	2 pt/A [a]	5.3	7.0
4-Speed	3.6 pt/A [b]	5.0	7.0
4-Speed XT	3.6 pt/A [b]	5.3	7.0
Banvel	2 pt/A [b]	5.0	7.0
Mecomec 2.5	8 pt/A [b]	5.0	7.0
Quicksilver T&O	13.4 oz/A [b]	5.0	7.0
+ NIS	0.25% v/v		
Trimec Bentgrass	5.4 pt/A [b]	4.7	7.0
Trimec Classic	3.6 pt/A [b]	5.0	7.0
Trimec Encore	3.6 pt/A [b]	5.3	6.3
Trimec Southern	4 pt/A [b]	5.3	7.0
Untreated		5.0	7.0
P-value		NS	NS

[a] Label rate for putting green applications.
[b] 2X putting green label rate.

Table 4. Herbicide effect on chlorophyll meter readings for creeping *Poa annua* and creeping bentgrass.

		Chlorophyll meter readings					
Treatment	Rate	2 Nov	17 Nov	2 Dec	2 Nov	17 Nov	2 Dec
		Poa annua			creeping bentgrass		
4-Speed	1.8 pt/A [a]	159	175	161	200	210 abc [b]	177 cdefg
4-Speed XT	1.8 pt/A [a]	154	168	152	192	211 abc	184 abcde
Banvel	1 pt/A [a]	161	180	167	198	203 cd	182 abcdef
Mecomec 2.5	4 pt/A [a]	158	180	175	193	201 cd	176 cdefg
Quicksilver T&O	6.7 oz/A [a]	161	188	169	204	221 ab	194 a
+ NIS	0.25% v/v						
Trimec Bentgrass	2.7 pt/A [a]	155	174	155	192	204 cd	179 cdefg
Trimec Classic	1.8 pt/A [a]	160	175	155	199	206 bcd	181 bcdef
Trimec Encore	1.8 pt/A [a]	165	176	164	189	196 cde	171 fg
Trimec Southern	2 pt/A [a]	165	177	160	198	207 bc	188 abc
4-Speed	3.6 pt/A [c]	159	176	166	185	184 e	171 efg
4-Speed XT	3.6 pt/A [c]	155	174	158	189	200 cde	178 cdefg
Banvel	2 pt/A [c]	157	170	155	190	189 de	167 g
Mecomec 2.5	8 pt/A [c]	150	168	155	192	201 cd	175 cdefg
Quicksilver T&O	13.4 oz/A [c]	162	181	170	201	227 a	184 abcd
+ NIS	0.25% v/v						
Trimec Bentgrass	5.4 pt/A [c]	150	167	151	189	202 cd	176 cdefg
Trimec Classic	3.6 pt/A [c]	159	174	159	193	200 cde	173 defg
Trimec Encore	3.6 pt/A [c]	159	179	168	183	195 cde	170 fg
Trimec Southern	4 pt/A [c]	156	182	169	189	199 cde	171 efg
Untreated		163	187	173	202	221 ab	192 ab
P-value		NS	NS	NS	NS	0.0010	0.0029

[a] Label rate for putting green applications.
[b] Within columns, means followed by the same letter are similar.
[c] 2X putting green label rate.

Postemergence Ground Ivy Control with Herbicide Combinations

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: Ground ivy (*Glechoma hederacea*) and dandelion (*Taraxacum officinale*) are common perennial broadleaves that are problematic weeds in turf. Fertilizing turf with nitrogen is known to reduce ground ivy and dandelion coverage compared to non-fertilized turf. Despite a beneficial reduction in broadleaf weeds from fertilization, herbicides are needed for effective control. The objective of this experiment was to evaluate Quali-Pro herbicide combinations and compare to other post emergence herbicides in cool-season situations for efficacy of broadleaf weeds. Quali-Pro 2-D (clopyralid + triclopyr) at 2 pt/A, 2,4-D + triclopyr + quinclorac, and Triplet SF (2,4-D + mecoprop + dicamba) provided the best control. Quali-Pro 3-D (2,4-D + mecoprop + dicamba) at 4 pt/A and Triplet SF were statistically similar on each rating date. There was a substantial benefit in ground ivy control when increasing the label rate of 2-D from 1 to 2 pt/A. All herbicide treatments with the exception of Quali-Pro 2-D at 1 pt/A effectively reduced dandelion populations compared to the untreated check. Quali-Pro 3-D at 4 pt/A and Triplet SF were statistically similar on each rating date.

Ground ivy (*Glechoma hederacea*) and dandelion (*Taraxacum officinale*) are common perennial broadleaves that are problematic weeds in turf. Fertilizing turf with nitrogen is known to reduce ground ivy and dandelion coverage compared to non-fertilized turf (Johnson and Bowyer, 1982; Kohler et al., 2004). Despite a beneficial reduction in broadleaf weeds from fertilization, herbicides are needed for effective control. The objective of this experiment was to evaluate the efficacy post-patent Quali-Pro herbicide combinations and compare to these herbicides to other post emergence herbicides for efficacy of broadleaf weeds.

Materials and Methods

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The area was an established Kentucky bluegrass blend with a history of ground ivy and dandelion pressure. Experimental design was a randomized complete block with three replications and an individual plot size of 25 ft^2. Plots were mown at 2 inches as needed. Plots were treated with herbicides on 3 June. Herbicides were applied in 40 gallons/acre water with a CO_2-pressurized sprayer at 30 psi. Ground ivy and dandelion were visually rated for percent cover. Injury to Kentucky bluegrass was rated on a scale of 9 to 1 with 9 = to no injury, 7 = acceptable injury, and 1 = completely brown turf. All data were analyzed using SAS (SAS Institute, Inc). Means separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Additional index words:
2,4-D; 2-D; 3-D; clopyralid; dicamba; MCPP (mecoprop); Quali-Pro; quinclorac, triclopyr; Triplet SF.

Patton, A., and D. Weisenberger. 2012. Postemergence Ground Ivy Control with Herbicide Combinations 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 60-62.

Results and Discussion

When rated on 8 July, 5 weeks after application, Quali-Pro 2-D (clopyralid + triclopyr) at 2 pt/A, 2,4-D + triclopyr + quinclorac, and Triplet SF (2,4-D + mecoprop + dicamba) provided the best control (Table 1). Quali-Pro 3-D (2,4-D + mecoprop + dicamba) at 4 pt/A and Triplet SF were statistically similar on each rating date (Table 1). There was a substantial benefit in ground ivy control when increasing the label rate of 2-D from 1 to 2 pt/A (Table 1). Generally, fluroxypyr and triclopyr are the most effective ingredients for ground ivy control. 2,4-D can be effective at higher rates but it is not typically as effective at rates applied with most herbicides mixtures. Additionally combinations of triclopyr and 2,4-D are generally effective for ground ivy control as seen with the 2,4-D + triclopyr + quinclorac treatment. Dicamba, clopyralid, and MCPP are not generally effective on ground ivy. 2-D contains triclopyr which is effective at controlling ground ivy. Although 2-D cannot be used on residential turf, it can be used effectively to control ground ivy on other turf sites.

Quinclorac (Drive XLR8, Drive 75DF, Eject 75DF, Quinclorac 75DF, QuinPro Herbicide) has been shown to be effective on some ground ivy populations in some Midwestern states, but has not provided adequate control in Purdue University testing with the biotype located at the Daniel Turfgrass Research Center. Ground ivy populations vary in their tolerance to herbicides, thus it would be wise to consider alternating herbicides or using tank-mixes when treating ground ivy.

Dandelion was a secondary weed in these plots. All herbicide treatments with the exception of Quali-Pro 2-D at 1 pt/A effectively reduced dandelion populations compared to the untreated check (Table 2). Quali-Pro 3-D at 4 pt/A and Triplet SF were statistically similar on each rating date (Table 2). Quinclorac and 2,4-D are generally more effective at dandelion control than triclopyr and clopyralid.

References

Johnson, B.J., and T.H. Bowyer,. 1982. Management of herbicide and fertility levels on weeds and Kentucky bluegrass turf. Agron. J. 74:845-850.

Kohler, E.A., C.S. Throssell, and Z.J. Reicher. 2004. Cultural and chemical control of ground ivy (*Glechoma hederacea*). HortScience 39(5): 1148-1152.

Table 1. Herbicide effects on ground ivy coverage.

Herbicide	rate	Ground ivy coverage			
		9 June	22 June	28 June	8 July
		%			
Untreated	--	77	88 a[a]	93 a	87 a
Quali-Pro 2-D	1 pt/A	70	47 b	47 b	63 b
Quali-Pro 2-D	2 pt/A	72	27 cd	13 de	20 de
Quali-Pro 3-D	3pt/A	70	30 c	33 bc	45 bc
Quali-Pro 3-D	4 pt/A	60	27 cd	22 cd	30 cd
2, 4-D amine	2.74 pt/A	70	18 cd	5 e	8 e
+triclopyr 3A	0.88 pt/A				
+Quali-Pro quinclorac	2.13 oz/A				
2, 4-D amine	2.74 pt/A	67	20 cd	23 cd	28 cd
+dicamba	0.25 pt/A				
+Quali-Pro quinclorac	2.13 oz/A				
Triplet SF	4 pt/A	57	15 d	15 de	25 de
P-value		NS	<0.0001	<0.0001	<0.0001

[a] Within columns, means followed by the same letter are similar.

Table 2. Herbicide effects on dandelion coverage.

Herbicide	rate	Dandelion coverage 9 June	8 July
		%	
Untreated	--	7	6 a [a]
Quali-Pro 2-D	1 pt/A	7	3 ab
Quali-Pro 2-D	2 pt/A	8	1 bc
Quali-Pro 3-D	3pt/A	8	1 bc
Quali-Pro 3-D	4 pt/A	10	1 bc
2, 4-D amine	2.74 pt/A	7	2 bc
+triclopyr 3A	0.88 pt/A		
+Quali-Pro quinclorac	2.13 oz/A		
2, 4-D amine	2.74 pt/A	8	1 bc
+dicamba	0.25 pt/A		
+Quali-Pro quinclorac	2.13 oz/A		
Triplet SF	4 pt/A	8	0 c
P-value		NS	0.0120

[a] Within columns, means followed by the same letter are similar.

Sequential Applications of Preemergence Crabgrass Herbicides for Enhanced Control – Three Year Summary

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: Lawn care operators (LCOs) have the capability to make sequential applications because their lawn care programs are structured into various rounds of applications. One question that lawn care operators pose is whether or not acceptable crabgrass control can be achieved when the active ingredient used in the initial application is followed by a different active ingredient in the second (sequential) application. The objectives of this study where to 1) determine if switching the active ingredient in sequential preemergence herbicide applications affects crabgrass control, and 2) compare the effectiveness of sequential preemergence herbicide applications to single preemergence herbicide applications for crabgrass control. Data support that equivalent crabgrass control can be expected when prodiamine, pendimethalin, and dithiopyr are used as part of a split application strategy regardless of which herbicide is used for the first and/or second application. The data also support that when the same total a.i/A is applied, sequential (split) applications will more effectively and consistently control crabgrass than a single application. These results confirm that there is more flexibility in selecting and using preemergence herbicides than previously thought and that LCOs using multiple rounds can split their preemergence application from one into two and gain increased crabgrass control without additional costs.

Sequential applications (split-applications) are known to provide better control of crabgrass (*Digitaria* spp.) than single applications (Dernoeden, 1984). Lawn care operators have the capability to make sequential applications because their lawn care programs are structured into various rounds of applications. One question that lawn care operators pose is whether or not acceptable crabgrass control can be achieved when the active ingredient used in the initial application is followed by a different active ingredient in the second (sequential) application. Previous research in the early 1990's indicated that it was best to use the same active ingredient in both applications (Reicher et al., 1991). However, new active ingredients and/or different formulations of active ingredients are now available and this strategy needs reexamining. The objectives of this study where to 1) determine if switching the active ingredient in sequential preemergence herbicide applications affects crabgrass control, and 2) compare the effectiveness of sequential preemergence herbicide applications to single preemergence herbicide applications for crabgrass control.

ADDITIONAL INDEX WORDS:
Barricade; Dimension; dithiopyr; LCO; pendimethalin, Pendulum; prodiamine; split.

Patton, A., D. Weisenberger and Z. Reicher. 2012. Sequential Applications of Preemergence Crabgrass Herbicides for Enhanced Control – Three Year Summary. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 63-65.

MATERIALS AND METHODS

The experiment was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The crabgrass area was a Kentucky bluegrass blend with a history of crabgrass pressure and the soil type was a silt loam with a pH of 7.2. Experimental design was randomized complete block with three replications and an individual plot size of 25 sq. ft. The crabgrass plot was mown at 1.5 inches in 2009 and 2010 and at 2.0 inches in 2011. The plots received no fertilization during the experiment, but had received 1.0 lb N/1000 ft^2 the previous fall using urea (46-0-0). Herbicides were applied to the crabgrass plots at the first of April (April 16, 9, and 12 in 2009, 2010, and 2011, respectively) with sequential applications made at the first of June (June 2, 1, and 2 in 2009, 2010, and 2011, respectively). A different experimental location was used in each year. A full list of herbicide treatments is provided in Table 1. Herbicides were applied in 87 gpa water with a CO_2-pressurized sprayer at 30 psi and herbicides were watered in after applications. An untreated check was included for comparison. Percent crabgrass coverage was visually estimated. Percent control was calculated as control=[(1-(crabgrass coverage in treated plot/crabgrass coverage in untreated check))*100]. All data were analyzed using SAS (SAS Institute, Inc.). Data were combined across three years and means across year are presented. Means were separated using Fisher's protected least significant difference when F tests were significant at α=0.05.

Results and Discussion

What if I miss the first application? As expected due to the early postemergence activity of dithiopyr, sequential applications of an untreated treatment on 9 April followed by dithiopyr in the first week of June resulted in less crabgrass when evaluated in late June compared to an untreated treatment on 9 April followed by pendimethalin, prodiamine, or another untreated treatment on 1 June (Table 1). This treatment simulates a missed preemergence application or a lawn care operator adding a new client in late spring. Better results might be expected if the full label rate (0.5 lb a.i./A) of dithiopyr were used in June rather than the half rate (0.25 lb a.i./A) used in this treatment design.

Can I switch active ingredients from the first to the second application? When crabgrass control was evaluated in August, all nine preemergence herbicide combinations (with dithiopyr, pendimethalin, or prodiamine first or last in the sequential application strategy) were similar and had less crabgrass than the untreated check (Treatment #16) or those sequential applications with an untreated treatment in their factorial design. Therefore, the data supports that equivalent crabgrass control can be expected when prodiamine, pendimethalin, and dithiopyr are switched in a split application strategy, which is different than a previous report by Reicher et al. (1991).

Do split (also known as sequential) applications help me to control crabgrass better? When evaluated early in June there were no differences across years between a split application strategy (regardless of active ingredient). However, crabgrass control in August and September was improved by sequential applications. The full preemergence application rate of pendimethalin and dithiopyr provided 78 and 76% crabgrass control, respectively, in August (Table 1). While these treatments were statistically similar to some of the sequential application treatments, all sequential applications with dithiopyr, pendimethalin, or prodiamine first or last in the sequential application strategy provided ≥91% crabgrass control. When analyzed across herbicides, all sequential applications (except those with the first or last application as untreated) provided greater control in August and September compared to full rates (Prodiamine 4FL at 0.75 lbs ai/acre; Dithiopyr 2EW at 0.5 lbs ai/acre; Pendimethalin 3.8 at 3.0 lbs ai/acre) applied preemergence (Table 2). This is consistent with previous research by Dernoeden (1984) and confirms that control can be improved by using the same total rate of preemergence herbicide split across two application dates.

Summary. Data from 2009 (Reicher and Weisenberger, 2010), 2010 (Patton et al. 2011) and data from 2011 (this report) support that equivalent crabgrass control can be expected when prodiamine, pendimethalin, and dithiopyr are used as part of a split application strategy regardless of which herbicide is used for the first and/or second application, which is slightly different than findings in the early 1990's. The data also support that when the same total a.i/A is applied, sequential (split) applications will more effectively and consistently control crabgrass than a single application. These results confirm that there is more flexibility in selecting and using preemergence herbicides than previously thought and that LCOs using multiple rounds can split their preemergence application from one into two and gain increased crabgrass control without additional costs. Similar research was conducted in Nebraska in 2011 and their findings confirm the results from Indiana presented in this summary.

References

Dernoeden, P.H.. 1984. Management of preemergence herbicides for crabgrass control in transition-zone turf. HortScience 19:443-445.

Patton, A., D. Weisenberger, and Z. Reicher. 2011. Sequential applications of preemergence crabgrass herbicides: Does the active ingredient in the sequential application have to be the same as used in the initial application? - 2010

Results. 2010 Annual Report - Purdue University Turfgrass Science Program. Available at: http://www.agry.purdue.edu/turf/report/2010/2010ResearchReport.pdf

Reicher, Z.J., C.S. Throssell, and J.L. Lefton. 1991. Annual grass control in cool season turf with sequential applications of unlike preemergence herbicides. Weed Technol. 5:387-391.

Reicher, Z.J. and D.V. Weisenberger. 2010. Sequential applications of preemergence crabgrass herbicides: Does the active ingredient in the sequential application have to be the same as used in the initial application? Purdue Turfgrass Research Annual Report. Available at: http://www.agry.purdue.edu/turf/report/2009/PDF/13_Reicher.pdf

Table 1. Crabgrass control after initial applications of preemergence herbicides on April followed by sequential applications in June in West Lafayette, Indiana. Means across 3 years.

Treatment	Herbicide applied on 9 Apr	Rate of application	Herbicide applied on 1 June[b]	Rate of application	Crabgrass control[a] 16 June	Crabgrass control[a] 11 August
		lbs ai/acre		lbs ai/acre	--------------%--------------	
1	Prodiamine 4FL	0.38	Prodiamine 4FL	0.38	98 a[c]	95 a
2	Prodiamine 4FL	0.38	Pendimethalin 3.8	1.5	98 a	93 abc
3	Prodiamine 4FL	0.38	Dithiopyr 2EW	0.25	100 a	91 abc
4	Prodiamine 4FL	0.38	Untreated		94 ab	71 de
5	Pendimethalin 3.8	1.5	Prodiamine 4FL	0.38	99 a	94 ab
6	Pendimethalin 3.8	1.5	Pendimethalin 3.8	1.5	100 a	93 ab
7	Pendimethalin 3.8	1.5	Dithiopyr 2EW	0.25	100 a	96 a
8	Pendimethalin 3.8	1.5	Untreated		97 ab	64 ef
9	Dithiopyr 2EW	0.25	Prodiamine 4FL	0.38	98 a	93 ab
10	Dithiopyr 2EW	0.25	Pendimethalin 3.8	1.5	99 a	91 abc
11	Dithiopyr 2EW	0.25	Dithiopyr 2EW	0.25	100 a	97 a
12	Dithiopyr 2EW	0.25	Untreated		90 ab	51 fg
13	Untreated		Prodiamine 4FL	0.38	42 c	30 hi
14	Untreated		Pendimethalin 3.8	1.5	39 c	16 ij
15	Untreated		Dithiopyr 2EW	0.25	84 b	37 gh
16	Untreated		Untreated		0 d	0 j
17	Prodiamine 4FL	0.65[d]			99 a	88 abcd
18	Pendimethalin 3.8	3.0			100 a	78 bcde
19	Dithiopyr 2EW	0.5			99 a	76 cde
20	Prodiamine 4FL	0.75[d]			98 a	89 ab

[a] Crabgrass control was calculated as control=[(1-(crabgrass coverage in treated plot/crabgrass coverage in untreated check))*100].
[b] Treatments were a split application with the second application being 1 June.
[c] Within columns, means followed by the same letter are similar. In each case except Prodiamine 4FL at 0.75 lbs ai/A, the mean is of three replications across three years.
[d] Prodiamine 4FL was applied at the full rate of 0.75 lbs active ingredient per acre in 2010 and 2011, but not in 2009. In all three years Prodiamine 4FL was applied at the rate of 0.65 lbs active ingredient per acre, which was slightly less than the full rate based on a miscalculation in 2009.

Table 2. Crabgrass control from preemergence herbicide application timings and sequentially applied preemergence herbicides in West Lafayette, Indiana in 2010 and 2011.

Herbicide application strategy	Crabgrass control[a] June	Crabgrass control[a] August	Crabgrass control[a] September
	-------------------%-------------------		
Preemergence timing: Preemergence herbicides (Prodiamine[b], Pendimethalin, and Dithiopyr) applied at label rate on 9 April	99 a[c]	82 b	73 b
Sequential timings: Preemergence herbicides (Prodiamine, Pendimethalin, and Dithiopyr) applied at half the label rate on 9 April and at half the label rate on 1 June	99 a	93 a	87 a

[a] Crabgrass control was calculated as control=[(1-(crabgrass coverage in treated plot/crabgrass coverage in untreated check))*100].
[b] Only the 0.75 lbs ai/acre rate was included in this analysis.
[c] Within columns, means followed by the same letter are similar.

Evaluating Acelepryn for adult preventive control of billbugs in Kentucky bluegrass turf

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: Billbugs are a common but often improperly diagnosed pest in turfgrass systems. As such, they become a frustration for professional Turfgrass Managers to deal with. Choosing effective insecticides, rates and timing are critical to successful control of these pests. This study is designed to shed light on the efficacy of various rates of Acelepryn applied at adult preventive timing against billbugs. Acelepryn is a relatively recent and novel product available for use by the turfgrass industry.

The following study was designed to evaluate different application rates of Acelepryn for control of billbugs in Kentucky bluegrass turf. Information of this kind is essential to developing a current and comprehensive pesticide profile for this novel chemistry.

MATERIALS AND METHODS

The experiment was located at the Nursery Complex at Purdue University (West Lafayette, IN) on a stand of turfgrass consisting primarily of Kentucky bluegrass maintained at 7.6 cm. Plots measuring 2.4 x 2.4 meters were arranged in a randomized complete-block design with 0.3 meter alleys between plots. Each treatment was replicated 4 times. All materials were applied using a hand-held CO_2 boom sprayer configured with four 8010 nozzles operating at 30 psi and calibrated to deliver a spray volume of 2 gal/1000ft^2. The combined density of billbug larvae, and pupae was determined on July 7 using a golf course cup cutter to remove 5 cores (4.25” diameter) from each plot to a depth of 3”. The soil and thatch in each core was carefully examined for all billbug life stages and the number of billbugs in each core was recorded. Variation in billbug larval/pupal densities was examined using main effects ANOVA and treatment means were compared using Fisher’s LSD test (α=0.05). Billbug species composition at the site consisted mainly of Sphenophorus parvulus with S. minimus and S. inaequalis also being present.

Field conditions on the April 15 treatment date were:
(1) Soil Temp.: 15°C
(2) Air Temp: 20°C
(3) Weather: Partly Cloudy, wind 5-7 mph
(4) Thatch: 1.0 cm

RESULTS:

All rates of Acelepryn provided acceptable levels of billbug control (Table 1). Acelepryn and treatments containing the two highest rates of Acelepryn consistently provided excellent control. These levels of control matched or exceeded levels of control provided by the insecticides standard (Merit). No indications of phytotoxicity were observed at any point during the study.

ADDITIONAL INDEX WORDS:
Efficacy tests, Acelepryn, Billbugs, Purdue University, Entomology, Turfgrass Insects

Richmond, D., T. Gibb, W. Baldauf, A Seiter and A. Nance. 2012. Evaluating Acelepryn for adult preventive control of billbugs in Kentucky bluegrass turf. Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 66-67

Table 1. Number of billbugs per square foot (±SE) and % control in plots of Kentucky bluegrass turf treated with different rates of Acelepryn. West Lafayette, Indiana 2011.

Treatment	Product	Rate (ml product/1000ft2)	Billbugs/ft2 (±SE)	% Control
1	Acelepryn 1.67SC	2.715	2.5±1.0 bc	80
2	Acelepryn 1.67SC	4.07	0.0±0.0 a	100
3	Acelepryn 1.67SC	5.43	1.0±1.0 ab	92
4	Merit 75WP	4.17	0.5±0.5 ab	96
5	Control	---	12.5±2.1 d	---

* Numbers within a column followed by different letters are significantly different (α=0.05)

Evaluating combinations of Pyriproxyfen and imidacloprid for control of Japanese beetle larvae in Kentucky Bluegrass turf

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: This study was designed to compare the efficacy of imidacloprid and pyriproxyfen, alone and in combination, for control of Japanese beetle grubs in cool season turfgrass. It was determined that all treatments containing imidacloprid provided excellent levels of control (> 95% mortality). Pyriproxyfen alone provided acceptable levels of control (>70%) but only at the highest rate tested (0.22 oz product/1000 ft^2). Further, Pyriproxyfen did not appear to significantly influence the activity of imidacloprid at either rate tested.

The primary objective of this study was to evaluate combinations of Pyriproxyfen and Imidacloprid for control of Japanese beetle larvae in Kentucky bluegrass turf.

MATERIALS AND METHODS

The experiment was located at the Nursery Complex at Purdue University (West Lafayette, IN) on a stand of turfgrass consisting primarily of Kentucky bluegrass maintained at 7.6 cm. Plots measuring 1.5 x 1.5 meters were arranged in a randomized complete-block design with 0.3 meter alleys between plots. Each treatment was replicated 4 times. All materials were applied using a hand-held CO_2 boom sprayer configured with four 8010 nozzles operating at 30 psi and calibrated to deliver a spray volume of 2 gal/1000ft^2.

Field conditions on the July 11 treatment date were:
(1) Soil Temp: 27°C
(2) Air Temp: 34°C
(3) Weather: Partly Cloudy, wind 0-5 mph
(4) Thatch: 1.0 cm

ADDITIONAL INDEX WORDS:
Efficacy tests, Pyriproxyfen, Imidacloprid, Interaction, Japanese beetles, grubs, Purdue University, Entomology, Turfgrass Insects

Richmond, D., T. Gibb, W. Baldauf, A Seiter and A. Nance. 2012. Evaluating combinations of Pyriproxyfen and imidacloprid for control of Japanese beetle larvae in Kentucky Bluegrass turf. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 68-69.

Japanese beetle larval infestations were created by driving three, 8" diameter pvc cylinders into each plot along its mid-line and caging two separate groups of 40 Japanese beetle adults (50:50 sex ratio) within each cylinder at two week intervals during July. At the time of caging, beetles were provided an apple wedge as a source of moisture and nutrition. Larval populations were assessed October 7, 2010 using a sod cutter to remove a strip of sod lying directly beneath the caging area of each plot and examining the soil to a depth of 3 inches. The number of Japanese beetle larvae were counted and recorded. Variation in Japanese beetle larval populations was examined using main effects ANOVA and treatment means were compared using Fisher's LSD test (α=0.05).

RESULTS:

All treatments significantly reduced Japanese beetle larval densities compared to the untreated control and all treatments containing imidacloprid provided average levels of control in excess of 95%. Pyriproxyfen alone provided acceptable levels of control (>70%) only at the highest rate tested (0.22 oz product/1000 ft^2) and pyriproxyfen did not significantly influence the activity of imidacloprid at either rate tested. However, 100% control of Japanese beetle larvae was only achieved by the treatment containing imidacloprid in combination with pyriproxyfen at the highest rate.

Table 1. Japanese beetle (JB) larval densities and percent control in plots of Kentucky bluegrass turf treated with various combinations of imidacloprid and pyriproxyfen. Applications made 11 July and evaluated 7 October. West Lafayette, Indiana 2011.

Treatment/Product	**Rate** (oz product/1000 ft^2)	**JB larvae/ft2** (±SE)	**% Control**
Untreated	---	26.8±4.3 c	---
QP Imidacloprid 2F	0.59	0.8±0.3 a	97.2
Pyriproxyfen EC	0.11	14.0±3.0 b	47.7
Pyriproxyfen EC	0.22	6.3±3.6 ab	76.6
QP Imidacloprid 2F Pyriproxyfen EC	0.59 0.11	1.3±0.9 a	95.3
QP Imidacloprid 2F Pyriproxyfen EC	0.59 0.22	0.0±0.0 a	100.0

*Values in same column followed by different letters are significantly different (α=0.05)

Influence of application timing on efficacy of granular formulations of grubicides against Japanese beetle larvae in Kentucky bluegrass turf

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: This study was designed to compare the efficacy of several currently available insecticides and times of application for the control of Japanese beetle grubs in cool season turfgrasses. All treatments studied significantly reduced white grub populations compared to untreated plots. Application timing (months) demonstrated no consistent influence on the efficacy of any of the materials used in this study.

The primary objective of this study was to describe the efficacy of various granular grub control formulations applied at different timings against Japanese beetle larvae.

MATERIALS AND METHODS

This experiment was located at the Nursery Complex at Purdue University (West Lafayette, IN) on a stand of turfgrass consisting primarily of Kentucky bluegrass maintained at 7.6 cm. Plots measuring 1.5 x 1.5 meters were arranged in a randomized complete-block design with 0.3 meter alleys between plots. Each treatment was replicated 4 times. Two separate sets if untreated control plots were created. All test materials were applied using shaker jars and plots were irrigated (1-2 cm) immediately after each application.

Field conditions on the April 15 treatment date were:
(1) Soil Temp.: 10°C
(2) Air Temp: 6°C
(3) Weather: Overcast, wind 5-20 mph
(4) Thatch: 1.0 cm

ADDITIONAL INDEX WORDS:
Efficacy tests, GrubEx, Imidacloprid, Thiamethoxam, Japanese beetles, grubs, Purdue University, Entomology, Turfgrass Insects

Richmond, D., T. Gibb, W. Baldauf, A Seiter and A. Nance. 2012. Influence of application timing on efficacy of granular formulations of grubicides against Japanese beetle larvae in Kentucky bluegrass turf. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 70-71.

Field conditions on the May 10 treatment date were:
(1) Soil Temp.: 15 °C
(2) Air Temp: 20 °C
(3) Weather: Cloudy, wind 5-7 mph
(4) Thatch: 1.0 cm

Field conditions on the June 13 treatment date were:
(1) Soil Temp.: 23 °C
(2) Air Temp: 22 °C
(3) Weather: Clear, wind 0-5 mph
(4) Thatch: 1.0 cm

Field conditions on the July 1 treatment date were:
(1) Soil Temp.: 23°C
(2) Air Temp: 26°C
(3) Weather: Overcast, wind 0-5 mph
(4) Thatch: 1.0 cm

Field conditions on the July 11 treatment date were:
(1) Soil Temp.: 33°C
(2) Air Temp: 27°C
(3) Weather: Partly Cloudy, wind 0-5 mph
(4) Thatch: 1.0 cm

Field conditions on the September 1 treatment date were:
(1) Soil Temp.: 11°C
(2) Air Temp: 27°C
(3) Weather: Cloudy, wind 5-7 mph
(4) Thatch: 1.0 cm

Field conditions on the August 1 treatment date were:
(1) Soil Temp.: 29°C
(2) Air Temp: 36°C
(3) Weather: Clear, wind 3-6 mph
(4) Thatch: 1.0 cm

Japanese beetle larval infestations were created by driving three, 8" diameter pvc cylinders into each plot along its mid-line and caging two separate groups of 40 Japanese beetle adults (50:50 sex ratio) within each cylinder at two week intervals during July. Larval populations were assessed October 6-7, 2011 using a sod cutter to remove a strip of sod lying directly beneath the caging area of each plot and examining the soil to a depth of 3 inches. The number of Japanese beetle larvae were counted and recorded. Variation in Japanese beetle larval populations was examined using main effects ANOVA and treatment means were compared using Fisher's LSD test (α=0.05).

RESULTS:

All treatments significantly reduced white grub populations compared to untreated controls and all treatments provided excellent levels of control. Application timing appeared to have no consistent influence on the efficacy of any of the materials used in this study. There were no indications of phytotoxicity observed during any point in the experiment.

Table 1. White grub densities and percent control in plots of Kentucky bluegrass turf treated on different dates with granular white grub insecticides. White grub populations assessed October 7, 2011. West Lafayette, Indiana 2011

Product	Active Ingredient	Formulation	Rate (lb AI/A)	Application Date	Japanese Beetle/ft^2 Mean(±SE)	% Control
Untreated #1	-	-	-	-	33.8+-7.2 a	0
GrubEx	w/clorotraniiliprole	10.08 GR	0.07	July 1	6.3±4.0 b	83.0
Meridian	thiamethoxam	.33 GR	0.04	Aug 1	6.8±5.5 b	80.0
Meridian	thiamethoxam	.33 GR	0.04	Sept 1	2.5±1.0 bc	93.3
Acelepryn GF	chlorantraniliprole	0.067GF	0.1	Apr 15	0.00±0.00 c	100.0
Acelepryn GF	chlorantraniliprole	0.067GF	0.1	May 10	2.00±2.00 c	92.2
Acelepryn GF	chlorantraniliprole	0.067GF	0.1	Jun 13	0.25±0.25 c	99.0
Merit GranFert	imidacloprid	0.2GF	0.3	Jun 13	0.00±0.00 c	100.0
Acelepryn GF	chlorantraniliprole	0.067GF	0.1	Jul 11	0.75±0.48 c	97.1
Merit GranFert	imidacloprid	0.2GF	0.3	Jul 11	0.25±0.25 c	99.0
Untreated #2	-	-	-	-	25.50±7.64 a	0

*Japanese beetle larval densities followed by the same letter are not significantly different (α=0.05)

Effects of early season fungicide application on dollar spot outbreaks, 2011

Purdue University
Turfgrass Science

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Summary: Recent promotional and anecdotal evidence suggest that early season – as early as the first or second mowing for putting greens – fungicide applications will delay dollar spot outbreaks and improve fungicide performance. There are no published research results that directly support the notion that early season fungicide are worthy of consideration. This research was designed to evaluate the contributions of early season fungicide applications towards dollar spot control on creeping bentgrass putting greens. Results show that plots treated in March and April of 2011 sustained significantly greater amounts of dollar spot than when plots were treated shortly prior to the first natural outbreak of the disease. This supports the principles that fungicides will be effective only when the pathogen is active and that fungicide residues are depleted rapidly from turf.

Materials and Methods

The research was conducted at the Purdue University Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN. The plots were located on a sward (identified as 16.9) of Pennlinks creeping bentgrass maintained at a height of 0.18 in. Irrigation and aerification operations were done according to standard practices for creeping bentgrass putting greens. During spring 2011, fertilizer (18-4-10) was applied at a rate of approximately 0.5 lb N per 1000 sq ft on April 11, May 16, and June 17. Individual treatment plots measured 3.3 ft by 6.6 ft (1m x 2m) and were randomized within each of the 4 replications.

The site had been thoroughly involved with dollar spot in past years. Therefore, no supplemental inoculum was applied.

The fungicide treatment used for all sprays was a tank mix of Banner Maxx (1.0 fl oz/M) and Chipco 26019 (2.0 oz/M). Applications were made using a custom-built boom sprayer. Three Tee-Jet air induction nozzles (AI9503EVS for the middle, AIUB8503EVS for both sides) were mounted approximately 12 in. apart on the boom located 14 in. from the ground. The sprayer was calibrated to deliver 2 gal per 1000 sq ft at 40 psi.

Fungicide was applied to each replicated treatment only once, on each of the following dates: March 23, March 30, April 6, April 13, April 20, April 27, May 4, May 11, and May 18. A designated "no-fungicide" check plot also was included. We were prepared to continue the applications through July 1, but stopped our weekly spray program once the natural outbreak of dollar spot occurred in the check plots.

The plots were inspected 3 times per week beginning with the initial application. Once symptoms began to appear in the plots, disease severity (infection centers per plot) was recorded on alternate days for a week. Disease severity data were subjected to analysis of variance and means separation procedures.

We used our Purdue Turfcast system to determine the daily environmental favorability for infection beginning on March 16. The daily values were compiled over time to describe the environmental favorability for dollar spot development over the experimental period.

Latin, R., and J. Daniels. 2012. Effects of early season fungicide application on dollar spot outbreaks, 2011. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 72-73.

Results and Discussion

Results of the 2011 experiment are presented in Figure 1. The right hand axis (Cumulative EFI) represents a running total of daily favorability for dollar spot infection based on temperature and moisture. (Environmental favorability index (EFI) values describe the daily disease pressure based on weather). The slow increase in EFI values from March 14 through April 20 indicates that infection and pathogen growth were limited. However, after that, the line trends markedly upward, showing increasingly favorable conditions for pathogen growth and disease development. The left hand vertical axis represents the average number of dollar spots that appeared in plots on May 24, just after the first natural outbreak of disease at the experimental site.

Results show that the date of fungicide application clearly influenced the level of dollar spot control. Fungicide applications during the weeks just prior to the initial outbreak of dollar spot symptoms provided excellent control—they averaged less than one spot per plot. Fungicide sprays applied prior to May 2, sustained significantly greater disease development.

Results reinforce the principle that in order to be effective, fungicide applications must be made while the pathogen is active. Only an active pathogen is able acquire the chemical toxin. If the pathogen is inactive, then toxic amounts of fungicide will not accumulate in fungal cells, and the treatment will have little or no effect on pathogen growth. Furthermore--in most cases--early season fungicide applications fail to contribute to acceptable dollar spot control because by the time pathogen activity accelerates, fungicide residues are often depleted to the point where there is insufficient chemical toxin to restrict fungal growth. This does not preclude the possibility that early season applications can be effective in some years. However, when they are effective, it is only because temperature and moisture conditions favored pathogen growth, and the growing fungal hyphae encountered sufficient amounts of fungicide to kill cells and stop further growth.

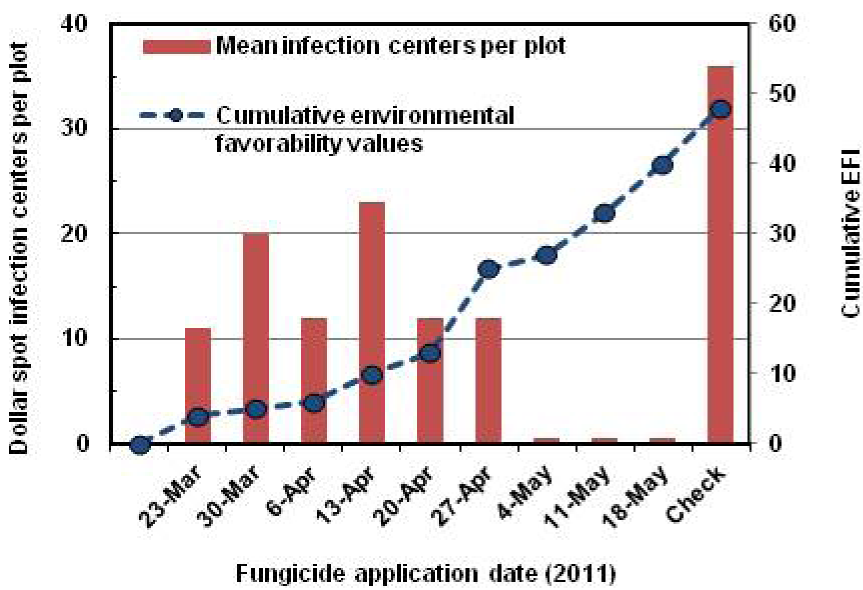

Figure 1. Dollar spot severity (recorded on May 24) associated with replicated plots sprayed once—beginning in mid-March through May 23, 2011. The column on the far right represents a no fungicide check plot. The dashed line tracks environmental favorability of infection by the dollar spot pathogen.

Integrating fungicide and genetic host resistance for control of dollar spot on creeping bentgrass

Purdue University
Turfgrass Science

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Summary: Dollar spot, caused by *Sclerotinia homoeocarpa*, is a common disease of creeping bentgrass (*Agrostis stolonifera*). The pathogen is most active during moist periods of warm days (70-85°F) and cool nights (60°F) during the growing season. Therefore, outbreaks can occur from spring through fall. Reducing the severity of dollar spot outbreaks is a concern for many golf course superintendents. Cultural practices, genetic host resistance and chemical fungicides all contribute to dollar spot control, but cultural practices alone cannot provide acceptable levels of control. Synthetic fungicides provide effective reliable control of the disease, but they must be applied repeatedly and therefore, are very expensive. Recently, several relatively new cultivars of creeping bentgrass have been shown to have good resistance to dollar spot infection. Our research was designed to investigate whether host resistance in a resistant (less susceptible) cultivar (Declaration) could be exploited to achieve acceptable levels of dollar spot control with reduced amounts of fungicide compared to more susceptible cultivars (Penncross and Independence). Results from 2011 demonstrate that dollar spot epidemics were less severe on Declaration than on Penncross and Independence. However, unlike implications of other studies, outbreaks on Declaration can become quite severe over time. This research also showed that, according to AUDPC values, dollar spot outbreaks were less severe in plots of Declaration treated with Daconil Ultrex at 1.8 oz/1000 ft^2 than in plots of Penncross and Independence treated with twice as much fungicide (Daconil Ultrex at 3.6 oz/1000ft^2).

Materials and Methods

Creeping bentgrass cultivars Declaration, Penncross, and Independence were selected to represent cultivars with high, medium, and low levels of dollar spot resistance, respectively (Bonos, 2005). Seeds of each cultivar were planted in field plots (3.3 ft x 6.6 ft) arranged in a completely randomized block design with 3 replications at the Daniel Turfgrass Research and Diagnostic Center in West Lafayette, IN., on August 15, 2010. Research was initiated the following summer after turf was well established at the experimental site. Three rates (equivalent to 0, 1.8 and 3.6 oz/1000 ft^2) of Daconil Ultrex 82.5WDG were applied to plots of each cultivar beginning on July 6, 2011.

Throughout the season, fungicide was re-applied when the average number of dollar infection centers in plots of each cultivar in each fungicide treatment reached the threshold of 8.0 per plot--or was applied 7 days after the previous application if the average number of dollar spots did not decrease below the 8.0 threshold by that time. The experiment was competed on October 4, 2011. Fungicide applications were made using a custom-built boom sprayer. Three Tee-Jet air induction nozzles (AI9503EVS for the middle, AIUB8503EVS for both sides) were mounted approximately 12 inches apart on the boom located 14 inches from the ground. The sprayer was calibrated to deliver 2.0 gal/1000 ft^2 at 40 psi. Infection centers were counted and recorded at 2- to 3-day intervals throughout the experimental period. Area under the disease progress curve (AUDPC) values were calculated from dollar spot counts in plots of each cultivar and fungicide combination (Latin, 2011). A two-way ANOVA test was applied to account for variation among treatments. A Tukey means separation procedure was used to demonstrate statistical significance among cultivar/fungicide combinations.

Liu, Y., J. Daniels, and R. Latin. 2012. Integrating fungicide and genetic host resistance for control of dollar spot on creeping bentgrass. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 74-75

Results and Discussion

With no fungicide application, disease severity in plots of all three cultivars increased during the experimental period (Fig. 1). AUDPC values for Declaration, Penncross, and Independence were 3293, 5043, and 7914, respectively. Interestingly, disease severity increased to highly unacceptable levels after 60 days in all plots that were not treated with fungicide—including those of the "resistant" cultivar Declaration. This result does not agree with other published trials involving creeping bentgrass cultivars and dollar spot resistance.

Less disease occurred in plots of Declaration treated with the low rate (1.8 oz/1000 ft^2) of Daconil Ultrex than in plots of Independence and Penncross treated with the high rate (3.6 oz/1000 ft^2) of Daconil Ultrex. Based on AUDPC values, less fungicide was required to limit dollar spot to certain levels on Declaration that on the other two cultivars. Furthermore, lower AUDPC values on Declaration were sustained with only 5 applications of Daconil Ultrex compared to 6-8 applications on Penncross and Independence (Table 1). From this preliminary research, it appears that resistance in Declaration can be utilized to limit dollar spot progress with less fungicide. However, in this experiment, acceptable levels of control were not achieved throughout the experiment. Although it is possible that the fungicide lacked sufficient efficacy to provide season-long control, it is more likely that the application threshold must be decreased (resulting in more frequent application) to limit the rate of disease progress and suppress symptom expression to levels acceptable for quality putting surface.

References

Latin, R. 2011. A Practical Guide to Turfgrass Fungicides. APS Press. St. Paul, MN.

Bonos, S.A., 2005. Creeping bentgrass cultivars with improved dollar spot resistance. Golf Course Management. September 2005: 96-100.

Figure 1. Dollar spot disease progress curves and corresponding AUDPC values for plots of Declaration, Independence, and Penncross that were not treated with fungicide.

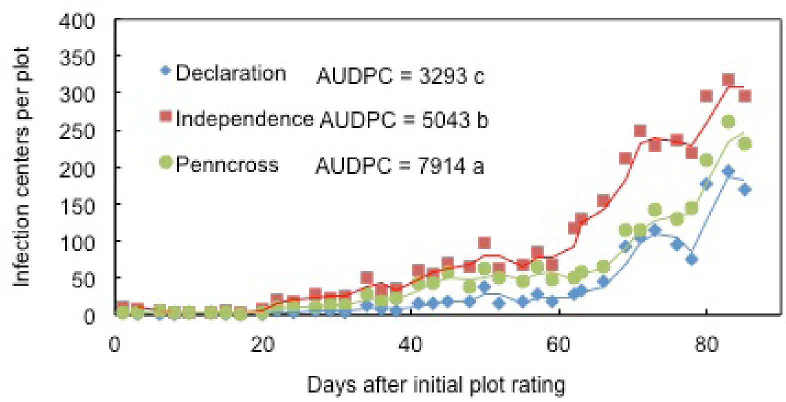

Table 1. Mean AUDPC for three cultivars treated with Daconil Ultrex at 1.8 and 3.6 oz/1000 ft^2.

Treatment[x] and rate/1000 ft^2	Cultivar	Number of applications	AUDPC
Daconil Ultrex 82.5WDG, 1.8 oz	Independence	8	2393.2 a[y]
Daconil Ultrex 82.5WDG, 1.8 oz	Penncross	8	1658.7 ab
Daconil Ultrex 82.5WDG, 1.8 oz	Declaration	5	820.0 bc
Daconil Ultrex 82.5WDG, 3.6 oz	Independence	8	1251.0 bc
Daconil Ultrex 82.5WDG, 3.6 oz	Penncross	6	1001.3 bc
Daconil Ultrex 82.5WDG, 3.6 oz	Declaration	5	614.5 c

[x] Treatments were applied at a threshold of 8 spots per plot or, after 7 days if the number of infection centers was not reduced below the 8 spot threshold..

[y] Values followed by the same letter are not significantly different using the Tukey test (α =0.05).

Residual efficacy of fungicides for brown patch management on creeping bentgrass, 2011

PURDUE UNIVERSITY
TURFGRASS SCIENCE

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SUMMARY: Brown patch, caused by *Rhizoctonia solani*, is a foliar disease of creeping bentgrass that causes significant damage during periods of hot, humid weather throughout the Midwest. Turf managers typically utilize an integrated approach to minimize disease damage. Practices such as adjusting fertility, limiting leaf wetness, selecting less susceptible cultivars, and applying fungicides preventatively have been shown to influence brown patch severity (Smiley et al., 2005). Fungicides used for controlling brown patch are applied at 7 to 28-day intervals per label directions. Once fungicide is delivered to the turf canopy, numerous factors will influence how long it will persist. Frequent mowing, microbial breakdown, photo-degradation, plant metabolism, removal from irrigation or rain, and volatilization can limit the amount of fungicide present (Latin, 2006). Depletion of effective fungicide residues during the latter half of the application interval predisposes turf to brown patch outbreaks if disease-favorable weather persists. The objective of this research was to describe the temporal nature of fungicide residues for controlling brown patch on creeping bentgrass maintained under fairway conditions. Results from the bioassay demonstrate differences in residual efficacy among the selected fungicides.

MATERIALS AND METHODS

A bioassay was conducted during the growing season of 2011. Experimental plots were established on creeping bentgrass (cv. Penneagle), maintained at 0.5 in. cutting height, at the Daniel Turfgrass Research and Diagnostic Center at Purdue University. Standard fertility, irrigation, and mowing practices for creeping bentgrass fairways were implemented. Five fungicides commonly used to control brown patch on golf course fairways were used in this experiment (Table 1). Fungicides were applied once to field plots (3.3 x 6.6 ft) arranged in a randomized block design with 4 replications. Each replication included a non-sprayed check. Applications were made using a custom-built boom sprayer. Three Tee-Jet air induction nozzles (AI9503EVS for the middle, AIUB8503EVS for both sides) were mounted approximately 12 in. apart on the boom located 14 in. from the ground. The sprayer was calibrated to deliver 2 gal per 1000 sq. ft. at 40 psi. In order to selectively control for Pythium blight and dollar spot, (and prevent their interference

Daniels, J., and R. Latin. 2012. Residual efficacy of fungicides for brown patch management on creeping bentgrass, 2011. 2011 Annu. Rep. - Purdue Univ. Turfgrass Sci. Progr. p. 76-78.

Table 1. Fungicides applied during 2011.

Treatment	Active Ingredient	Fungicide Class	Rate (Product/1000 ft^2)
Untreated			
Heritage TL (Syngenta)	Azoxystrobin	Quinone Outside Inhibitor (QoI)	2.00 fl oz
Prostar 70 WP (Bayer)	Flutolanil	Carboxamide	2.20 oz
Tourney 50 WDG (Valent)	Metconazole	Demethylation Inhibitor (DMI)	0.37 oz
Endorse WP (Cleary Chemical)	Polyoxin D	Polyoxin	4.00 oz
Insignia (BASF)	Pyraclostrobin	Quinone Outside Inhibitor (QoI)	0.90 oz

with *R. solani* development), mefenoxam (Subdue Maxx, Syngenta) and boscalid (Emerald, BASF) were applied 1 week prior to start of experiment. Turf was sampled by removing 4.25 in. diameter plugs with a cup-cutter beginning the day treatments were applied. Sampling occurred on days 0, 3, 7, 10, 14, 17, and 21. After sampling, plugs were inoculated with white sorghum seeds infested with an isolate of *R. solani* (Purdue isolate RZ0104). Approximately 3-4 grains were placed at the center of each turf plug. The plugs were then incubated in a controlled environment (86°F with >95% relative humidity) for approximately 48 h. Following incubation, disease progress was determined by measuring and recording the diameter of symptomatic patches on each individual turf plug (Figure 1). Data were subjected to repeated measures analysis of variance using Statistica (version 7.1; StatSoft, Inc., Tulsa, OK). Residual efficacy (RE) for each sampling date was determined by comparing the patch diameters on fungicide-treated and untreated plugs as follows: RE = 1 – (patch diameter treated plug / patch diameter untreated plug).

Results and Discussion

The bioassay approach was successful in describing the temporal nature of fungicide residues for different fungicides over the course of the experiment (Figure 2). Brown patch development differed among fungicide treatments and sampling dates (Table 2). All fungicide treatments were effective at suppressing brown patch initially, but differences in residual efficacy were apparent 3 days after application. By the fourth sampling date (10 days after fungicide application), all fungicides were similar to the untreated check. Of the fungicides tested, Prostar provided the greatest residual efficacy. This supports our observations in field trials where Prostar consistently provided high levels of brown patch control.

The results of this bioassay demonstrate that the residual efficacy of fungicides for brown patch control may be less than anticipated when consulting label-recommended spray intervals. This information is of utmost concern for high value golf turf where periodic fungicide applications are applied to limit disease-related damage and maintain turf quality. Shorter application intervals may be required to prevent severe outbreaks when environmental conditions are especially favorable for brown patch establishment and spread. Future research will continue to investigate the decline in residual efficacy through an analytical approach in order to improve scheduling fungicide applications for brown patch control.

References

Latin, R. 2006. Residual efficacy of fungicides for control of dollar spot on creeping bentgrass. Plant Dis. 90:571-575.

Smiley, R.W., Dernoeden, P.H., and Clarke, B.B. 2005. Compendium of Turfgrass Diseases. 3rd ed. American Phytopathological Society, St. Paul, MN.

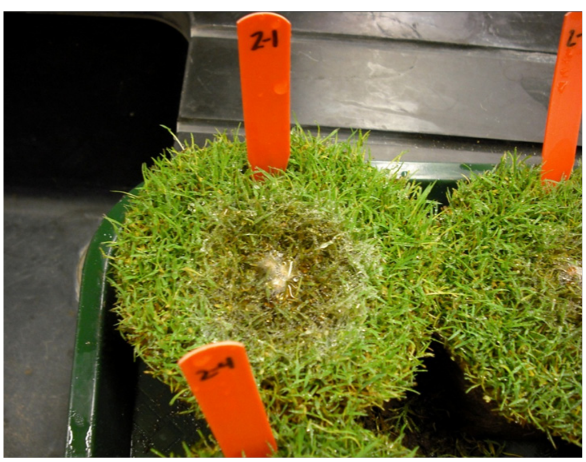

Figure 1. Brown patch diameters were recorded following 48 h incubation period in a disease conducive, controlled environment (86°F with >95% relative humidity).

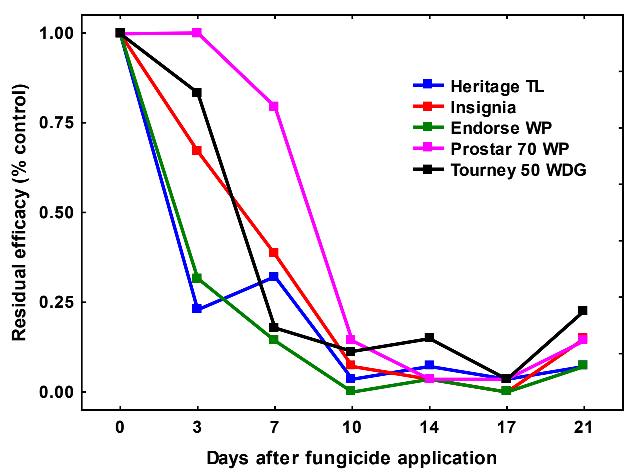

Figure 2. Residual efficacy means for five fungicides (Heritage TL, Prostar 70 WP, Tourney 50 WDG, Endorse WP, and Insignia) were plotted to describe the depletion in fungicide residues over time.

Table 2. Mean brown patch diameters (cm) for treatments applied on June 8, 2011 for each of the 7 sampling dates.

	Days after fungicide application[1]													
Treatment	0		3		7		10		14		17		21	
Azoxystrobin	0.00	a	4.00	bc	4.00	ab	6.50	a	6.25	a	6.75	a	6.50	a
Flutolanil	0.00	a	0.00	a	1.12	a	5.75	a	6.50	a	6.50	a	5.75	a
Metconazole	0.00	a	1.00	ab	5.25	b	6.00	a	5.50	a	6.75	a	5.25	a
Polyoxin D	0.00	a	3.50	bc	5.75	b	7.00	a	6.50	a	7.00	a	6.25	a
Pyraclostrobin	0.00	a	1.75	ab	3.75	ab	6.25	a	6.25	a	7.00	a	5.75	a
Untreated Check	6.25	b	5.25	c	6.25	b	6.75	a	6.50	a	6.75	a	6.75	a

[1]Values within columns followed by the same letter are not significantly different at P=0.05, Tukey HSD test.