Annual bluegrass suppression in a creeping bentgrass fairway utilizing various application rates, timings and combinations of paclobutrazol, trinexapac-ethyl and prodiamine. 2005-2007: Purdue University

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Objective: To evaluate the the ability of the plant growth regulators (PGRs), paclobutrazol (Trimmit 2SC), trinexapac-ethyl (Primo MAXX 1EC) when applied at various application rates, timings and combinations with and without prodiamine (Barricade 65WG) for the control of annual bluegrass in a creeping bentgrass fairway.

Experimental Procedures:

This field study consisting of nine chemical treatments and an untreated control was conducted at the W.H. Daniel Turfgrass Research and Diagnostic Center at Purdue University, West Lafayette IN, from May 2005 – Oct. 2007. The study area consisted of two year old mixed sward of creeping bentgrass (*Agrostis stolonifera* 'Pencross') and annual bluegrass (*Poa annua*) grown on a Starks-Fincastle silt-loam (fine-silty, mixed, mesic Aeric Ochraqualf) with pH of 7.2. Throughout the growing season the study area was mowed at 0.5 inches three times per week with clippings returned, irrigated to promote growth and fertilized with approximately 3.0 lbs N/1000 ft^2. Insecticides and fungicides (e.g. chlorothalonil) were applied on a curative basis when required. All treatments were applied with a pressurized CO_2 (35 psi) sprayer equipped with TeeJet XR 8003 tips calibrated to deliver 1.0 gallon of spray volume per 1000 ft^2. Treatments were initiated on 18 May, 2005 and subsequent treatments applied; 6 June, 27 June, 18 July, 9 Aug., 30 Aug., 20 Sept., and 11 Oct. In 2006 treatments were initiated on 18 May and repeat applications occurred on 7 June, 28 June, 19 July, 9 Aug., 29 Aug., 20 Sept., and 12 October. In 2007 treatments were inititated on 18 May and repeat applications occurred on 9 June, 29 June, 20 July, 10 Aug., 29 Aug., 21 Sept. and 17 October.

The product rates, application rates are all footnoted in each of the data tables. Plots were 5 x 5 ft and arranged in a randomized complete block with four replications and 6" borders between each plot. Irrigation, approximately 0.25 inches, was applied via an overhead irrigation system within 24 hours of application once the plant growth regulators had dried on the leaf surface.

Plots were visually assessed regularly throughout the study for color, quality, and percentage visible annual bluegrass. Color was assessed on a 0-10 scale with 0=brown turf and 10=dark green. Creeping bentgrass quality was assessed on a 0-10 scale with 0=poor quality turf, 10-excellent and 7=acceptable golf course fairway turf. When clearly visible and discernable the amount of annual bluegrass present was assessed on a linear 0-100 % scale where 0=no annual bluegrass present and 100 % is total plot coverage. Canopy greenness was quantified using a hand-held meter (FieldScout CM-1000, Spectrum Technologies Inc.) taking five measurements per plot on a systematic grid pattern that measured the four corners and center of each plot. All data was subjected to analysis of variance using the SAS system (Statistical Analysis Systems Institute Inc., Cary, N.C.) and mean separation performed using Fisher's protected least significant difference test at the ($P<0.05$) level.

Results:

Annual Bluegrass Suppression

At the initiation of the study ABG populations were relatively low 6.5-7.3% (Table 1). Throughout the first study year there was no difference for any chemical product or PGR/Barricade regime. In the second full year of applications, however, by the final rating date in 2006, 13 Dec., treatment differences were evident (Table 2). The least ABG, $\leq$ 5%, was observed in those plots receiving a May and Aug. Barricade application. Additionaly, plots treated with 8 oz/A Trimmit 8 times throughout the growing season were similar with rather low ABG populations. This treatement, however, was not different than the 24, 16, 8, 8, 8, 24, 16, 8 oz/A Trimmit regime. Where Primo Maxx was substituted during the summer months ABG was not different (11.5% ABG) than the untreated control (15% ABG).

During the third year of treatment applications, 2007, the magnitude of treatment separation continued to widen (Table 3). On the first rating date, 26 Mar., ABG ranged from < 1 % to 6.5% with 16.3 % in the untreated turf. Peak ABG was observed on 7 May, with ABG ranging from 2.8 – 16.5%, compared to 28.8 % in the untreated turf. By the final rating date, 30 Nov., the trends for ABG populations continued with two top statistical programs being the 24, 16, 8, 8, 8, 24, 16, 8 oz/A Trimmit and the 8 oz/A Trimmit 8 times + Barricade regimes, < 2 % ABG which were not statistically different than 24, 16, PM, PM, PM, 24, 16, 8 oz/A + Barricade or the Barricade alone regimes, 3.5 and 4.6 % ABG, respectively. In the spring of 2008 there will be two more ratings to further assess the winter effects of these PGR +/- Barricade regimes. For a frame of reference, after three years, ABG increased from 7.0 to nearly 30 % in the untreated control. Whereas in the Barricade treated turf ABG decreased from nearly 7.0 % to < 5%.

Visual Appearance

For visual turfgrass quality (TQ), when averaged across the three years of this study there were no significant differences among treatments (Table 4). When the data is evaluated more closely, however, there was no difference for TQ in the first two years of the study. This would strongly influence the overall study mean values. When evaluating the third year of applications, however, four treatments had superior mean annual TQ. These four treatments were the same treatments which possessed the least amount of annual bluegrass and all contained Barricade as part of their ABG suppression regimes (Table 3). In addition, there were some seasonal differences observed in individual years on individual rating dates but these ratings did not dramatically affect the overall TQ values (data not presented).

For visual color there were no statistical differences for individual study years or the study mean (Table 4). There were some minor differences on individual rating dates (data not presented). In addition to visual ratings, canopy greenness was quantified with reflectance measurements. Although the values were different, unitless spectrum units for canopy greenness, the general trends were similar (Table 4). Some slight differences in programs were evident, however, this could be explained by plant morphological factors like canopy density, leaf orientation which may slightly affect the reflectance of the instrument. In addition there were some differences for canopy greenness in individual years and measurement dates (data not presented).

Summary

For ABG suppression in an existing creeping bentgrass fairway with relatively low, 6-8 %, initial ABG populations, a PGR like Trimmit applied every 21 days during the growing season at a consistent rate, 8 oz/A or varying seasonal rates will keep populations relatively stable. Where Primo Maxx was substituted for Trimmit during the summer months, ABG populations doubled to approximately 15%. Where Trimmit was tank-mixed with Primo Maxx there was no reduction or substantial ABG population change. The biggest difference in ABG populations was observed in any of the treatments where Barricade was applied alone or with a PGR-regime, which resulted in final ABG populations ranging from 1.6 – 4.6 %, compared to nearly 30 % ABG in the untreated control. These treatments also had the best visual TQ after three consecutive years of applications. The effectiveness of Barricade for ABG suppression is not .., It is important to remember that ABG is a winter annual and although it is known to germinate during almost any month, it's peak germination window is from mid-August through early December in the cool-humid region. Thus, Barricade must be active in the soil prior to this period.

Many golf course managers may wish to avoid Barricade applications on fairways due to the fact that this product is a pre-emergent herbicide and when applied would limit the ability to re-seed should any substantial turf thinning or damage occur from seasonal stress, equipment malfunctions or vandalism. Where Barricade is used, activated charcoal prior to seeding or sodding will be necessary to replant.

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Table 1. Annual bluegrass cover as affected by various applications of paclobutrazol (Trimmit 2SC), trinexapac-ethyl (Primo MAXX 1EC) and prodiamine (Barricade 65 WG) on 'Penncross' fairway creeping bentgrass at Purdue University 2005.

Treatment [a] (8 Rounds)		13 May	23 May	6 Jun	13 Jun	20 Jun	27 Jun	5 Jul	11 Jul	18 Jul
Trimmit	Barricade									
(oz/A/round)	(0.38 lbs/A)	(% Cover 0-100) [b]								
24, 16, 8, 8, 8, 24, 16, 8	None	6.8 a[c]	8.5 a	7.0 a	6.3 a	5.0 a	6.0 a	4.8 a	6.3 abc	3.8 a
24, 16, 8, 8, 8, 24, 16, 8	S+F[d]	6.5 a	6.0 a	5.0 a	4.3 a	5.0 a	7.5 a	5.5 a	4.5 bc	3.5 a
24, 16, PM[e], PM, PM, 24, 16, 8	None	7.3 a	7.5 a	5.8 a	5.0 a	6.0 a	7.5 a	4.8 a	4.0 bc	3.0 a
24, 16, PM, PM, PM, 24, 16, 8	S+F	6.8 a	7.3 a	6.5 a	6.3 a	6.5 a	8.3 a	7.5 a	5.8 bc	2.8 a
16 x 8 applications	None	6.5 a	4.5 a	4.0 a	4.3 a	4.5 a	4.5 a	3.0 a	3.0 c	3.0 a
16 x 8 applications	S+F	7.0 a	6.0 a	7.5 a	5.0 a	4.8 a	6.0 a	5.5 a	6.5 ab	4.3 a
8, 8, 16, 16, 16, 24, 24, 16	None	6.8 a	4.8 a	5.3 a	5.3 a	4.8 a	4.0 a	4.0 a	4.3 bc	4.8 a
8, 8, (16, 16, 16, 16, 16)+PM[f], 16	None	7.3 a	6.8 a	4.8 a	4.8 a	4.8 a	5.0 a	7.3 a	9.3 a	5.0 a
None	S+F	6.5 a	7.0 a	5.8 a	5.3 a	6.0 a	5.8 a	6.3 a	3.3 bc	3.8 a
Untreated	None	7.0 a	9.5 a	7.0 a	6.8 a	4.8 a	5.8 a	6.8 a	4.0 bc	4.8 a

[a] Treatments were applied on 18 May, 6 June, 27 June, 18 July, 9 Aug., 30 Aug., 20 Sept., and 11 Oct. 2005 in 1 gal H_2O/1000 ft^2.
[b] Annual bluegrass was assessed visually on a linear 0-100 % scale where 0=no annual bluegrass present and 100 % is total plot coverage.
[c] Means in the same column followed by the same letter are not significantly different according to Fisher's protected LSD t-test (p=0.05).
[d] Barricade was applied spring (S) on 18 May and fall (F) on 9 Aug. or not at all.
[e] Primo Maxx 1 EC (PM) was applied at 0.25 oz/1000 ft^2.
[f] Trimmit and PM were applied at 16 oz/A and 0.14 oz/1000 ft^2 for rounds 3-7 respectively.

Table 2. Annual bluegrass cover as affected by various applications of paclobutrazol (Trimmit 2SC), trinexapac-ethyl (Primo MAXX 1EC) and prodiamine (Barricade 65 WG) on 'Penncross' fairway creeping bentgrass at Purdue University 2006.

Treatment [a] (8 Rounds)		25 Apr	16 May	20 May	5 Jun	14 Jul	13 Dec
Trimmit	Barricade						
(oz/A/round)	(0.38 lbs/A)	---------- (% Cover 0-100) [b] ----------					
24, 16, 8, 8, 8, 24, 16, 8	None	6.8 a[c]	9.8 ab	7.3 a	5.0 a	4.3 a	7.8 cd
24, 16, 8, 8, 8, 24, 16, 8	S+F[d]	7.8 a	8.3 a	6.8 a	4.3 a	4.8 a	1.6 a
24, 16, PM[e], PM, PM, 24, 16, 8	None	8.8 a	11.5 abc	9.0 a	3.8 a	7.0 ab	11.5 de
24, 16, PM, PM, PM, 24, 16, 8	S+F	9.0 a	11.3 ab	8.8 a	4.8 a	4.8 a	1.9 a
16 x 8 applications	None	6.3 a	7.3 a	7.0 a	5.3 a	4.0 a	5.1 abc
16 x 8 applications	S+F	5.3 a	8.3 a	6.3 a	3.5 a	4.0 a	2.5 ab
8, 8, 16, 16, 16, 24, 24, 16	None	9.5 a	9.5 ab	8.3 a	5.5 a	5.3 ab	7.0 bcd
8, 8, (16, 16, 16, 16, 16)+PM[f], 16	None	9.3 a	13.0 bc	10.5 a	9.0 b	8.3 bc	7.0 bcd
None	S+F	7.3 a	10.3 ab	7.8 a	5.5 a	6.8 ab	4.6 abc
Untreated	None	12.0 a	16.0 c	12.3 a	9.0 b	11.0 c	15.3 e

[a] Treatments were applied on 18 May, 7 June, 28 June, 19 July, 9 Aug., 29 Aug., 20 Sept., and 12 Oct. 2006 in 1 gal H_2O/1000 ft^2.
[b] Annual bluegrass was assessed visually on a linear 0-100 % scale where 0=no annual bluegrass present and 100 % is total plot coverage.
[c] Means in the same column followed by the same letter are not significantly different according to Fisher's protected LSD t-test (p=0.05).
[d] Barricade was applied spring (S) on 18 May and fall (F) on 9 Aug. or not at all.
[e] Primo Maxx 1 EC (PM) was applied at 0.25 oz/1000 ft^2.
[f] Trimmit and PM were applied at 16 oz/A and 0.14 oz/1000 ft^2 for rounds 3-7 respectively.

Table 3. Annual bluegrass cover as affected by various applications of paclobutrazol (Trimmit 2SC), trinexapac-ethyl (Primo MAXX 1EC) and prodiamine (Barricade 65 WG) on 'Penncross' fairway creeping bentgrass at Purdue University 2007 and spring 2008.

		2007							2008	
Treatment [a] (8 Rounds)		26 Mar	20 Apr	7 May	1 Jun	9 Jun	22 Jun	30 Nov	XX Apr	XX May
Trimmit	Barricade									
(oz/A/round)	(0.38 lbs/A)	---------- (% Cover 0-100) [b] ----------								
24, 16, 8, 8, 8, 24, 16, 8	None	6.3 b	8.3 c	12.0 c	11.8 d	9.0 b	9.8 bc	9.3 bc		
24, 16, 8, 8, 8, 24, 16, 8	S+F[d]	0.8 a	2.1 ab	2.8 a	3.3 ab	1.8 a	1.6 a	1.6 a		
24, 16, PM[e], PM, PM, 24, 16, 8	None	6.5 b	9.0 c	16.5 c	12.8 d	10.0 b	13.8 c	14.3 c		
24, 16, PM, PM, PM, 24, 16, 8	S+F	1.0 a	2.1 ab	3.8 ab	4.5 abc	2.5 a	4.0 ab	3.5 ab		
16 x 8 applications	None	5.0 b	7.5 c	10.5 bc	8.5 bcd	7.5 b	8.5 bc	8.8 bc		
16 x 8 applications	S+F	1.0 a	1.1 a	3.0 a	2.3 a	1.3 a	1.5 a	1.5 a		
8, 8, 16, 16, 16, 24, 24, 16	None	5.0 b	7.3 c	10.8 c	9.3 cd	10.0 b	6.5 ab	8.0 bc		
8, 8, (16, 16, 16, 16, 16)+PM[f], 16	None	6.5 b	8.8 c	11.5 c	12.3 d	10.0 b	9.0 bc	8.0 bc		
None	S+F	4.3 ab	6.3 bc	11.5 c	9.5 cd	10.0 b	6.6 ab	4.6 ab		
Untreated	None	16.3 c	23.8 d	28.8 d	27.5 e	25.0 c	23.0 d	27.5 d		

[a] Treatments were applied on 18 May, 9 June, 29 June, 20 July, 10 Aug., 29 Aug., 21 Sept., and 17 Oct. 2007 in 1 gal H_2O/1000 ft^2.
[b] Annual bluegrass was assessed visually on a linear 0-100 % scale where 0=no annual bluegrass present and 100 % is total plot coverage.
[c] Means in the same column followed by the same letter are not significantly different according to Fisher's protected LSD t-test (p=0.05).
[d] Barricade was applied spring (S) on 18 May and fall (F) on 29 Aug. or not at all.
[e] Primo Maxx 1 EC (PM) was applied at 0.25 oz/1000 ft^2.
[f] Trimmit and PM were applied at 16 oz/A and 0.14 oz/1000 ft^2 for rounds 3-7 respectively.

Table 4. Quality, color and canopy greeness measurements as affected by various applications of paclobutrazol (Trimmit 2SC), trinexapac-ethyl (Primo MAXX 1EC) and prodiamine (Barricade 65 WG) on 'Penncross' fairway creeping bentgrass at Purdue University 2005-07.

Treatment [a] (8 Rounds)		05 Ave.	06 Ave.	07 Ave.	Study Mean	05 Ave.	06 Ave.	07 Ave.	Study Mean	05 Ave.	06 Ave.	07 Ave.	Study Mean
Trimmit	Barricade												
(oz/A/round)	(0.38 lbs/A)	---------- (Quality 0-10)[b]----------				---------- (Color 0-10)[c]----------				---------- (Canopy greeness)[d]----------			
24, 16, 8, 8, 8, 24, 16, 8	None	7.9 a[e]	7.8 a	7.4 bcd	7.7 a	7.8 a	7.8 a	8.1 a	7.9 a	315 a	292 a	403 a	336 a
24, 16, 8, 8, 8, 24, 16, 8	S+F[f]	7.8 a	8.0 a	8.0 ab	7.9 a	7.6 a	8.0 a	8.2 a	8.0 a	312 a	299 a	393 a	335 a
24, 16, PM[g], PM, PM, 24, 16, 8	None	7.9 a	7.7 a	7.3 cd	7.6 a	7.7 a	7.8 a	8.0 a	7.8 a	319 a	295 a	404 a	339 a
24, 16, PM, PM, PM, 24, 16, 8	S+F	8.3 a	8.1 a	8.1 ab	8.1 a	8.2 a	8.1 a	8.2 a	8.2 a	323 a	307 a	398 a	342 a
16 x 8 applications	None	7.8 a	7.8 a	7.7 bc	7.8 a	7.7 a	8.0 a	8.3 a	8.0 a	315 a	298 a	397 a	337 a
16 x 8 applications	S+F	7.8 a	8.0 a	8.5 a	8.1 a	7.8 a	8.1 a	8.7 a	8.2 a	317 a	304 a	406 a	342 a
8, 8, 16, 16, 16, 24, 24, 16	None	7.7 a	7.8 a	7.5 bcd	7.6 a	7.4 a	7.8 a	8.0 a	7.7 a	312 a	292 a	389 a	331 a
8, 8, (16, 16, 16, 16, 16)+PM[h], 16	None	7.8 a	7.6 a	7.6 bcd	7.6 a	7.7 a	7.8 a	8.2 a	7.9 a	321 a	301 a	402 a	341 a
None	S+F	8.0 a	7.7 a	7.9 ab	7.9 a	8.0 a	7.6 a	8.4 a	8.0 a	323 a	303 a	403 a	343 a
Untreated	None	8.1 a	7.7a	7.0 d	7.6 a	8.0 a	7.6 a	7.8 a	7.8 a	319 a	299 a	394 a	337 a

[a] Treatments were applied in 1 gal H_2O/1000 ft^2 on 18 May, 6 June, 27 June, 18 July, 9 Aug., 30 Aug., 20 Sep., and 11 Oct. during 2005, 18 May, 7 June, 28 June, 19 July, 9 Aug., 29 Aug., 20 Sept., and 12 Oct. 2006 on 18 May, 9 June, 29 June, 20 July, 10 Aug., 29 Aug., 21 Sept., and 17 Oct. during 2007.

[b] Quality was rated on a 0-10 scale with 0=poor, 10=excellent and 7=acceptable.

[c] Color was rated on a 0-10 scale with 0=brown, 10=dark green.

[d] Canopy greeness measurements were taken using a hand-held chlorophyll meter (FieldScout CM-1000, Spectrum Technologies Inc.)

[e] Means in the same column followed by the same letter are not significantly different according to Fisher's protected LSD t-test (p=0.05).

[f] Barricade was applied spring (S) on 18 May and fall (F) on 9 Aug. (2005 and 2006) and 29 Aug. (2007) or not at all.

[g] Primo Maxx 1 EC (PM) was applied at 0.25 oz/1000 ft^2.

[h] Trimmit and PM were applied at 16 oz/A and 0.14 oz/1000 ft^2 respectively.