HortScience 43(2):509–513. 2008.

Selective Creeping Bentgrass Control in Kentucky Bluegrass and Tall Fescue with Mesotrione and Triclopyr Ester

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Additional index words. *Agrostis stolonifera*, *Poa pratensis*, *Festuca arundinacea*, postemergence herbicides

***Abstract*. Creeping bentgrass (*Agrostis stolonifera* L.; CBG) is a common weed in home lawns and golf course roughs in many regions of the United States. Currently, no herbicides are registered for selective control of CBG in cool-season grasses. The objective of this field study was to evaluate the ability of mesotrione and triclopyr ester to selectively remove CBG from Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.). Mesotrione (0.14 and 0.21 kg·ha^{-1} a.i.) and triclopyr ester (0.56 and 1.12 kg·ha^{-1} a.i.) were applied on a 2-week interval two, three, or four times in Connecticut and Maryland in 2005, and three or four times in Maryland in 2006. Two applications of mesotrione at 0.21 kg·ha^{-1} a.i. provided marginally acceptable CBG control, but three or four applications at 0.14 or 0.21 kg·ha^{-1} a.i. provided excellent CBG control. Mesotrione elicited little or no injury to Kentucky bluegrass, but generally caused objectionable injury in tall fescue for about 7 to 14 d after each application. Triclopyr applied at 0.56 kg·ha^{-1} a.i. reduced CBG cover, but the level of control generally was unacceptable, regardless of application frequency. Three or four applications of triclopyr (1.12 kg·ha^{-1} a.i.) effectively controlled CBG in Connecticut in 2005 and Maryland in 2006. Triclopyr caused no visual injury to tall fescue, regardless of rate or application frequency. Four triclopyr applications to Kentucky bluegrass, however, were phytotoxic and reduced stand density, especially at the high rate (1.12 kg·ha^{-1} a.i.). Three summer applications of mesotrione (0.14 kg·ha^{-1} a.i.) or triclopyr (1.12 kg·ha^{-1} a.i.) provided the best combination of turfgrass safety and CBG control. Chemical names used: [(3,5,6-trichloro-2-pyridinyl)oxy]acetic acid (triclopyr ester); 2-[4-(methylsulfonyl)-2-nitrobenzoyl]-1,3-cyclohexanedione (mesotrione)**

Creeping bentgrass (CBG) is a common weed in home lawns and golf course roughs and green surrounds in many regions of the United States. CBG is extremely competitive because of its stoloniferous growth habit. Once lawns, roughs, green surrounds, and other turfgrass areas are invaded by CBG, it can rapidly dominate the stand (Branham et al., 2005). Currently, no herbicides are registered that are known to safely and effectively remove CBG from desirable cool-season turfgrasses. The most widely used methods of removing CBG from cool-season turfgrasses include physical removal or the use of a nonselective herbicide. The use of a nonselective herbicide is undesirable in many situations because they may not completely eliminate the CBG in a single application, and large areas would require overseeding (Branham et al., 2005). In an unpublished Maryland study, however, four summer applications of the ester formulation of triclopyr applied at 1.12 kg·ha^{-1} a.i. were shown to safely control CBG in tall fescue (P.H. Dernoeden, unpublished data). Triclopyr ester is labeled for the control of selected broadleaf weeds, suppression of bermudagrass (*Cynodon* spp.), and control of kikuyu grass (*Pennisetum clandestinum* Hochst. ex Chiov.; Dow AgroSciences, Indianapolis). Mesotrione is a herbicide that is labeled for use in corn (*Zea mays* L.) and was reported to be phytotoxic to CBG (Askew et al., 2003; Bhowmik and Riego, 2003; Syngenta Crop Protection, Greensboro, NC). More recently, researchers have reported on the use of mesotrione to selectively control CBG in Kentucky bluegrass (Beam et al., 2006; Branham et al., 2005; Jones and Christians, 2005). In the first year of a 2-year Illinois study, Branham et al. (2005) reported that two or three applications of mesotrione at 0.28 or 0.42 kg·ha^{-1} a.i. beginning in early June provided inconsistent levels (13%–92%) of CBG control. The 0.42 kg·ha^{-1} a.i. rate applied three times, however, provided 92% to 100% CBG control in both years. The generally poor level of CBG control observed in the first year may have been because of cooler temperatures at the time treatments initially were applied. In the second year, however, the aforementioned mesotrione treatments provided between 91% and 100% CBG control. They observed only short-lived discoloration in Kentucky bluegrass, which recovered in about 2 weeks after treatment. Jones and Christians (2005) reported that two applications of mesotrione at 0.70 and 1.12 kg·ha^{-1} a.i. in Iowa provided 38% and 99% CBG control in Kentucky bluegrass, respectively. In Virginia, Beam et al. (2006) applied mesotrione twice at 0.28 kg·ha^{-1} a.i. or three times at 0.06 and 0.17 kg·ha^{-1} a.i. beginning in September. All mesotrione treatments provided ≥92% CBG control in both study years while causing some short-lived injury to Kentucky bluegrass. Mesotrione also has herbicidal activity on several other common turfgrass weeds, including crabgrass (*Digitaria* spp.), nimblewill (*Muhlenbergia schreberi* J.F. Gmel.), white clover (*Trifolium repens* L.), and yellow nutsedge (*Cyperus esculentus* L.; Askew et al., 2003; Dernoeden et al., 2007; Keese et al., 2005). Some turfgrass managers may prefer to apply this herbicide in the summer to control a broader spectrum of weeds.

Triclopyr ester has received only limited study for the purpose of selective CBG control, and it merits further study. Although mesotrione has been shown to be effective, additional regional studies also are warranted to confirm or identify the most effective rate(s) and application frequency for selective CBG control. The aforementioned mesotrione studies were conducted in Kentucky bluegrass and perennial ryegrass (*Lolium perenne* L.). In the mid-Atlantic region, however, tall fescue has become the preferred species to use on home lawns and is gaining wide acceptance for use in golf course rough's and green surrounds (Bevard, 2007). The objectives of this study were to compare and fine tune mesotrione and triclopyr ester rates and summer application frequencies for the purpose of selective CBG control in tall fescue and Kentucky bluegrass. This field study was conducted in Connecticut and Maryland.

Materials and Methods

Connecticut 2005. This portion of the study was conducted at the University of Connecticut Plant Science Research and Education Facility located in Storrs. Soil was a Paxton fine sandy loam (coarse-loamy,

Received for publication 11 June 2007. Accepted for publication 31 Oct. 2007.

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mixed, active, mesic Oxyaquic Dystrudepts) with a pH of 6.4 and 5.4% organic matter. An established stand of Kentucky bluegrass (cultivar unknown) contaminated with an average of 39% CBG at the time the study was initiated was used. The area was maintained as a low-maintenance home lawn and was mowed about once per week to a height of 6.5 cm. The area received no spring fertilization and was irrigated only to prevent drought stress. To control crabgrass (*Digitaria* spp.), the area received an application of siduron [1-(2-methylcyclohexyl)-3-phenylurea; 5.6 $kg \cdot ha^{-1}$ a.i.] and bensulide (O,O-diisopropyl S-2-phenylsulfonylaminoethyl phosphorodithioate; 9 $kg \cdot ha^{-1}$ a.i.) on 25 Apr. and 28 May 2005, respectively. The pre-emergence herbicides were watered-in within 24 h. No other pesticides were applied to this site.

Maryland 2005 and 2006. This portion of the study was conducted at the University of Maryland Paint Branch Turfgrass Research Facility in College Park. Tall fescue, cv 'Millennium', was seeded in Oct. 2001. However, the seeder was contaminated with an unknown cultivar of CBG. By 2005, the CBG was uniformly distributed and infested about 35% to 50% of the site at the time treatments were initiated in both 2005 and 2006. Soil was a Keyport silt loam (fine, mixed, semiactive, mesic Aquic Hapludult) with a pH of 5.8 and 2.2% organic matter. The site was mowed once or twice weekly to a height of about 6.0 cm, and was irrigated in summer as needed to avoid drought stress. Prodiamine [N3,N3-Di-n-propyl-2,4-dinitro-6-(trifluoromethyl)-m-phenylenediamine; 0.73 $kg \cdot ha^{-1}$ a.i.] was applied in Apr. 2005 and 2006 to control crabgrass. No other pesticides were applied in either year.

Plots measured 1.5 × 1.5 m at both sites in 2005 and 1.8 × 2.3 m in Maryland in 2006, and were arranged in a randomized complete block with four replications. Two rates of mesotrione and triclopyr ester (hereafter triclopyr) were applied two, three, or four times in 2005 and three or four times in 2006. The herbicide treatments were applied on about a 2-week interval on the dates footnoted in the data tables. Mesotrione was tank-mixed with 0.25% (by volume) of nonionic surfactant (X-77). The herbicides were applied using a flat fan nozzle (8004E) with a CO_2 pressurized (262 kPa) backpack sprayer in 467 $L \cdot ha^{-1}$ water. The percentage of plot area infested by CBG was assessed visually on a 0% to 100% scale, where 0 = no CBG present and 100 = entire plot area covered with green, living CBG. Kentucky bluegrass quality was assessed on a 0 to 10 scale, where 0 = entire plot area brown or dead and 10 = optimum greenness and density. Herbicide injury to CBG and tall fescue were rated on a 0 to 5 scale where 0 = no injury; 2.5 = objectionable level of injury; and 5 = bentgrass or tall fescue entirely brown or dead. Bareground was evaluated on a 0% to 100% scale, where 0 = no bareground and 100 = entire plot area void of living turf. Herbicide injury ratings were used to assess the speed of herbicide performance in CBG, whereas percentage of CBG cover data were used as a measure of control. Treatments resulting in ≤3% CBG cover were judged subjectively to have provided an excellent level of control, which would be considered acceptable by professional turfgrass managers. Percentage of CBG cover and bareground data were square root transformed before analysis, but actual means are shown. Data were analyzed using SAS procedure PROC MIXED (SAS Institute, Cary, NC). Significantly different means were separated using Tukey's or Fisher's protected least significant difference test ($P \leq 0.05$) as indicated in the data tables. To determine the influence of rate and number of applications on CBG cover and bareground ratings, preplanned contrasts were performed within and between each herbicide evaluated. Contrasts were performed only on data from the last rating date in each year using the 'Estimate' procedure in SAS.

Results

Connecticut 2005. Injury ratings were used to describe the rate of herbicide activity on CBG, whereas percentage of CBG cover was used as a measure of control. Herbicides were applied initially on 13 June, but little or no CBG injury was observed in plots treated with mesotrione by 17 June [i.e., 4 d after treatment (DAT); Table 1]. By 20 June (7 DAT), all herbicide treatments had elicited significant CBG injury. Individual CBG leaves injured by mesotrione and triclopyr appeared bleached-white or brown in color, respectively. After the second application of mesotrione, injury to the CBG became severe in early July. Most CBG within mesotrione-treated plots appeared severely injured on nearly all rating dates after the third application on 9 July. Data collected 2 Aug. indicated that CBG control would be less effective in plots treated twice with mesotrione because CBG injury ratings were lower than those observed in plots treated three or four times with mesotrione.

On 17 June, injury to CBG in plots treated with triclopyr initially appeared more rapidly than was observed in mesotrione-treated plots (Table 1). CBG in plots treated with triclopyr applied at 1.12 $kg \cdot ha^{-1}$ a.i. generally had a higher injury rating when compared with plots treated with 0.56 $kg \cdot ha^{-1}$ a.i. on 27 June (14 DAT). Between 9 July and 2 Aug., CBG within plots treated three times with the high rate or four times at both triclopyr rates appeared mostly brown or dead. Plots receiving two (both rates) or three triclopyr applications at the low rate (0.56 $kg \cdot ha^{-1}$ a.i.) generally exhibited less CBG injury when compared with the other triclopyr treatments.

According to field notes, the percentage of plot area covered with green (i.e., living) CBG ranged from 36% to 41% in the control (i.e., untreated plots) between 8 June and 11 Nov. Three months after the study was initiated (i.e., 19 Sept.), living CBG populations within all herbicide-treated plots were reduced, when compared with the control (Table 2). On the final rating date (i.e., 11 Nov.), plots treated twice with mesotrione (0.14 $kg \cdot ha^{-1}$ a.i.) and triclopyr (both rates), and two or three times with the low triclopyr rate (0.56 $kg \cdot ha^{-1}$ a.i.) had CBG levels equivalent to the control. All other treatments provided a similar level of CBG control. Excellent control (≤3% CBG), however, was observed in plots receiving ≥3 applications of mesotrione (both rates) and triclopyr (1.12 $kg \cdot ha^{-1}$ a.i.).

Orthogonal contrasts were performed for percentage of CBG cover data on the final rating date in each year. The CT contrasts showed that three or four applications of mesotrione were more effective than two, and that there were no CBG control differences using three versus four applications (Table 3). When averaged across all numbers of application, the 0.21 $kg \cdot ha^{-1}$ a.i. rate of mesotrione was more effective than 0.14 $kg \cdot ha^{-1}$ a.i. in controlling CBG. The contrasts for triclopyr data were the same as for mesotrione; that is, three or four applications were more effective than two, and the high

Table 1. CBG injury in response to multiple applications of mesotrione and triclopyr ester in Storrs, 2005.

			CBG injury[z]			
	Rate	Applications	17 June	27 June	9 July	2 Aug.
Treatment	($kg \cdot ha^{-1}$ a.i.)	(no.)[y]	(0–5)			
Mesotrione 4SC	0.14	2	0.0 e[x]	2.3 d	3.1 e	2.0 e
Mesotrione 4SC	0.21	2	0.5 de	3.4 ab	4.0 bc	3.4 cd
Mesotrione 4SC	0.14	3	0.0 e	3.5 a	3.5 de	4.6 ab
Mesotrione 4SC	0.21	3	0.3 e	3.4 ab	4.0 bc	4.9 a
Mesotrione 4SC	0.14	4	0.0 e	2.4 cd	3.3 de	4.4 ab
Mesotrione 4SC	0.21	4	0.5 de	3.4 ab	3.8 cd	4.9 a
Triclopyr Ester 4L	0.56	2	1.1 cd	2.3 d	3.4 de	3.1 d
Triclopyr Ester 4L	1.12	2	1.3 bc	3.1 ab	4.4 ab	4.0 bc
Triclopyr Ester 4L	0.56	3	1.4 bc	2.4 cd	3.6 cd	4.0 bc
Triclopyr Ester 4L	1.12	3	1.5 abc	3.1 ab	4.5 a	5.0 a
Triclopyr Ester 4L	0.56	4	2.1 a	2.9 bc	4.0 bc	4.5 ab
Triclopyr Ester 4L	1.12	4	1.9 ab	3.4 ab	4.3 ab	5.0 a
Untreated	–	–	0.0 e	0.0 e	0.0 f	0.0 f

[z]CBG injury was rated visually on a 0 to 5 scale where 0 = no CBG injury and 5 = CBG entirely brown or dead.

[y]Treatments were applied twice on 13 and 27 June, three times on 13 and 27 June and 9 July, or four times on 13 and 27 June and 9 and 27 July 2005.

[x]Means in a column followed by the same letter are not significantly different according to Fisher's protected least significant difference test ($P \leq 0.05$).

Table 2. CBG cover, Kentucky bluegrass quality, and percentage of plot area bareground in response to multiple applications of mesotrione and triclopyr ester in Storrs, 2005.

Treatment	Rate (kg·ha^{-1} a.i.)	Applications (no.)[w]	CBG cover[z] 19 Sept.	CBG cover[z] 11 Nov.	Kentucky bluegrass quality[y] 27 June	Kentucky bluegrass quality[y] 3 July	Kentucky bluegrass quality[y] 9 July	Bareground[x] 11 Nov.
			(%)		(0–10)			%
Mesotrione 4SC	0.14	2	13 bc[v]	21 ab	8.3 a	7.3 abc	7.9 ab	2 c
Mesotrione 4SC	0.21	2	6 b-e	6 bcd	8.0 ab	7.4 ab	7.5 abc	3 c
Mesotrione 4SC	0.14	3	0 de	1 cd	8.3 a	7.6 a	8.0 a	7 bc
Mesotrione 4SC	0.21	3	1 de	1 c	8.0 ab	7.3 abc	7.4 abc	7 bc
Mesotrione 4SC	0.14	4	3 cde	2 cd	8.1 a	7.3 a-d	7.7 abc	9 bc
Mesotrione 4SC	0.21	4	0 e	0 d	7.9 abc	7.4 ab	7.6 abc	6 bc
Triclopyr Ester 4L	0.56	2	19 ab	24 ab	7.1 c	6.8 bcd	6.9 c	1 c
Triclopyr Ester 4L	1.12	2	7 b-e	13 abc	7.5 abc	6.6 bcd	7.0 bc	7 bc
Triclopyr Ester 4L	0.56	3	9 bcd	18 ab	7.5 abc	6.5 cd	6.9 c	6 bc
Triclopyr Ester 4L	1.12	3	3 cde	1 d	7.1 c	6.8 bcd	7.0 bc	10 bc
Triclopyr Ester 4L	0.56	4	3 cde	6 bcd	7.5 abc	6.4 d	7.3 abc	32 b
Triclopyr Ester 4L	1.12	4	0 e	2 cd	7.3 bc	6.4 d	6.9 c	77 a
Untreated	—	—	40 a	34 a	8.1 a	8.0 a	7.9 ab	5 c

[z]Percentage of CBG cover was rated visually on a 0% to 100% scale where 0 = no CBG present and 100 = entire plot area covered with CBG.
[y]Kentucky bluegrass quality was assessed visually on a 0 to 10 scale where 0 = entire plot area brown or dead and 10 = optimum greenness and density.
[x]Percentage of bareground was visually rated on a 0 to 100 scale where 0 = no bareground and 100 = entire plot area void of living turfgrass.
[w]Treatments were applied twice on 13 and 27 June, three times on 13 and 27 June and 9 July, or four times on 13 and 27 June and 9 and 27 July 2005.
[v]Means in a column followed by the same letter are not significantly different according to Tukey's protected least significant difference test for percentage of cover and bareground data and Fisher's protected least significant difference test for quality data ($P \leq 0.05$). Percentage of cover and bareground data were transformed, but actual means are shown.

Table 3. Contrasts among application frequency and herbicide rate treatments for percentage of CBG cover and bareground data obtained on the final rating date in each year.

Contrast	Storrs, 2005 % of CBG cover	Storrs, 2005 % of bareground	% of CBG cover, College Park 2005	% of CBG cover, College Park 2006
Mesotrione				
2 vs. 3 applications	*** [z]	NS	NS	—[y]
2 vs. 4 applications	***	*	NS	–
3 vs. 4 applications	ns	NS	NS	NS
0.14 vs. 0.21 kg·ha^{-1}.a.i.	*	NS	NS	NS
Triclopyr				
2 vs. 3 applications	**	NS	NS	—
2 vs. 4 applications	***	***	**	—
3 vs. 4 applications	NS	***	NS	*
0.56 vs. 1.12 kg·ha^{-1}.a.i.	***	***	***	***
Mesotrione vs. Triclopyr				
Overall	**	***	***	***
2 vs. 2 applications	NS	NS	***	—
3 vs. 3 applications	**	NS	***	***
4 vs. 4 applications	NS	***	***	***

[z]NS = not significantly different; *, **, and *** indicate significant differences at $P \leq 0.05$, ≤ 0.01, and ≤ 0.001, respectively.
[y]Treatment not evaluated in 2006.

rate was most effective. Overall, mesotrione was more effective than triclopyr in controlling CBG, especially when applied three times.

Visual quality ratings were used as a measure of herbicide injury to Kentucky bluegrass. When compared with the control, none of the mesotrione treatments reduced Kentucky bluegrass quality on any rating date between 27 June and 5 Oct. (Table 2; some data not shown). Numerically lower quality ratings, however, generally were observed in triclopyr-treated Kentucky bluegrass between 27 June and 18 July (some data not shown). On 3 July, after the second application of herbicides, all triclopyr-treated plots exhibited inferior quality when compared with the control. By 9 July, only selected triclopyr treatments reduced quality significantly, but quality data among triclopyr treatments were statistically equivalent. By 18 July, the quality of triclopyr-treated Kentucky bluegrass generally was equivalent to the control (data not shown). Plots were evaluated for bareground on 11 Nov. Bareground ratings were greater in plots treated four times with both rates of triclopyr (32%–77% bareground) versus the control (5% bareground). Mesotrione contrasts indicated that there was more bareground in plots treated four times (6%–9%) versus two (2%–3%), which was attributed to better CBG control with more frequent applications. Contrasts verified that triclopyr was more damaging to Kentucky bluegrass than mesotrione. There were no bareground differences among plots treated with two or three times with triclopyr, and four applications were most damaging. Although four applications of triclopyr had been most phytotoxic to Kentucky bluegrass, this injury was not immediately evident during the summer.

Maryland 2005. Injury to CBG and tall fescue were not routinely monitored in 2005. About 1 week after treatment, mesotrione elicited a bleaching or whitening on the upper CBG canopy, whereas lower canopy leaves remained green. The injury to CBG at this time was uniform, regardless of mesotrione rate, and dissipated within 7 to 10 d (data not shown). Unlike CT, injury elicited by triclopyr in CBG was slower to appear. There was only slight injury to tall fescue in mesotrione-treated plots after the second application on 6 July, which appeared as a bleaching of older leaves (data not shown). No tall fescue injury was observed in plots treated with triclopyr. No other injury ratings were obtained in 2005.

After two applications of the herbicides, CBG cover was evaluated on 6 July. At that time, plots treated with both mesotrione rates had substantially less green CBG cover (1%–5%) when compared with plots treated with the low rate of triclopyr (39%–41% CBG cover) and the control (60% CBG cover; Table 4). Treatments were applied last on 20 July for plots receiving four herbicide applications. All mesotrione treatments had provided equivalent CBG control by 6 July. Triclopyr applied at the high rate (1.12 kg·ha^{-1} a.i.) three times and both rates applied four times had provided a level of CBG control equivalent to mesotrione. Plots treated twice with either rate of triclopyr or three times with the low rate had CBG levels similar to the control. Data collected on 7 Sept. showed that all mesotrione treatments provided equivalent CBG control, and only the 0.14 kg·ha^{-1} a.i. rate applied twice provided less than excellent control. Contrast statements indicated that there were no differences among the number of mesotrione applications or rates (Table 3). The high rate of triclopyr provided equivalent CBG control, regardless of being applied two, three, or four times. Contrasts showed that four triclopyr applications were more effective than two, but the high rate provided the greatest level of CBG control. Overall, contrasts indicated that mesotrione provided better CBG control than triclopyr, regardless of the number of applications. None of the triclopyr treatments, however, provided an acceptable level of CBG control in 2005.

Maryland 2006. Because of space limitations, the herbicides were applied only three or four times in 2006. It took about 2 weeks (i.e., 16 July) for CBG treated with mesotrione to show uniform herbicide injury, and injury intensified shortly after the second application on 23 June (Table 5). Four days after the third application on 7 July, mesotrione-treated CBG exhibited severe injury. Data collected on 13 and 28 July indicated that all mesotrione treatments had severely injured if not killed the CBG. As was observed in 2005 in Maryland, the CBG responded more slowly to triclopyr. Differences in injury between triclopyr rates did not become apparent until 7 July. Injury to CBG by the low triclopyr rate (0.56 kg·ha^{-1} a.i.) generally was less versus the high rate (1.12 kg·ha^{-1} a.i.) between 7 and 28 July. Injury to CBG by the high rate of triclopyr did not become equivalent to that observed in mesotrione-treated plots until 28 July.

Little or no injury to tall fescue was observed in triclopyr-treated plots (Table 5). Injury to tall fescue in response to mesotrione took the form of leaf whitening, and injury level generally was low and moderately severe at the low and high rate, respectively. Tall fescue injury in plots treated with the high mesotrione rate was most objectionable on 30 June and 13 July, about 10 days after the second and third application of mesotrione, respectively. By 28 July, significant injury to tall fescue was observed only in plots treated four times with the high mesotrione rate, but the level of injury (i.e., 1.4) was low (data not shown). Enhanced injury was not observed after the fourth application, and the tall fescue had fully recovered by 11 Aug. (data not shown). The injury to tall fescue, which included some chlorosis, only was objectionable for about 7 to 14 d.

Mesotrione greatly reduced CBG cover ratings after the second application on 30 June (Table 6). There were no rate or application frequency differences among mesotrione treatments on any date. July was marked by supraoptimal temperature stress, and living CBG was almost totally eliminated on 28 July by mesotrione. There was no significant reduction in CBG cover in triclopyr-treated plots on 30 June. Most triclopyr treatments reduced CBG cover by 13 July when compared with the untreated control. On 21 July, plots treated with the high rate of triclopyr had less CBG cover than plots treated with the low rate. CBG cover ratings obtained on 28 July and 25 Aug. generally were statistically equivalent in plots treated with mesotrione and triclopyr applied at the high rate. On the final rating date (i.e., 25 Aug.), all treatments except the low rate of triclopyr had provided excellent CBG control. The low rate of triclopyr applied three times had provided inferior CBG control when compared with all other herbicide treatments. Contrast statements for the final rating date showed that there were no CBG control differences between three versus four applications of mesotrione, and no difference between mesotrione rates. Triclopyr contrasts showed that four applications provided better CBG control than three, and that the high rate provided a higher level of CBG control than the low rate. Overall, contrasts indicated that mesotrione provided more effective CBG control than triclopyr, regardless of application frequency.

Table 4. CBG cover in response to multiple applications of mesotrione and triclopyr ester in College Park, 2005.

Treatment	Rate (kg·ha^{-1} a.i.)	Applications (no.)^{y}	CBG cover^{z} 6 July	10 Aug.	7 Sept.
			(%)		
Mesotrione 4 SC	0.14	2	5 c^{x}	4 d	5 cd
Mesotrione 4 SC	0.21	2	1 c	3 cd	3 cd
Mesotrione 4 SC	0.14	3	4 c	2 cd	1 d
Mesotrione 4 SC	0.21	3	2 c	1 d	1 d
Mesotrione 4 SC	0.14	4	5 c	1 d	2 d
Mesotrione 4 SC	0.21	4	2 c	1 d	1 d
Triclopyr Ester 4L	0.56	2	39 ab	50 ab	45 ab
Triclopyr Ester 4L	1.12	2	11 bc	29 abc	16 bc
Triclopyr Ester 4L	0.56	3	41 ab	51 ab	42 ab
Triclopyr Ester 4L	1.12	3	16 bc	8 cd	12 cd
Triclopyr Ester 4L	0.56	4	40 ab	16 bcd	18 bc
Triclopyr Ester 4L	1.12	4	13 bc	3 cd	11 cd
Untreated	—	—	60 a	62 a	52 a

^{z}Percentage of CBG cover was rated visually on a 0% to 100% scale where 0 = no CBG present and 100 = entire plot area covered with CBG.
^{y}Treatments were applied twice on 8 and 21 June, three times on 8 and 21 June and 9 July, or four times on 8 and 21 June and 6 and 20 July 2005.
^{x}Means in a column followed by the same letter are not significantly different according to Tukey's significant difference test ($P \leq 0.05$). Data were transformed, but actual means are shown.

Discussion

Multiple applications of mesotrione (0.14 and 0.21 kg·ha^{-1} a.i.) and triclopyr (1.12 kg·ha^{-1} a.i.) substantially reduced CBG cover at both locations. Mesotrione generally was just as effective when applied three or four times, therefore, only three summer annual applications appear necessary. There was no difference between mesotrione rate in Maryland in either year, but the higher rate was more effective in Connecticut. Regardless, three applications of mesotrione at 0.14 or 0.21 kg·ha^{-1} a.i. provided acceptable CBG control in both states. Branham et al. (2005) concluded that at least two and preferably three applications of mesotrione at 0.25 or 0.42 kg·ha^{-1} a.i. would

Table 5. CBG and tall fescue injury in response to multiple applications of mesotrione and triclopyr ester in College Park, 2006.

Treatment	Rate (kg·ha^{-1} a.i.)	Applications (no.)^{y}	Injury^{z} CBG 16 June	CBG 23 June	CBG 7 July	CBG 13 July	CBG 28 July	Tall fescue 23 June	Tall fescue 30 June	Tall fescue 13 July
			(0–5)							
Mesotrione 4 SC	0.14	3	2.4 a^{x}	3.6 ab	4.6 a	5.0 a	4.9 a	0.6 c^{x}	1.8 b	1.6 b
Mesotrione 4 SC	0.21	3	2.4 a	4.3 a	4.9 a	5.0 a	5.0 a	1.5 a	2.6 a	2.8 a
Mesotrione 4 SC	0.14	4	2.5 a	3.0 b	4.8 a	4.9 ab	5.0 a	1.0 b	1.9 b	1.5 b
Mesotrione 4 SC	0.21	4	2.5 a	3.9 ab	5.0 a	5.0 ab	5.0 a	1.5 a	2.5 a	2.8 a
Triclopyr Ester 4L	0.56	3	1.3 b	1.1 c	1.8 c	1.6 d	2.1 b	0.0 d	0.3 b	0.1 c
Triclopyr Ester 4L	1.12	3	1.3 b	1.6 c	2.6 b	3.6 bc	4.3 a	0.0 d	0.3 b	0.0 c
Triclopyr Ester 4L	0.56	4	1.0 b	1.1 c	2.1bc	1.4 d	3.0 b	0.0 d	0.5 b	0.1 c
Triclopyr Ester 4L	1.12	4	1.3 b	1.8 c	2.8 b	3.2 c	4.5 a	0.0 d	0.3 b	0.3 c
Untreated	—	—	0.0 c	0.0 d	0.0 d	0.0 e	0.0 c	0.0 d	0.0 b	0.0 c

^{z}CBG and tall fescue injury were rated visually on a 0 to 5 scale where 0 = no injury; 2.5 = objectionable injury; 5.0 = CBG or tall fescue foliage entirely brown or dead.
^{y}Treatments were applied three times on 5 and 19 June and 3 July, or four times on 5 and 19 June and 3 and 17 July 2006.
^{x}Means in a column followed by the same letter are not significantly different according to Fisher's protected least significant difference test ($P \leq 0.05$).

Table 6. CBG cover in response to multiple applications of mesotrione and triclopyr ester in College Park, 2006.

Treatment	Rate (kg·ha⁻¹ a.i.)	Applications (no.)[y]	CBG cover[z] 30 June	7 July	13 July	21 July	28 July	25 Aug.
			%					
Mesotrione 4 SC	0.14	3	4 bc[x]	3 c	2 c	1 ef	1 de	1 cd
Mesotrione 4 SC	0.21	3	2 c	2 c	1 c	1 f	0 e	0 d
Mesotrione 4 SC	0.14	4	3 bc	3 c	1 c	1 ef	0 e	0 d
Mesotrione 4 SC	0.21	4	2 c	3 c	0 c	1 f	0 e	0 d
Triclopyr Ester 4L	0.56	3	24 a	22 ab	14 b	18 b	13 b	11 b
Triclopyr Ester 4L	1.12	3	14 ab	13 bc	7 bc	6 cd	3 cd	3 cd
Triclopyr Ester 4L	0.56	4	26 a	25 ab	21 ab	14 bc	6 bc	5 bc
Triclopyr Ester 4L	1.12	4	15 ab	12 bc	6 bc	4 de	1 cde	1 cd
Untreated	–	–	30 a	31 a	36 a	31 a	32 a	38 a

[z]Percentage of CBG cover was rated visually on a 0% to 100% scale where 0 = no CBG present and 100 = entire plot area covered with CBG.

[y]Treatments were applied three times on 5 and 19 June and 3 July, or four times on 5 and 19 June and 3 and 17 July 2006.

[x]Means followed by the same letter in a column are not significantly different according to a Tukey's protected least significant difference test ($P \leq 0.05$). Data were transformed, but actual means are shown.

be required to eliminate CBG in Illinois. Beam et al. (2006) reported that 0.06 or 0.17 kg·ha⁻¹ a.i. applied three times or 0.28 kg·ha⁻¹ a.i. applied two times resulted in ≥98% CBG control within 14 weeks after treatments were initiated in the Virginia study. In Maryland and Connecticut, however, three mesotrione (0.14 or 0.21 kg·ha⁻¹ a.i.) applications were required to provide ≥97% CBG control in about the same period of time. No herbicide treatment, however, consistently eliminated CBG in Maryland or Connecticut. There were no spring CBG cover ratings the following year, and surviving CBG would likely require retreatment at some future time. As pointed out by Branham et al. (2005), CBG that recovers can rapidly repopulate bare areas, therefore, regular applications of mesotrione will be required to eliminate CBG. Mesotrione elicited generally short-lived injury to tall fescue and little or no injury to Kentucky bluegrass. Tall fescue leaves bleached by the herbicide recovered or were removed fairly rapidly by mowing, as was observed in Kentucky bluegrass by Beam et al. (2006).

The high rate of triclopyr provided a greater level of CBG control than the low rate at all sites. Three triclopyr applications were generally as effective as four in controlling CBG. Triclopyr reduced the quality of Kentucky bluegrass after the second application in Connecticut, however, four applications of triclopyr were phytotoxic. All triclopyr rates and timings, however, were safe to tall fescue in Maryland. Although triclopyr provided less than acceptable control in Maryland in 2005, three applications of triclopyr (1.12 kg·ha⁻¹ a.i.) likely will provide the best combination of safety and selective CBG control in tall fescue and Kentucky bluegrass.

The speed at which a herbicide acts on its target can be important. For lawn care operators, a rapid response is often desirable. In this study, both herbicides caused visual injury in CBG about 1 week after application. However, extremely severe damage to CBG generally did not appear for a few days after the third application of mesotrione. For triclopyr, rate of injury varied between states, but extremely severe CBG damage generally was noted about 2 weeks after the second and third applications in Connecticut and Maryland, respectively. It should also be noted that mesotrione and triclopyr have herbicidal activity on several weed species. Because large areas of bareground may develop where susceptible weed populations are high, overseeding likely will be required. Hence, future research should focus on potential soil residuals of these herbicides and their impact on overseeded turfgrass species.

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