Accepted for publication 6 June 2007. Published 31 August 2007.

Herbicide Selection and Application Timing in the Fall Affects Control of Ground Ivy

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Reicher, Z. J., and Weisenberger, D. V. 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.

Abstract

Specific timing of fall applications of broadleaf weed herbicides is not refined to maximize control of ground ivy. The objective of our three-year study was to determine how application timing in fall affects control of ground ivy with five different herbicide treatments. Herbicides were applied on 1 and 15 September, 1 and 15 October, and 1 and 15 November of 2003, 2004, and 2005. When rated in December following application, applications of all herbicides were most effective if applied prior to 1 November. However, November applications of all herbicides resulted in control similar to earlier applications when rated the following June. Triclopyr was the most effective and consistent in controlling ground ivy, with 27 of 36 applications reducing cover to ≤ 1% compared to > 50% in untreated plots. Long-term control from triclopyr was not affected significantly by application date. Adding isoxaben to triclopyr improved long-term control over triclopyr alone in five of six November applications. Fluroxypyr provided ≤ 10% cover by June in 15 of the 18 applications and applications on 1 September through 1 November were most effective. Poorest control resulted from 2,4-D+MCPP+dicamba. Adding carfentrazone to 2,4-D+MCPP+dicamba dramatically improved short-term control of ground ivy from November applications, but had little long-term benefit on any application date.

Introduction

Ground ivy or creeping Charlie (*Glechoma hederacea* L.) is a creeping perennial weed in cooler climates of the northeastern and midwestern United States (7). Once ground ivy is established, controlling it is challenging for lawn care operators (LCO). In a 2000 survey of Indiana LCO, 31% of customer lawns contained ground ivy (5). Furthermore in that survey, 49% of responding LCO reported poor or fair control of ground ivy, 40% reported non-uniform control, and 86% indicated repeated herbicide applications were necessary for successful ground ivy control.

Ground ivy stolons creep beneath the turf canopy when colonizing new areas, spreading rapidly through vegetative propagation of new ramets along these stolons, and extensive rooting occurs from these stolons (1,4). Kohler et. al (5) reported the preemergence herbicide isoxaben reduced spread of ground ivy stolons up to 80%, suggesting that isoxaben combined with an effective postemergence herbicide may improve control over that expected from the postemergence herbicide alone. Kohler also found that 2,4-D, triclopyr, or fluroxypyr applied once in mid-October at their high label rates were the most effective among ten different herbicide combinations used (5). However, control rarely exceeded 80% by even the most effective treatments in that study, and control from individual herbicides varied among years of the two-year study. Further work by Kohler, et. al (6), found that individual biotypes of ground ivy exist among populations, which varied markedly in their susceptibility to 2,4-D or triclopyr. Though our earlier work answered many questions on ground ivy control, ground ivy remains difficult to control.

Broadleaf herbicide applications in turfgrass are commonly recommended in the fall for most effective control. Fall applications coincide with increased basipetal transport of photosynthate and thus improved translocation of herbicide (13). Most weed research is with spring-applications for agricultural weeds, and few published reports are available on timing of fall application of broadleaf herbicides. Hansen and Branham (3) showed broadleaf herbicides applied in late September effectively controlled dandelions (*Taraxacum officinale*) when rated in November following application, whereas herbicides applied later in fall provided decreasing control the later they were applied. However, when rated the following spring, just the opposite trends occurred where applications later in fall provided better control than September applications. The authors speculated that later germinating dandelions avoided the earlier applications, but it was unclear if dandelions that received September applications survived better over the winter than those receiving October or November applications. Wilson and Michiels (15) evaluated fall application timing of dicamba on control of Canada thistle when rated the following summer. They found Canada thistle control increased when dicamba was applied 1 or 10 days after the first killing frost (-3°C) compared to applications made 11 or 5 days before the first killing frost. This improved control of Canada thistle was attributed to the herbicide reducing sucrose and short-chain fructan levels in the roots, thus decreasing winter survival. Turfgrass extension publications occasionally mention that broadleaf weed control improves after the first frost (11), but little data exists outside of anecdotal observations. The objective of our study was to determine how application timing in the fall affects control of ground ivy with five different herbicide treatments.

Determining Affect of Herbicide Timing on Ground Ivy Control

Field plots measuring 1.5 by 1.5 m were located in full sun in Kentucky bluegrass (*Poa pratensis* L. 'America') with a uniform stand of ground ivy at the W. H. Daniel Turfgrass Research Center in West Lafayette, IN. The soil was a Chalmers silt loam (fine silty mixed mesic Typic Haplaquoll) with a 7.0 pH, 4.7% organic matter, P at 219 kg/ha, and K at 510 kg/ha. Plots were irrigated as needed to prevent drought stress, mowed two times per week at 6.4 cm with clippings returned, and received N at 49 kg/ha/year. A factorial design was used with five herbicide treatments and six application dates, plus an untreated check for comparison. Herbicides included 2,4-D+MCPP+dicamba at 1.07+0.336+0.098 kg/ha, respectively (custom formulated by PBI Gordon for this study); 2,4-D+MCPP+dicamba+ carfentrazone at 1.07+0.336+0.098+0.035 kg/ha, respectively (Speedzone from PBI Gordon); fluroxypyr at 0.2793 kg/ha (Spotlight from Dow AgroSciences); triclopyr at 1.12 kg/ha (Turflon Ester from Dow AgroSciences), and triclopyr+isoxaben at 1.12 + 1.12 kg/ha, respectively (Turflon Ester and Gallery from Dow AgroSciences). Application dates were 1 September ± 3 days, 15 September ± 2 days, 1 October ± 1 day, 15 October ± 1 day, 1 November ± 2 days, and 15 November ± 2 days. All herbicide treatments were applied in 814 L/ha water with a CO_2-pressurized backpack sprayer using a three-nozzle (TeeJet XR80015VS, Spraying Systems Co., Wheaton, IL) boom at 207 kPa. Three replications were used in a randomized complete block design and the study was done on separate but adjacent sites beginning in September of 2003, 2004, and 2005. Percent cover of ground ivy was visually rated in December and June following application. Percent ground ivy cover was arcsine transformed to improve homogeneity of error variances, which allowed all three years of data to be combined for analysis. Statistical analysis was done with PROC ANOVA (Version 9.1, SAS Institute Inc., Cary, NC) and back-transformed means are presented and separated with LSD at $P \leq 0.05$.

December Ground Ivy Cover

Averaged over years and herbicides, applications made from 1 September through 15 October were equally effective reducing ground ivy cover to 4% or less by December (Table 1). Applications on 1 and 15 November were less effective, reducing ground ivy cover to 16% and 34%, respectively. However, a significant year × application date interaction occurred (Table 2) where the

1 November applications reduced ground ivy cover to 8% in 2003, but to only 18% and 21% in 2004 and 2005, respectively (Table 1). The improved control in 2003 was probably due to higher air temperatures 24 to 72 h after application (Fig. 1), as absorption and translocation of broadleaf herbicides increase with temperature (8).

Table 1. Back-transformed percent cover of ground ivy as affected by application timing of herbicides in fall. Data was recorded in December and June following application, and means are averaged over three replications and five herbicide treatments.

Application date	December				June			
	2003	2004	2005	Mean	2004	2005	2006	Mean
	Ground ivy cover (%)							
1 September	1a	1ab	4b	2a	8bc	4bc	11c	8a
15 September	1a	0a	4b	2a	11c	1a	9c	7a
1 October	1a	2b	0a	1a	3a	3ab	1a	3a
15 October	2b	6c	4b	4a	2a	9cd	3bc	4a
1 November	8b	18d	21c	16b	4ab	12de	11c	9a
15 November	30c	28e	42d	34c	27d	17e	31d	25b
Untreated check	45	35	73	51	55	48	55	53

Means followed by the same letter are not signficantly different at $P \leq 0.05$.

Table 2. ANOVA for three years of ground ivy cover with herbicides applied at various times in the fall. Data was arcsine transformed prior to analysis.

Source	**df**	**Dec**	**June**
Year (Y)	2	**	**
Application date (AD)	5	**	**
Herbicide (H)	4	**	**
AD*H	20	**	*
Y*AD	10	**	**
Y*H	8	NS	**
Y*AD*H	40	NS	*

**, *, NS = Significant at $P \leq 0.01$, $P \leq 0.05$, and non significant, respectively.

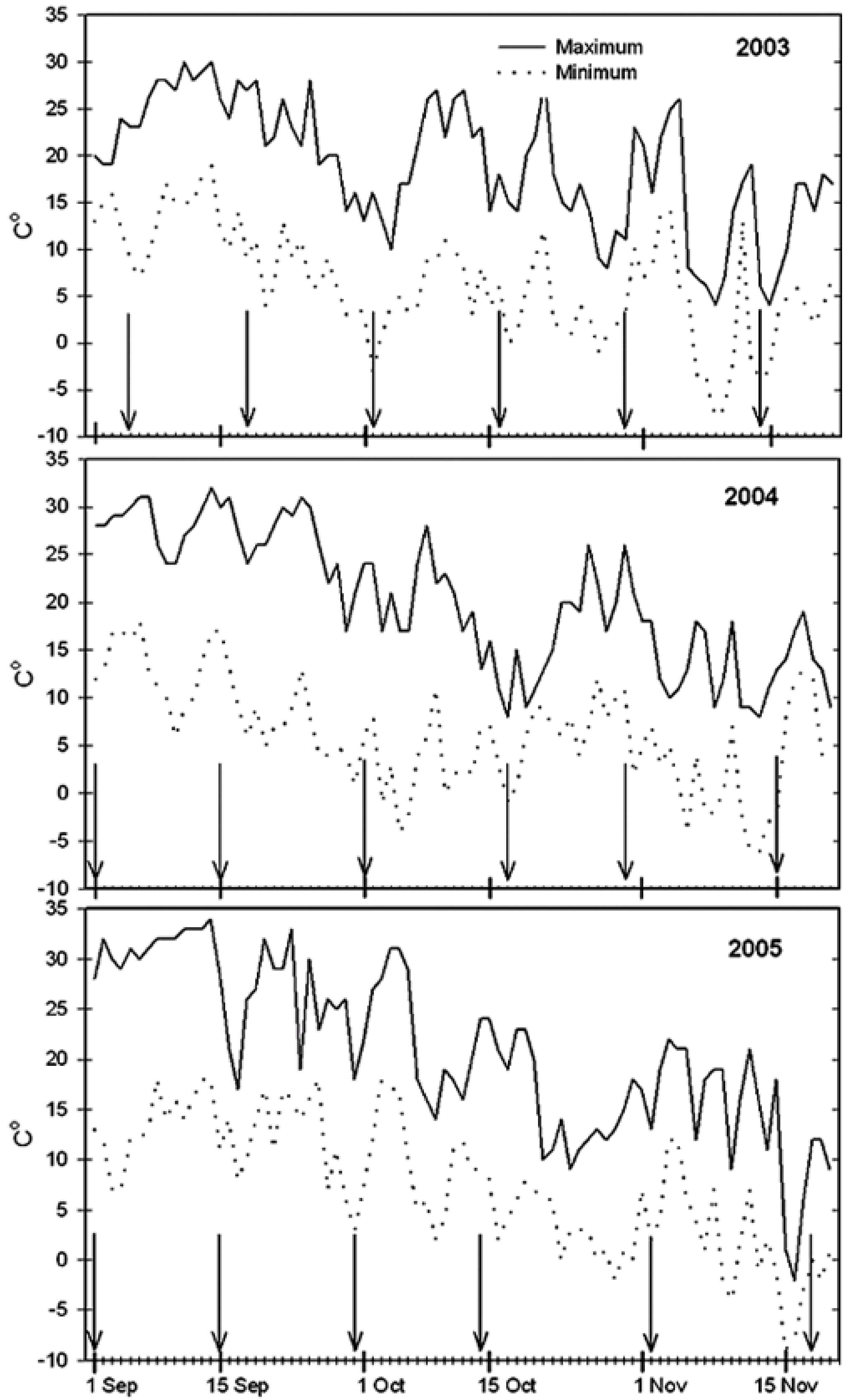

Fig. 1. Maximum and minimum air temperatures recorded in West Lafayette, IN, during 2003 through 2005. Arrows represent application dates.

Averaged over years and application dates, 2,4-D+MCPP+dicamba+ carfentrazone provided the lowest cover of ground ivy when rated in December (Table 3). However, a significant application date × herbicide interaction revealed that 2,4-D+MCPP+dicamba+carfentrazone excelled in ground ivy control compared to the other herbicides only when applied on 1 and 15 November. All herbicide treatments applied from 1 September through 15 October reduced cover of ground ivy to 10% compared to 51% in the untreated plots, but 2,4-D+MCPP+dicamba was the least effective of the herbicides (Fig. 2). Even though all herbicide treatments applied on 1 and 15 November reduced ground ivy cover compared to the check, 2,4-D+MCPP+dicamba+carfentrazone applied on 1 November was the only treatment to reduce ground ivy cover to 10% or less. The improvement in control in the November applications with carfentrazone was expected since carfentrazone is a fast-acting contact herbicide (14). The low apparent activity of the rest of the herbicides applied in November was also expected with the cooler temperatures in late fall, and is consistent with others reporting control from late fall applications did not become apparent until the following spring (3,5).

Table 3. Back-transformed percent cover of ground ivy as affected by application timing of herbicides in fall. Means are averaged over three replications in each of three years and over six application dates.

	December	June
Herbicide	**Ground ivy cover** (%)	
2,4-D+MCPP+dicamba	13c	19c
2,4-D+MCPP+dicamba+carfentrazone	6a	17c
Triclopyr	11b	3ab
Triclopyr +isoxaben	8ab	1a
Fluroxypyr	10b	7b

Means followed by the same letter are not significantly different at $P \leq 0.05$.
Untreated check plots contained 51% and 53% ground ivy cover in December and June, respectively.

June Ground Ivy Cover

Averaged over years and herbicides, applications made from 1 September through 1 November were equally effective reducing ground ivy cover to ≤ 9%, but applications on 15 November reduced ground ivy cover to only 25% cover compared to 53% in the untreated plots (Table 1). Averaged over years and application dates, triclopyr+isoxaben, triclopyr alone, and fluroxypyr reduced ground ivy to ≤ 7% cover when measured in June (Table 3). However, 2,4-D+MCPP+dicamba with and without carfentrazone reduced cover to only 19% and 17%, respectively (Table 3). Kohler et al. (5) indicated that 2,4-D was highly effective on ground ivy in spite of other contrary reports in other states (9,12). However, biotypes of ground ivy exist with varying susceptibility to 2,4-D (6) and populations with low sensitivity to 2,4-D may be present in these plots. Consistent with our previous findings (5), MCPP or dicamba appear to be marginally effective for control of ground ivy. Addition of carfentrazone to 2,4-D+MCPP+dicamba did not reduce long-term efficacy of the other active ingredients on ground ivy in this study as was suggested by Breeden and McElroy (2) on white clover (*Trifolium repens*).

A significant year × application date × herbicide interaction occurred in ground ivy cover rated in June following application (Table 2). Regardless of year or application date, triclopyr-containing treatments performed most consistently providing ≤ 1% cover from 27 of the 36 applications (Fig. 3). This is consistent with our previous work showing triclopyr to be highly effective on ground ivy (5). Adding isoxaben to triclopyr never decreased control from triclopyr, and combining it with triclopyr improved June control in five out of the six November applications in this study. This is also consistent with our earlier work where isoxaben reduced spread of ground ivy and resulted in ground ivy roots that were short, stubby, black, and did not penetrate the soil

(5). Fluroxypyr provided ≤ 10% cover from all application dates in 2003 and 2004, and from applications on 1 October, 15 October, and 1 November in 2005 (Fig. 3).

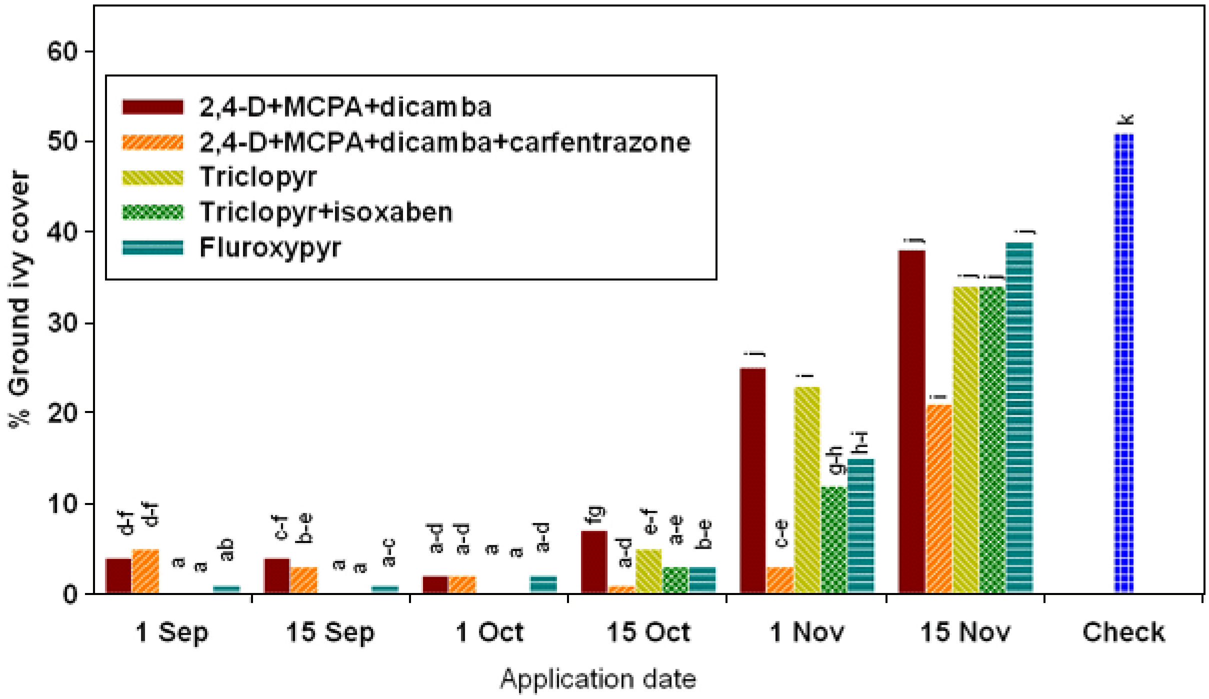

Fig. 2. Back-transformed percent cover of ground ivy in December as affected by application timing of herbicides in fall. Means are averaged over three replications and three years of the study. Means followed by the same letter are not significantly different at $P \leq 0.05$.

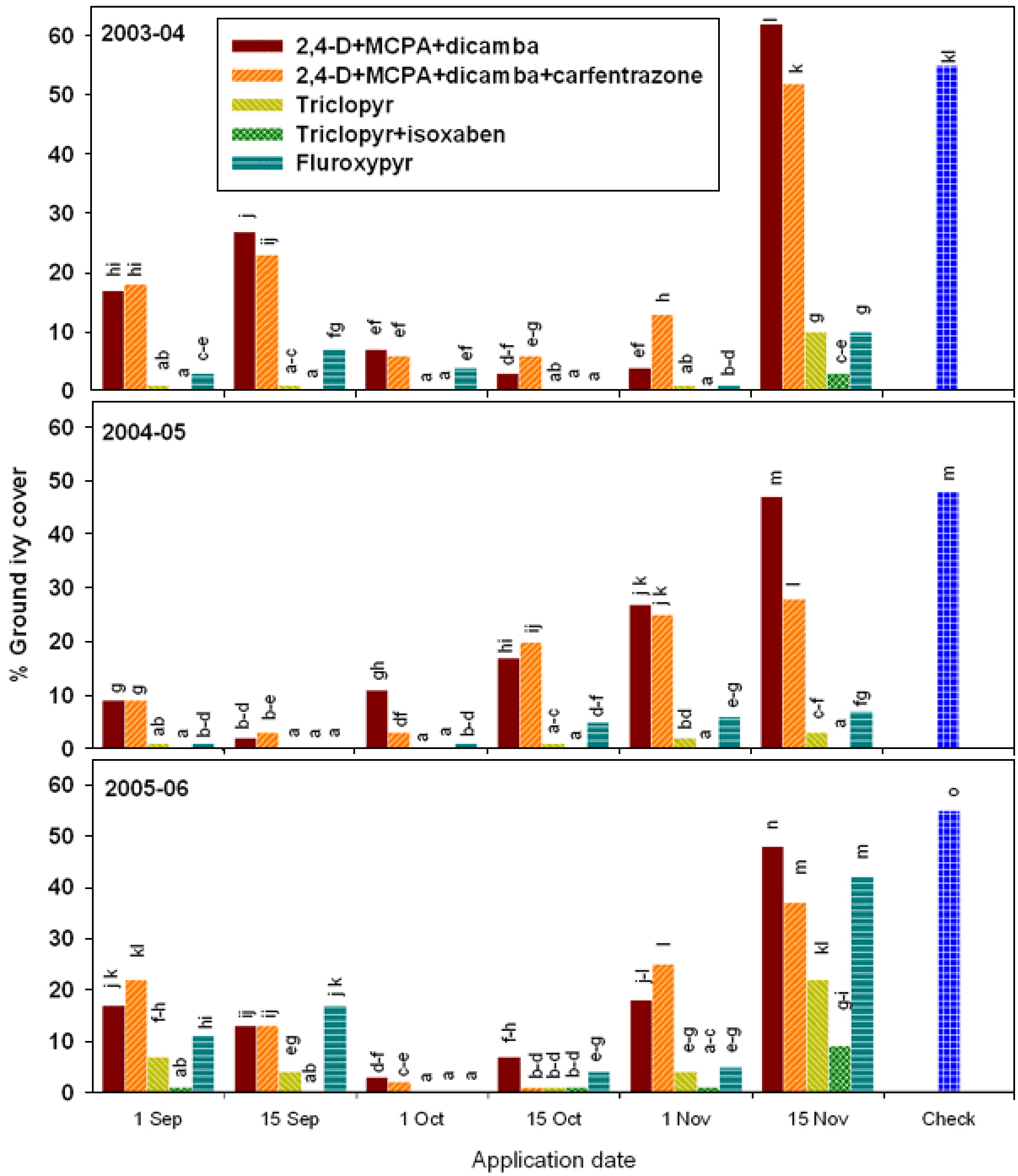

Fig. 3. Back-transformed percent cover of ground ivy in June as affected by application timing of herbicides in fall. Means are averaged over three replications and means followed by the same letter are not significantly different at $P \leq 0.05$.

The most inconsistent June control resulted from 2,4-D+MCPP+dicamba with or without carfentrazone. Applications of 2,4-D+MCPP+dicamba produced ≤ 10% cover on ground ivy in June when applied from 1 October through 1 November in 2003, 1 and 15 September in 2004, and 1 and 15 October in 2005 (Fig. 3). Adding carfentrazone produced ≤ 10% cover of ground ivy when applied 1 and 15 October in 2003, 1 September through 1 October in 2004, and 1 and 15 October 2005 (Fig. 3). This inconsistency could not be attributed to temperature patterns (Fig. 1), but could be a reflection of marginal and inherently inconsistent activity on ground ivy. The addition of carfentrazone reduced June control of ground ivy from 2,4-D+MCPP+dicamba only once, when applied on 1 November 2003. Conversely, carfentrazone improved control from 2,4-

D+MCPP+dicamba when applied on 15 November of all years, and had no effect on ground ivy control on any of the other application dates. Therefore, antagonism of carfentrazone to 2,4-D+MCPP+dicamba does not appear to pose a problem in fall applications for ground ivy control. The question remains if carfentrazone could be added to more effective ground ivy herbicides like triclopyr or fluroxypyr to achieve quick results from November applications without sacrificing long-term control for LCO.

Though it is thought that broadleaf weed control improves after the first frost (11), occurrence of frost is variable depending on many factors including air temperature, wind, cloud cover, and proximity to heat source (10). Wilson and Michiels (15) used the first killing frost (-3°C) to schedule herbicide applications, which may be slightly more predictable and widespread across a region. Wilson and Michiels went on to report that control of Canada thistle with dicamba improved dramatically after the first killing frost (15). This does not appear to be the case with ground ivy in our study as the dates of first killing frost (-3°C) were 2 October 2003, 5 October 2004, and 9 November 2005, and trends in control from any of the treatments were unaffected by application date relative to the first killing frost.

Conclusions

Triclopyr was the most effective and consistent herbicide in our study for controlling ground ivy and with the exception of only the 15 November 2005 application, triclopyr-containing treatments reduced ground ivy cover to ≤ 10% on all application dates. Application date in the fall is not critical with triclopyr, but the most consistent and effective control was seen with applications from 1 September through 1 November. Adding isoxaben to triclopyr may be justified in November applications to improve long-term control of ground ivy in high value or especially difficult situations. Fluroxypyr also performed well on ground ivy in this study, though slightly less effective and consistent than triclopyr. Applications of fluroxypyr should also be made from 1 September through 1 November for the most effective ground ivy control. The herbicide 2,4-D+MCPP+dicamba was the most inconsistent performer in our study, but most effective long-term control resulted from this herbicide with applications on 1 October. The addition of carfentrazone to 2,4-D+MCPP+dicamba dramatically improved short-term control of ground ivy from November applications, but long-term benefit was marginal.

Acknowledgment

We would like to thank the Midwest Regional Turf Foundation for providing financial support to allow this research as well as Gary Custis of PBI Gordon for providing the formulations of 2,4-D+MCPP+dicamba with and without carfentrazone.

Purdue Agriculture Research Program Journal Number 2007-18122.

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