

Late Fall and Early Spring Application of Granular Preemergence Herbicide on a Fertilizer Carrier for Season-Long Crabgrass Control¹

Zachary J. Reicher², Daniel V. Weisenberger³, Michael W. Melichar⁴,
Daniel L. Loughner⁴, Jeffrey A. Borger⁵, and Matthew B. Naedel⁵

Department of Agronomy and Horticulture
University of Nebraska, Lincoln, NE 68583

Abstract

Though sprayable preemergence herbicides will provide season-long control of crabgrass when applied in fall or early spring in the northern states, little work has been done with the now popular granular formulations of preemergence herbicide on a fertilizer carrier. Dimension (dithiopyr) or Barricade (proflam) on a fertilizer carrier were applied in October, November, March, April, May, or June in three trials and crabgrass control was monitored the summer following application. A single granular application of 0.56 kg ai-ha⁻¹ (0.5 lb ai-A⁻¹) of Dimension in November or March can provide control equivalent to that expected from typical mid-April applications. Barricade at 0.72 kg ai-ha⁻¹ (0.65 lb ai-A⁻¹) applied in November or March provided season-long crabgrass control equivalent to traditional mid-April application timing, though season-long crabgrass control from a November application of Barricade at 0.72 kg ai-ha⁻¹ (0.65 lb ai-A⁻¹) can be improved by a sequential May application of 0.28 kg ai-ha⁻¹ (0.25 lb ai-A⁻¹). Adding a sequential May application of Dimension at 0.28 kg ai-ha⁻¹ (0.25 lb ai-A⁻¹) only minimally improved crabgrass control over a November Dimension application at 0.56 kg ai-ha⁻¹ (0.5 lb ai-A⁻¹). Granular formulations of preemergence herbicide on a fertilizer carrier applied in November or March can provide season-long control similar to when applied at the traditional timing in mid-April in the Midwest and Mid-Atlantic regions of the United States. However, it is important for season-long crabgrass control to use the high label rate or follow with a sequential application in early summer if lower rates are used in the fall.

Index words: weed management, lawn care, turf.

Species used in this study: Kentucky bluegrass (*Poa pratensis* L.).

Herbicides used in this study: Dimension (dithiopyr), S,S-dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3,5-pyridinedicarbothioate; Barricade (proflam) 2,4 dinitro-N3,N3-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine.

Significance to the Nursery Industry

Preemergence crabgrass herbicides are usually applied to turf areas in mid- to late-April on cool-season turfgrasses throughout much of the upper Midwest and Mid-Atlantic region, but this coincides with a tremendous labor demand for mowing as well as windy or rainy spring weather that limits applications. Previous research has shown that sprayable formulations of preemergence herbicides applied in the early spring or late fall can provide season-long control of crabgrass. However, preemergence herbicides on fertilizer carriers are now widely used in the industry. This report shows that granular formulations of preemergence herbicide on a fertilizer carrier applied in late fall or early spring can provide season-long control similar to when applied at the traditional timing in mid-April in the Midwest and the Mid-Atlantic regions of the United States. However, results from our research combined with other reports suggest it is important for season-long crabgrass control to use the high label rate or follow with a sequential application in early summer if lower rates are used in the fall.

Introduction

Labels of preemergence crabgrass herbicides normally recommend application two weeks prior to crabgrass germination. Thus, applications are often timed for mid- to late-April on cool-season turfgrasses throughout much of the upper Midwest and Mid-Atlantic regions of the U.S. However, this coincides with a tremendous labor demand for mowing as well as windy or rainy spring weather that limits applications. Furthermore, professional lawn care applicators may have hundreds of accounts making it physically impossible to make all applications during two to three weeks in early April. Lastly, lawn care operators seek income as early as possible each spring. The end result is preemergence crabgrass herbicides are being applied to home lawns earlier in spring than in the past. Furthermore, preemergence herbicides are sometimes applied with the last fertilization in fall because of convenience on parks, golf courses, and other properties that are not maintained under annual contracts.

Previous research has shown that late fall or early spring applications of preemergence herbicides are often effective for season-long control of crabgrass. Research in Illinois (5), Indiana (8), Iowa, (1), Maryland (4), Rhode Island (11), and New York (10) showed late fall or early spring preemergence herbicide applications can be effective for season-long crabgrass control, but control from these products can be variable depending on the active ingredient, rate, and specific timing of application (2). Furthermore, the previously mentioned research, other than Taylorsen (11), was done with sprayable formulations of herbicides and are not completely relevant for herbicide/fertilizer combinations, which are

¹Received for publication November 2, 2010; in revised form January 11, 2011.

²Professor and corresponding author. zreicher2@unl.edu.

³Research Agronomist. Department of Agronomy, Purdue University, West Lafayette, IN 47907. danw@purdue.edu.

⁴Field Scientist. Dow AgroSciences, 9330 Zionsville Road, Indianapolis, IN 46268. mwmelichar@dow.com; dloughner@dow.com.

⁵Instructor and Research Technician, respectively. Department of Crop and Soil Sciences, The Pennsylvania State University, University Park, PA 16802. jab267@psu.edu; mbn112@psu.edu.

Table 1. Site information for experimental locations in Indiana for 2006–07 (IN06-07) and 2007–08 (IN07-08) and Pennsylvania in 2007–08 (PA07-08).

Parameter	Location		
	IN06-07 ^a	IN07-08	PA07-08
Kentucky bluegrass variety	Unknown	Unknown	Midnight
Mowing height	2.54 cm (1 in)	2.54 (1 in)	3.8 (1.5 in)
Mowing frequency	2× per week	2× per week	1× per week
Irrigation	to prevent stress	to prevent stress	to prevent stress
Soil texture	Chalmers silt loam (fine silty mixed mesic Typic Haplaquoll)	Chalmers silt loam (fine silty mixed mesic Typic Haplaquoll)	Hagerstown silt loam (fine, mixed, semiaactive, mesic Typic Hapludalf)
USDA Hardiness Zone	5a	5a	5b–6b
Soil pH	7.2	7.2	6.9
Soil P	222 kg·ha ⁻¹ (198 lbs·A ⁻¹)	198 kg·ha ⁻¹ (177 lbs·A ⁻¹)	140 kg·ha ⁻¹ (125 lbs·A ⁻¹)
Soil K	489 kg·ha ⁻¹ (437 lbs·A ⁻¹)	489 kg·ha ⁻¹ (437 lbs·A ⁻¹)	338 kg·ha ⁻¹ (302 lbs·A ⁻¹)
Percent soil organic matter	3.8%	3.8%	2.7%
Annual N	49 kg·ha ⁻¹ (44 lbs·A ⁻¹)	49 kg·ha ⁻¹ (44 lbs·A ⁻¹)	49 kg·ha ⁻¹ (44 lbs·A ⁻¹)
Application dates	October 16 November 17 March 21 April 17 May 15 June 11	October 15 November 19 March 14 April 17 May 15 June 16	November 8 November 29 March 25 April 17 May 21 June 11
Rating dates	June 11 July 12 August 30	June 27 July 17 August 15	June 25 — August 20

^aIN06-07 = herbicides applied in fall 2006 and spring 2007, rated in 2007 in West Lafayette, IN; IN07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in West Lafayette, IN; and PA07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in University Park, PA.

popular today. Therefore we designed a study to answer the following questions:

- Compare late fall through late spring applications of a Dimension/fertilizer combination for season-long crabgrass control;
- Compare late fall through late spring applications of a Barricade/fertilizer combination for season-long crabgrass control;
- Compare a single November application to a November plus sequential May application of Dimension/fertilizer or Barricade/fertilizer combinations for season-long crabgrass control; and
- Compare two rates of a Dimension/fertilizer combination applied from March through June for season-long crabgrass control.

Materials and Methods

Evaluating herbicide timing for crabgrass control. Three field trials were conducted in this study including one in Indiana in 2006–2007, and one trial in both Indiana and Pennsylvania in 2007–2008. Field plots measuring 1.5 × 1.5 m (5 × 5 ft) were located in full sun in Kentucky bluegrass (*Poa pratensis* L.) at the W. H. Daniel Turfgrass Research

Center in West Lafayette, IN, or at the Valentine Turfgrass Research Center at University Park, PA. A history of extensive populations of large crabgrass (*Digitaria sanguinalis* L. Scop.) existed at the Indiana location, whereas small crabgrass (*Digitaria ischaemum* Schreb. ex Muhl.) was common in Pennsylvania. Specific site details are listed in Table 1 and soil temperature and precipitation are shown in Fig. 1. All applications were granular formulations of either 0.103% Dimension on a 19-0-6 fertilizer or 0.21% Barricade on 19-0-5 fertilizer (both supplied by Lebanon Seaboard Corporation, Lebanon, PA). Treatments included Dimension at 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) or Barricade 0.72 kg ai·ha⁻¹ (0.65 lb ai·A⁻¹) applied in October, November, March, April, May, or June; Dimension 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) applied in November followed by a sequential application of 0.28 kg ai·ha⁻¹ (0.25 lb ai·A⁻¹) in May; Barricade at 0.72 kg ai·ha⁻¹ (0.65 lb ai·A⁻¹) applied in November followed by a sequential application of 0.28 kg ai·ha⁻¹ (0.25 lb ai·A⁻¹) in May; and Dimension at 0.42 kg·ha⁻¹ (0.38 lb ai·A⁻¹) applied in March, April, May, or June. An untreated check was included for comparison, but fertilizer-only or sprayable formulations standards were not included because of space limitations. Herbicide treatments were applied in Indiana using hand-held shaker jars and in Pennsylvania with a hand-held shaker box

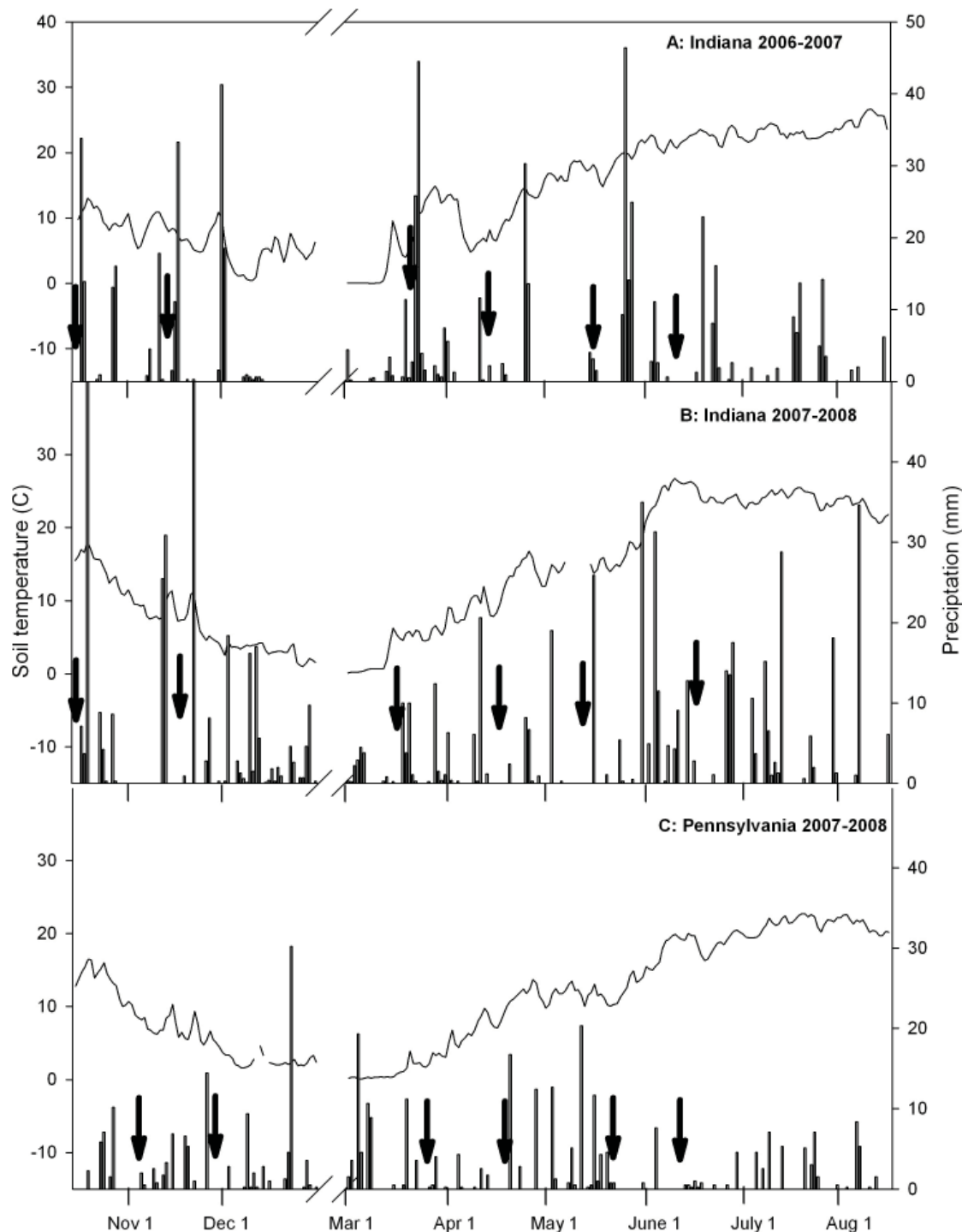


Fig. 1. Precipitation excluding irrigation and average daily soil temperatures at 10 cm under turfed soil for Indiana in 2006–07 (A), Indiana in 2007–08 (B), and Pennsylvania in 2007–08 (C). Arrows indicate application dates.

with mesh dispersion screens. Three replications were used in a randomized complete block design for each of the three trials. Percent cover of crabgrass was visually rated in June, July (Indiana only), and August following application. Cover data could not be combined over the three trials and thus, crabgrass cover data from each trail were analyzed individually with PROC ANOVA (SAS Institute, Version 9.1, Cary, NC) and Fishers protected LSD(0.05) was calculated using the experiment-wise error and used to separate means. For

presentation, percent crabgrass cover from each plot was converted to percent control with the following equation:

Percent control = $[1 - (\% \text{ cover in treated plot} \div \% \text{ cover in check plot})] \times 100$.

Results and Discussion

Dimension/fertilizer combination for season-long crabgrass control. There was no difference due to application

Table 2. Crabgrass control from fall- or spring-applied Dimension/fertilizer combination in Indiana in 2006–07 (IN06-07) and 2007–08 (IN07-08) and Pennsylvania in 2007–08 (PA07-08) when rated in the summer after application.

Herbicide and rate	Timing	July ratings		August ratings		
		IN06-07 ^a	IN07-08	IN06-07	IN07-08	PA07-08
		% control ^b				
Dimension ^c 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	Oct	95a ^{wv}	96a	54c	68b	72ab
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	Nov	96a	91a	69bc	81ab	85ab
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	March	97a	96a	85ab	86ab	90a
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	Apr	97a	96a	89a	82ab	88ab
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	May	96a	100a	75ab	100a	83ab
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	June	76b	21b	10d	12c	68b
Untreated check ^u (% cover)		78	73	98	95	100

^aIN06-07 = herbicides applied in fall 2006 and spring 2007, rated in 2007 in West Lafayette, IN; IN07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in West Lafayette, IN; and PA07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in University Park, PA.

^b% Control = [1 – (% cover in treated plot ÷ mean cover in untreated plots)] × 100.

^cDimension formulation was 0.103% on 19-0-6 fertilizer.

^wMeans are over three replications.

^vMeans in a column followed by the same letter are not significantly different with Fisher's Protected LSD (0.05).

^uCrabgrass cover in the untreated check provided for reference only.

timing with Dimension at 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) by the June rating dates and all timings provided 95% or better control in all three trials (data not shown). By the July rating dates, all 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) Dimension applications provided > 95% control except the November application in Indiana during the 2007–2008 season (IN07-08) at 91% and June applications in Indiana during the 2006–2007 season (IN06-07) and IN07-08 that provided 76 and 21% control, respectively (Table 2). It must be noted that these areas had intentional extremely high crabgrass density with 73 to 78% crabgrass cover in the check plots by July and thus control above 80% would be considered acceptable. The poor performance of the June applications was not expected. Crabgrass was predominantly in the 3- to 5-leaf stage at this application and Dimension is an effective postemergence herbicide in sprayable or granular formulations when applied to crabgrass before tillering (3, 7, 8, 10, 12). However, Taylorson (12) did mention that an emulsifiable concentrate of Dimension was more effective than the granular formulation when applied to crabgrass at the 2- to 4-leaf stage. Crabgrass control decreased from July to August from all applications of Dimension at 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹), but March, April, or May applications provided > 80% control in all experiments. The November timing of Dimension at 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) also provided > 80% control in August in two of the three experiments, which was equivalent to the March, April, or May applications. In addition, the October application at University Park during the 2007–2008 season (PA07-08) provided control equivalent to applications made from March through June. This demonstrates that a single granular application of 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) of Dimension in November or March can provide control equivalent to that expected from typical spring application timings, as was demonstrated in other reports with liquid formulations (4, 9).

Barricade/fertilizer combination for season-long crabgrass control. Fermanian and Haley (6) found rates lower than our 0.72 kg ai·ha⁻¹ (0.65 lb ai·A⁻¹) rate of Barricade to

be effective for season-long crabgrass control when applied in November in Illinois. However, 0.72 kg ai·ha⁻¹ (0.65 lb ai·A⁻¹) of Barricade is significantly lower than the current high label rate and thus was overall less effective than Dimension applied at 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) in this study. Regardless of this, all fall and spring timings provided equivalent control by June in all trials (data not shown). By July ratings, March, April, and May applications provided equivalent control (≥ 76%) in IN06-07 and all applications from October through May provided equivalent control (≥ 88%) in IN07-08 (Table 3). Even at this rate and under high crabgrass pressure, late fall or March applications of a Barricade/fertilizer combination provided control through July that was equivalent to traditional April applications. By the August rating, April applications of Barricade provided the highest control (75%) in IN06-07, whereas November, March, April, or May applications provided similar control in IN07-08 (58 to 82%), and October, November, March, or April applications provided similar control in PA07-08 (40 to 60%) (Table 3). Even though the rate of Barricade may not have been high enough in this study to consistently provide 80% control season-long, November or March applications provided control similar to that expected from the traditional application timing of mid-April in two of the three trials. As expected, the June applications of Barricade provided no control of crabgrass by July and 28% or less control by in August (Table 3).

Single versus sequential applications. Crabgrass control from single November applications of Barricade at 0.72 kg ai·ha⁻¹ (0.65 lb ai·A⁻¹) was improved by a sequential May application of 0.28 kg ai·ha⁻¹ (0.25 lb ai·A⁻¹) when rated in July and August in IN06-07 and when rated in August in PA-07-08 (Table 4). This suggests that if low rates of preemergence herbicides are used in the initial fall timing, a sequential application in late spring would be beneficial. For the turf manager, an application in fall plus a sequential application in late May till increases flexibility by eliminating the April applications when most labor is needed for

Table 3. Effect of fall- or spring-applied Barricade Indiana for 2006–07 (IN06-07) and 2007–08 (IN07-08) and Pennsylvania in 2007–08 (PA07-08) when rated in the summer after application.

Herbicide and rate	Timing	July ratings		August ratings		
		IN06-07 ^z	IN07-08	IN06-07	IN07-08	PA07-08
		% control ^y				
Barricade ^x 0.72 kg ai·ha ⁻¹ (0.65 lb ai·A ⁻¹)	Oct	66b ^{wv}	88a	12c	51b	47ab
Barricade 0.72 kg ai·ha ⁻¹ (0.65 lb ai·A ⁻¹)	Nov	62b	89a	12c	58ab	40abc
Barricade 0.72 kg ai·ha ⁻¹ (0.65 lb ai·A ⁻¹)	March	86a	93a	49b	63b	60a
Barricade 0.72 kg ai·ha ⁻¹ (0.65 lb ai·A ⁻¹)	Apr	93a	93a	75a	82a	55a
Barricade 0.72 kg ai·ha ⁻¹ (0.65 lb ai·A ⁻¹)	May	76ab	92a	14c	72ab	25c
Barricade 0.72 kg ai·ha ⁻¹ (0.65 lb ai·A ⁻¹)	June	–9c	0b	2c	0c	28bc
Untreated check ^u (% cover)		78	73	98	95	100

^zIN06-07 = herbicides applied in fall 2006 and spring 2007, rated in 2007 in West Lafayette, IN; IN07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in West Lafayette, IN; and PA07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in University Park, PA.

^y% Control = [1 – (% cover in treated plot ÷ mean cover in untreated plots)] × 100.

^xBarricade formulation was a 0.21% on 19-0-5 fertilizer.

^wMeans are over three replications.

^vMeans in a column followed by the same letter are not significantly different with Fisher's Protected LSD (0.05).

^uCrabgrass cover in the untreated check provided for reference only.

mowing. The sequential application of Dimension improved crabgrass control over the initial application only on one rating date which was August in IN06-07, suggesting that November application of 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) of Dimension/fertilizer combination may be at a high enough rate to provide adequate season-long control. When using a sequential application of a herbicide/fertilizer combination, the added nitrogen could improve turf vigor and potentially improve crabgrass control. Dernoeden et al. (5) reported that increasing nitrogen rate did not affect crabgrass populations in plots treated with preemergence herbicide, but it did decrease crabgrass populations in non-treated plots.

Rate of Dimension/fertilizer combination applied in the spring. Dimension applied at either 0.42 kg·ha⁻¹ (0.38 lb

ai·A⁻¹) or 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) provided equivalent control regardless of application date in all trials with one exception (Table 5). Only the March application of 0.56 kg ai·ha⁻¹ (0.5 lb ai·A⁻¹) outperformed the March application of 0.42 kg·ha⁻¹ (0.38 lb ai·A⁻¹) when rated in July in IN07-08 and when rated in August in IN07-08 and PA07-08. This again suggests that as one applies preemergence herbicide on a fertilizer carrier early, it is critical to use higher rates for the best season-long control. However, practitioners often use rates as low as 0.20 kg·ha⁻¹ (0.18 lb ai·A⁻¹) per label instructions on Dimension/fertilizer combinations which could decrease consistency of control or the chances for breakthrough (2).

Granular formulations of preemergence herbicide on a fertilizer carrier applied in late fall or early spring can provide

Table 4. Effect of November or November + May applications of Barricade or Dimension on crabgrass control in Indiana in 2006–07 (IN06-07) and 2007–08 (IN07-08) and Pennsylvania in 2007–08 (PA07-08) when rated in the summer after application.

Herbicide and rate	Timing	July ratings		August ratings		
		IN06-07 ^z	IN07-08	IN06-07	IN07-08	PA07-08
		% control ^y				
Barricade ^x 0.72 kg ai·ha ⁻¹ (0.65 lb ai·A ⁻¹)	Nov	62b ^{wv}	89a	12c	58bc	40b
Barricade 0.72 + 0.28 kg ai·ha ⁻¹ (0.65 + 0.25 lb ai·A ⁻¹)	Nov + May	96a	82a	69b	68bc	85a
Dimension ^u 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	Nov	96a	91a	69b	81ab	85a
Dimension 0.56 + 0.28 kg ai·ha ⁻¹ (0.5 + 0.25 lb ai·A ⁻¹)	Nov + May	100a	100a	97a	100a	98a
Untreated check ^l (% cover)		78	73	98	95	100

^zIN06-07 = herbicides applied in fall 2006 and spring 2007, rated in 2007 in West Lafayette, IN; IN07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in West Lafayette, IN; and PA07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in University Park, PA.

^y% Control = [1 – (% cover in treated plot ÷ mean cover in untreated plots)] × 100.

^xBarricade formulation was a 0.21% on 19-0-5 fertilizer.

^wMeans are over three replications.

^vMeans in a column followed by the same letter are not significantly different with Fisher's Protected LSD (0.05).

^uDimension formulation was 0.103% on 19-0-6 fertilizer.

^lCrabgrass cover in the untreated check provided for reference only.

Table 5. Crabgrass control from two rates of Dimension when applied at various spring timings in Indiana for 2006–07 (IN06-07) and 2007–08 (IN07-08) and Pennsylvania in 2007–08 (PA07-08) when rated in the summer after application.

Herbicide and rate	Timing	July ratings		August ratings		
		IN06-07 ^a	IN07-08	IN06-07	IN07-08	PA07-08
		% control ^y				
Dimension ^x 0.42 kg ai·ha ⁻¹ (0.38 lb ai·A ⁻¹)	March	97a ^{wv}	52b	69bc	44b	67c
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	March	97a	96a	85ab	86a	90a
Dimension 0.42 kg ai·ha ⁻¹ (0.38 lb ai·A ⁻¹)	April	96a	87a	75abc	72ab	75abc
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	April	97a	96a	89a	82a	88ab
Dimension 0.42 kg ai·ha ⁻¹ (0.38 lb ai·A ⁻¹)	May	94a	98a	61c	92a	65c
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	May	96a	100a	75abc	100a	83abc
Dimension 0.42 kg ai·ha ⁻¹ (0.38 lb ai·A ⁻¹)	June	62b	43bc	6d	18c	70abc
Dimension 0.56 kg ai·ha ⁻¹ (0.5 lb ai·A ⁻¹)	June	76b	21c	10d	12c	68bc
Untreated check ^u (% cover)		78	73	98	95	100

^aIN06-07 = herbicides applied in fall 2006 and spring 2007, rated in 2007 in West Lafayette, IN; IN07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in West Lafayette, IN; and PA07-08 = herbicides applied in fall 2007 and spring 2008, rated in 2008 in University Park, PA.

^y% Control = [1 – (% cover in treated plot ÷ mean cover in untreated plots)] × 100.

^xDimension formulation was 0.103% on 19-0-6 fertilizer.

^wMeans are over three replications.

^vMeans in a column followed by the same letter are not significantly different with Fisher's Protected LSD (0.05).

^uCrabgrass cover in the untreated check provided for reference only.

season-long control similar to when applied at the traditional timing in mid-April in the Midwest and the Mid-Atlantic regions of the United States. However, it is important to use the high label rate or follow with a sequential application in May if lower rates are used in the fall.

Literature Cited

1. Agnew, M.L. and N.E. Christians. 1989. Influence of application dates on the effectiveness of four preemergence herbicides for crabgrass control. *International Turfgrass Society Research Journal* 6:299–301.
2. Bhowmik, P.C. and S.W. Bingham. 1990. Preemergence activity of dinitroaniline herbicides used for weed control in cool-season turfgrasses. *Weed Technol.* 4:387–393.
3. Bingham, S.W., W.J. Chism, and R.L. Shaver. 1991. Crabgrass control in bluegrass with Dimension. *Proc Northeast Weed Sci. Soc.* 45:115.
4. Dernoeden, P.H. 1993. November applied preemergence herbicides for smooth crabgrass control the following summer. *International Turfgrass Society Research Journal* 7:219–297.
5. Dernoeden, P.H., M.J. Carroll, and J.M. Krouse. 1993. Weed management and tall fescue quality as influenced by mowing, nitrogen, and herbicides. *Crop Sci.* 33:1055–1061.
6. Fermanian, T.W. and J.E. Haley. 1994. Fall applications of Barricade for spring crabgrass (*Digitaria* spp.) control. *Weed Tech.* 8:612–616.
7. Melichar, M., D. Loughner, A. Alexander, R. Smith, and J. Breuninger. 2008. Postemergent application of Dimension for control of crabgrass (*Digitaria* species) in turfgrass. *ASA/CSSA/SSSA Abstracts. Online* <http://a-c-s.confex.com/crops/2008am/webprogram/Paper40139.html>. [40139].
8. Neal, J.C., C.C. Morse, and M.T. Macksel. 1995. Postemergent crabgrass control with granular herbicides. *Proc Northeast Weed Sci. Soc.* 49:75.
9. Reicher, Z.J. and C.S. Throssell. 1993. Efficacy of fall and spring-applied preemergence herbicides for annual grass control in Kentucky bluegrass. *International Turfgrass Society Research Journal* 7:273–276.
10. Riego, D.C., T.E. Dutt, and J.P. Downs. 1993. Performance of fertilizer and clay granular formulations of Dimension in cool season turf. *Proc Northeast Weed Sci. Soc.* 47:96.
11. Rossi, F.W., J.C. Neal, and A.F. Senesac. 1989. Comparison of seasonal preemergent herbicide application timings for crabgrass, *Digitaria* sp., control in cool-season turfgrass. *Abstracts Weed Sci Soc. Am.* 29:34–35.
12. Taylorson, R.B. 1995. Efficacy of Dimension formulations for crabgrass control at several application timings. *Proc Northeast Weed Sci. Soc.* 49:70.