Postemergence Control of Bittercress

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Three experiments were conducted to evaluate the effectiveness of postemergence applied herbicides for controlling bittercress (*Cardamine* sp.) in container-grown crops. 'Big Blue' and 'Variegata' liriope (*Liriope muscari*), China Girl™ holly (*Ilex* China Girl™ holly), and 'Midnight Flare' azalea (*Rhododendron* 'Midnight Flare') were also treated to evaluate herbicide phytotoxicity. When comparing bittercress control in variegated liriope in Experiment 2 and bittercress control at 15 days after treatment (DAT) in Experiment 3, Gallery™ provided excellent postemergence bittercress control (98% to 100%) at the recommended rate [1.1 kg ai ha^{-1} (1.0 lb ai acre^{-1})] with no injury to liriope, holly, or azalea. Manage™ provided good bittercress control (89% to 90%) at [0.03 kg ai ha^{-1} (0.03 lb ai acre^{-1})] but caused slight injury to liriope. Image™ provided good bittercress control (73% to 99.5%) at 0.07 kg ai ha^{-1} (0.062 lb ai acre^{-1}), but caused severe injury to azalea. Trimec Southern™ provided good bittercress control (77% to 100%) at 0.31 kg ai ha^{-1} (0.28 lb ai acre^{-1}), but caused severe injury to liriope and azalea.

INTRODUCTION

Bittercress (*Cardamine* sp.) is a serious weed problem in container nurseries (Ryan, 1977). Though it is considered a winter annual, it has become a season-long problem in nurseries due to the favorable environment provided by daily overhead irrigation. Ryan (1977) demonstrated that an herbicide program consisting of frequent and repeated applications of a preemergence herbicide is necessary for season-long bittercress control. When a proper weed management program is not maintained, bittercress can be one of the most prolific weeds to infest nursery containers (Cross and Skroch, 1992). Infestation can occur just after plants are removed from overwintering, when preemergence applications are made to unweeded containers, when a scheduled herbicide application is postponed or skipped, or towards the end of the season when the chemical barrier from previous applications begins to wear off.

Since preeemergence weed control programs fail to control all weeds, alternatives are needed that provide postemergence control. Research with imidazolinone and sulfonylurea herbicides demonstrated effective postemergence control of nutsedge in container-grown plants, with little to no phytotoxicity on landscape crops (Hurt and Vencill, 1994; Hurt and Vencill, 1994). However, limited herbicide research has evaluated postemergence control of broadleaf weeds in container-grown landscape crops. The objective of this study was to evaluate herbicides for postemergence control of bittercress in container-grown landscape crops.

MATERIALS AND METHODS

Three experiments were conducted to evaluate bittercress control with various rates of herbicides applied postemergence. All treatments were applied with a CO_2 backpack sprayer using an 8004-flat fan nozzle tip, with a pressure of 193 kPa (28 psi) and calibrated to deliver 193 liters ha^{-1} (20 gal acre^{-1}).

Experiment 1. On 25 June 1997, variegated liriope (*Liriope muscari* 'Variegata') liners were selected from Flowerwood Nursery, Loxley Alabama, which also contained uniform populations of bittercress that ranged from 0.5 to 2 cm (0.2 to 0.8 inches) tall. Plants were treated with the following herbicides: Manage™ (halosulfuron) at 0.03, 0.07, 0.15 kg ai ha^{-1}(0.03, 0.06, and 0.13 lb ai $acre^{-1}$) (Monsanto); Image™ (imazaquin) at 0.29, 0.58, 1.2 kg ai ha^{-1} (0.25, 0.5, and 1.0 lb ai $acre^{-1}$) (American Cyanamid); Action (fluthiacet-methyl) at 0.16, 0.31, 0.63 kg ai ha^{-1} (0.14, 0.28, and 0.56 oz ai $acre^{-1}$) (Novartis); and Resource (flumichlorac pentyl ester) at 0.03, 0.07, 0.13 kg ai ha^{-1} (0.03, 0.05, and 0.11 lb ai $acre^{-1}$) (Valent). Manage and Image are postemergence herbicides labeled for broadleaf weed and nutsedge control in established turf grasses. In other studies evaluating postemergence nutsedge control, these products caused no phytotoxicity to liriope (Hurt and Vencill, 1994; Hurt and Vencill, 1994). Action™ and Resource™ are new postemergence herbicides used for broadleaf weed control in corn and soybeans. The low and middle rates of all treatments reflect the lower and upper limits of the manufacturer's recommended rate. All treatments consisted of 10 single plant replicates in a completely randomized design.

Data collected included weed counts at 15 and 50 days after treatment (DAT), top fresh weight (TFW) and top dry weight (TDW) of both bittercress and liriope at 50 DAT. Liriope was evaluated for phytotoxicity, with ratings from 1 to 5 (1 = no damage, 2 = slight damage, 3 = moderate damage, 4 = severe damage, and 5 = dead plant) at 15 DAT.

Experiment 2. Container-grown 'Big Blue' and variegated liriope were over seeded with bittercress on 15 May 1998, and placed in 47% shade. At the time of treatment (15 June), bittercress in the containers with the 'Big Blue' liriope were 4.6 to 5.6 cm (1.8 to 2.2 inches tall) and beginning to flower; while bittercress in the containers with variegated liriope were 2.3 to 3.3 cm (0.9 to 1.3 inches) tall and not flowering. In experiments 2 and 3, there were 10 to 20 bittercress seedlings per pot.

Containers were treated with the following herbicides: Manage™ at 0.02, 0.03, 0.07 kg ai ha^{-1}(0.02, 0.03, and 0.06 lb ai $acre^{-1}$); Image™ at 0.07 0.15, 0.29 kg ai ha^{-1}(0.06, 0.13, and 0.25 lb ai $acre^{-1}$); Trimec Southern™ at 0.16, 0.31, 0.66 kg ai ha^{-1} (0.14, 0.28, and 0.57 lb ai $acre^{-1}$); and Gallery™ (isoxaben) at 0.6, 1.2, and 2.3 kg ai ha^{-1}(0.5, 1.0, and 2.0 lb ai $acre^{-1}$). Rates of Manage™ and Image™ were lowered so that the low and middle rates of the previous test were the same as the middle and high rates of this test. Trimec Southern™ rates were all lower than the manufacturer's recommended rate (PBI/Gordon). Low and middle rates of Gallery™ represent the lower and upper limits of the manufacturer's recommended rate (Dow Elanco). Gallery™ is labeled as a preemergence herbicide for controlling broadleaf weeds in nursery crops and was used in this test based on a suggestion by Albert Van Hoogmoed (Overlook Nursery, Mobile, Alabama) that it provided postemergence bittercress control. This suggestion was supported by earlier research by Schneegurt, et al. (1994) on the postemergence activity of isoxaben. All treatments consisted of 10 single plant replicates in a completely randomized design.

Data collected included percent bittercress control at 7 and 15 DAT, bittercress TFW and TDW at 20 DAT, and a phytotoxicity rating from 1 to 5 on the liriope at 7, 15, 30, and 60 DAT (1 = no injury, 2 = slight injury, 3 = moderate injury, 4 = heavy injury, and 5 = plant death).

Experiment 3. One-gallon containers were filled with a medium consisting of pinebark and sand (7 : 1, v/v) amended with 8.9 kg m^{-3} (15 lb yd^{-3}) of Osmocote 17N-7P-12K , 3.0 kg m^{-3} (5 lb yd^{-3}) of dolomitic limestone, and 0.9 kg m^{-3} (1.5 lb yd^{-3}) of Micromax micronutrients. Containers without plants were overseeded with bittercress

on 15 May 1998. The following herbicides were applied on 10 June 1998 when bittercress plants were between 0.5 to 2 cm (0.2 to 0.8 inches) tall: Manage™ at 0.02, 0.03, and 0.06 kg ai ha^{-1} (0.02, 0.03, and 0.06 lb ai $acre^{-1}$) ; Image™ at 0.07, 0.15, and 0.29 kg ai ha^{-1} (0.06, 0.13, and 0.25 lb ai $acre^{-1}$) ; Trimec Southern™ at 0.16, 0.31, and 0.66 kg ai ha^{-1} (0.14, 0.28, and 0.57 lb ai $acre^{-1}$); and Gallery™ at 0.58, 1.2, and 2.3 kg ai ha^{-1} (0.5, 1.0, and 2.0 lb ai $acre^{-1}$). In addition, six single plant replications of 'Midnight Flare' azalea (*Rhododendron* 'Midnight Flare') and China Girl™ holly (*Ilex* China Girl™ holly) were treated to evaluate injury to azalea and holly.

Data collected included percent bittercress control at 7 and 15 DAT, bittercress TFW and TDW at 20 DAT, and phytotoxicity to holly and azalea at 7, 15, 30, and 60 DAT (1 = no injury, 2 = slight injury, 3 = moderate injury, 4 = severe injury, and 5 = plant death).

Data from all tests were subjected to analysis of variance. Contrast analysis was used to determine if there was a significant difference between the herbicides and the control, and regression analysis was used to determine if there was a rate response within a herbicide.

RESULTS

In Experiment 1 at 15 DAT, all rates of Manage™ and the two lower rates of Image™ resulted in bittercress weed counts lower than the nontreated control. At 50 DAT, all rates of Manage™ and Image™ resulted in 100% bittercress control, while Action™ and Resource™ provided poor control with all rates (data not shown).

However, all Manage™ and Image™ treatments resulted in injury ratings higher than the nontreated controls. Injury was characterized by necrosis and leaf rotting in the plant crown. This caused about 50% reduction in TFW of liriope compared to nontreated controls. Top fresh weight of variegated and 'Big Blue' liriope from Manage™ treatments were 4.6 and 7.8 g, respectively, 3.7 and 7.2 g from Image™ treatments, and 10.1 and 14.6 g for nontreated controls. These data are in contrast to Hurt and Vencill, who reported no visual injury to liriope 4 weeks after treatment from Manage™ and Image™ applications (this test used similar Image™ rates to those used by Hurt and Vencill (1994), however, our Manage™ rates were higher).

In Experiment 2, Manage™ and Image™ rates were lowered to determine if injury could be reduced and bittercress control maintained. At 15 DAT with 'Big Blue' liriope, only the middle and high rates of Gallery™ provided 90% bittercress control or greater, with control increasing linearly and quadratically with increasing rate (Table 1). Bittercress control also increased linearly with Manage™, however, 83% control with the highest rate was considered unacceptable. In the variegated liriope where the bittercress had not begun to flower, bittercress control was generally better. For example, the middle and high rate of Manage™, the high rates of Image™ and Trimec Southern™, and the middle and high rate of Gallery™ all provided 90% control or greater. Control increased linearly with increasing Manage™ rates, and increased linearly and quadratically with increasing rates of Image™ and Gallery™. There was no rate response with the Trimec Southern™ treatments. Improved bittercress control in variegated liriope was likely due to the smaller, nonflowering bittercress, compared to flowering bittercress in 'Big Blue' liriope containers.

At 30 DAT, the highest Image™ rate and all rates of Trimec Southern™ caused statistically significant, though slight, injury to 'Big Blue' liriope. On a rating scale of 1 - 5 where 1 = no injury, the highest Image rate received an injury rating of 1.5,

Table 1. Postemergence bittercress control in container-grown *Liriope muscari* and *Rhododendron* 'Midnight Flare' landscape crops.

Treatments	Rate lb ai acre^{-1}	Experiment 2				Experiment 3			
		Bittercress control (%) 15 DAT		Bittercress TFW^{y}(g)		Bittercress control (%)		'Midnight Flare' injury^{z}	Bittercress TFW^{x} (g)
		'Big Blue'	'Variegata'	'Big Blue'	'Variegata'	7 DAT	15 DAT		
Control		0.0	0.0	16.5	10.3	0.0	0.0	1.0	3.29
Manage™	0.02	14.0	66.0	3.4	1.9	9.0	89.0	1.0	1.68
	0.03	55.0	90.0	2.2	2.3	7.0	89.0	1.0	0.53
	0.06	83.0	99.0	0.7	0.0	48.0	99.0	1.0	0.14
Significance^{w}		L^{*}	L^{*}	NS	NS	Q^{*}	NS	NS	NS
Image™	0.03	3.0	5.0	9.2	5.2	56.0	93.0	2.0	0.24
	0.06	6.0	73.0	7.4	1.1	61.0	99.5	2.2	0.01
	0.13	43.0	95.0	2.3	0.2	82.0	99.8	2.7	0.02
Significance		NS	$L^{***}Q^{***}$	NS	$L^{***}Q^{**}$	NS	NS	L^{*}	NS
Trimec Southern™	0.14	55.0	58.0	3.4	2.1	90.0	100.0	3.2	0.00
	0.28	50.0	77.0	2.1	0.8	100.0	100.0	3.2	0.00
	0.57	72.0	97.0	0.8	0.1	100.0	100.0	4.3	0.00
Significance		NS	NS	NS	NS	L^{*}	NS	NS	NS

Treatments	Rate lb ai acre^{-1}	Experiment 2 Bittercress control (%) 15 DAT 'Big Blue'	Experiment 2 Bittercress control (%) 15 DAT 'Variegata'	Experiment 2 Bittercress TFW^{y}(g) 'Big Blue'	Experiment 2 Bittercress TFW^{y}(g) 'Variegata'	Experiment 3 Bittercress control (%) 7 DAT	Experiment 3 Bittercress control (%) 15 DAT	Experiment 3 'Midnight Flare' injury^{z}	Experiment 3 Bittercress TFW^{x} (g)
Gallery™	0.5	29.0	78.0	5.0	1.6	82.0	94.0	1.0	0.07
	1.0	90.0	98.0	0.8	0.2	85.0	100.0	1.0	0.00
	2.0	98.0	100.0	0.2	0.0	84.0	100.0	1.0	0.80
Significance		$L^{***}Q^{***}$	$L^{***}Q^{**}$	$L^{***}Q^{***}$	$L^{***}Q^{**}$	NS	$L^{*}Q^{*}$	NS	NS

^{z}Scale from 1 to 5 where 1 = no injury, 2 = slightly injury, 3 = moderate injury, 4 = severe injury, 5 = plant death.
^{y}Top fresh weight recorded 15 DAT (July 1, 1998).
^{x}Top fresh weight recorded 20 DAT (June 30, 1998).
^{w}Indicates a linear or quadratic response from the rate applied.
*Significant P $\leq$0.05
**Significant P $\leq$0.01
*** Significant P $\leq$0.001

and the low, medium, and high rates of Trimec Southern™ received a rating of 1.3, 1.3, and 2.0, respectively. Manage™ and Gallery™ caused no injury to liriope at any rate. There was no injury to variegated liriope (data not shown).

In Experiment 3 at 7 DAT, only the three rates of Trimec Southern™ provided 90% bittercress control or greater. However, by 15 DAT, the low and middle rates of Manage™ provided 89% control, and all other treatments provided greater than 90% control. At 15 DAT, only Gallery™ provided a linear and quadratic increase in percent control with increasing rates.

Manage™ and Gallery™ caused no injury to 'Midnight Flare' azalea or China Girl™ holly at any rate throughout the experiment. By 30 DAT, comparison of injury ratings (scale from 1 to 5) from Image™ and Trimec Southern™ with contrast analysis showed that both Trimec Southern™ (3.6) and Image™ (2.0) caused significant injury to azalea when compared to nontreated controls (1.0). Injury from Image™ increased linearly with increasing rate, and was first detected at 15 DAT and was characterized by chlorosis and red spotting of the new foliage. By 30 and 60 DAT, signs of injury were more pronounced and were characterized by stunting and rosetting of new foliage. Injury from Trimec Southern™ was detected at 7 DAT and became progressively worse. It was characterized by twisting of the stems near the apical tip, red coloration of the foliage throughout the plant, early defoliation, and eventual plant death. No injury from any treatment was detected on the China Girl™ holly.

DISCUSSION

Our results show that effective postemergence bittercress control can be obtained with little or no phytotoxicity by using spray applied herbicides. Gallery™ provided excellent bittercress control at the recommended rate with no injury to liriope, azalea, or holly. However, our tests also indicated that postemergence control from Gallery™ could be dependent on the size and growth stage of bittercress. This would agree with reports received from growers that control varies from application to application. Nonetheless, postemergence bittercress control from Gallery™ has great potential due to its broad label for use in container-grown landscape crops.

The other herbicides tested showed promise, but had limitations due to injury. Manage™ at the recommended rate provided good bittercress control with slight injury to liriope, and no injury to azalea and holly. Image™ at low rates (0.03, 0.06, and 0.125 lb ai $acre^{-1}$) controlled bittercress with no injury to liriope and holly, but caused significant injury on azalea. Trimec Southern™ gave excellent control of bittercress, but caused slight injury to liriope and severe injury to azalea.

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