Preemergence Control of Doveweed (*Murdannia nudiflora*) in Container-Grown Nursery Crops[1]

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Abstract

Preemergence herbicides were evaluated for control of doveweed (*Murdannia nudiflora*), a summer annual weed of increasing importance in nurseries of the southeastern United States. In the first experiments, broad-spectrum nursery herbicides OH2 (oxyfluorfen + pendimethalin), Snapshot TG (isoxaben + trifluralin), and BroadStar (flumioxazin) were compared. OH2 and Snapshot provided poor and variable control whereas BroadStar controlled doveweed 82 to 100%. In the second set of experiments, recommended rates of all major active ingredients labeled for use in container nursery crops and landscape plantings were compared for control of doveweed. Doveweed was controlled ≥ 95% by BroadStar, Pennant Magnum (*s*-metolachlor), and Tower (dimethenamid-*p*). Barricade (prodiamine), Dimension (dithiopyr), Gallery (isoxaben), OH2, Pendulum (pendimethalin), Regal O-O (oxyfluorfen + oxadiazon), Ronstar (oxadiazon), Rout (oxyfluorfen + oryzalin), Showcase (trifluralin + isoxaben + oxyfluorfen), Snapshot TG, and Surflan (oryzalin) did not control doveweed.

Index words: preemergence herbicide, *Aneilema nudiflora*, *Commelina nudiflora*, Commelinaceae, container-grown nursery crops, nakedstem dewflower, weed control.

Species used in this study: doveweed [*Murdannia nudiflora* (Linn.) Brenan].

Herbicides used in this study: Barricade (prodiamine), 2,4-dinitro-*N*3,*N*3-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine; BroadStar (flumioxazin), 2-[7-fluoro-3,4-dihydro-3-oxo-4-(2-propynyl)-2*H*-1,4-benzoxazin-6-yl]-4,5,6,7-tetrahydro-1*H*-isoindole-1,3(2*H*)-dione; Dimension (dithiopyr), *S*,*S*-dimethyl-2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3,5-pyridinedicarbothioate; Gallery (isoxaben), *N*-[3-(1-ethyl-1-methylpropyl)-5-isoxazolyl]-2,6-dimethoxybenzamide; OH2 (oxyfluorfen), 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene, plus (pendimethalin), *N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine; Pendulum (pendimethalin); Pennant Magnum (*s*-metolachlor), 2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide; Regal O-O (oxyfluorfen) plus (oxadiazon), 3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one; Ronstar (oxadiazon); Rout (oxyfluorfen) plus (oryzalin), 4-(dipropylamino)-3,5-nitrobenzenesulfonamide; Showcase (trifluralin), 2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine, plus (isoxaben) plus (oxyfluorfen); Snapshot TG (isoxaben) plus (trifluralin); Surflan (oryzalin); Tower (dimethenamid-*p*), 2-chloro-*N*-[(1-methyl-2-methoxy)ethyl]-*N*-(2,4-dimethyl-thien-3-yl)-acetamide.

Significance to the Nursery Industry

Doveweed is a summer annual weed that is difficult to control and increasing in importance in nurseries, landscapes, and glyphosate-resistant crops in the southeastern United States. Most herbicides labeled for the nursery and landscape trades, including glyphosate, do not control doveweed. Of the preemergence herbicides tested and currently labeled for use in nursery crops, only BroadStar, Pennant Magnum and Tower controlled doveweed. However, to minimize the risk of crop plant injury, follow all label precautions and avoid treating tender new growth or sensitive species when applying these herbicides.

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Introduction

Doveweed is a summer annual weed in the dayflower family, Commelinaceae, which includes other problem weeds such as tropical spiderwort (*Commelina benghalensis*), Asiatic dayflower (*Commelina communis*), spreading dayflower (*Commelina diffusa*), and marsh dayflower (*Murdannia keisak*) (13, 19). Doveweed is native to India (10), occurs in at least 16 crops in 23 countries (19), and has been considered the third worst weed of the Commelinaceae worldwide (6). Doveweed has become a common weed in southeastern United States nursery crops (13), cotton (*Gossypium hirsutum*), soybean (*Glycine max*) (20), and turf (7, 17, 20). The range of distribution in the United States includes the southeastern states from Texas to North Carolina as well as Hawaii (4). It is common in wet areas such as drainage ditches and low areas with standing water but will also grow in cultivated lands where doveweed forms dense mats that compete with crops and is difficult to remove (6, 13, 19).

Doveweed is a difficult weed to control, as are other members of the Commelinaceae (13, 19). Glyphosate does not control doveweed (20). In agricultural crops where adoption of glyphosate-resistant technology has increased, glyphosate has become the primary means of controlling weed populations, resulting in the decline in both cultivation practices and use of herbicides with soil residual activity. Consequently, in such cropping systems populations of doveweed and related species have increased (5, 18, 20).

There has been limited research on control of Commelinaceae weeds in nursery crops and prior to the initiation of

this research there were no published reports on preemergence control of doveweed in nursery crops. In 2005, Stamps and Chandler (16) reported doveweed control with BroadStar (flumioxazin) and Rout (oxyfluorfen + oryzalin) in nursery crops. However, other herbicides containing oxyfluorfen, such as OH2 (oxyfluorfen + pendimethalin) and Regal O-O (oxyfluorfen + oxadiazon), did not control doveweed, suggesting the oryzalin component of Rout was responsible for the observed control (16).

Control of other Commelinaceae species has been studied in greater detail. In cotton, postemergence control of tropical spiderwort was improved when *s*-metolachlor or flumioxazin were added to glyphosate treatments (5). In production of leatherleaf fern (*Rumohra adiantiformis*), prodiamine reduced spreading dayflower coverage with increasing application rates (15). Kuhns and Harpster (8) reported in 2002 that the preemergence herbicides simazine, oryzalin, oxyfluorfen, oxadiazon, flumioxazin, azafenidin and sulfometuron-methyl controlled Asiatic dayflower ≤ 59% in Douglas fir (*Pseudotsuga menzesii*) production. In that study, flumioxazin provided the best control at 59%. In a separate study by the same authors, Asiatic dayflower was controlled by flumioxazin, dithiopyr, and by a combination of simazine plus metolachlor plus oxyfluorfen (9). Based on previous research, simazine and oxyfluorfen provided no control of Asiatic dayflower; therefore, the control observed from the combination treatment was attributed to metolachlor. In Fraser fir (*Abies fraseri*) production, Asiatic dayflower was controlled ≥ 95% with *s*-metolachlor + oxyfluorfen, ≥ 92% with flumioxazin, and 100% with azafeniden; whereas, oxyfluorfen, oxadiazon, lactofen, simazine plus napropamide, and sulfometuron-methyl were ineffective (1). Similarly, Mervosh and Ahrens (11) reported excellent control of Asiatic dayflower in balsam fir (*Abies balsamea*) with flumioxazin and azafeniden, good control with oxyfluorfen plus *s*-metolachlor that declined throughout the growing season, some control with *s*-metolachlor alone or in combination with simazine, and poor control with isoxaben. However, azafenidin has not been approved by the U.S. Environmental Protection Agency and is not commercially available.

Based on the aforementioned reports with other members of the Commelinaceae and on limited reports with doveweed, herbicide efficacy on this species warrants further investigation. Therefore, the objective of this research was to evaluate the efficacy of nursery and landscape herbicides for preemergence control of doveweed.

Materials and Methods

General procedures. Experiments were conducted in North Carolina and Virginia. In North Carolina, nursery trade #2 pots [7 liter (2 gal)] were filled with a pine bark plus sand (7:1 v/v) substrate which was amended with 4.7 kg·m^{-3} (8 lb·yd^{-3}) 15N-0.9P–4.2K (15-4-10) controlled release fertilizer with micronutrients, 10 to 12 month release formulation (Harrell's Inc., Lakeland, FL). Pots were overhead irrigated with about 0.33 in (0.8 cm) water then each pot was surface-seeded with 30 to 40 doveweed seeds. In Virginia, nursery trade #1 [3.8 liter (1 gal)] were filled with pine bark then top dressed with 15 ml of 15N-3.3P-3.3K (15-11-8) plus micronutrients (Osmocote, The Scotts Co., Marysville, OH). Pots were seeded with 30 to 40 doveweed seeds per pot and seeds were lightly mixed into the surface of the substrate. Doveweed seeds were locally collected one year prior by each investigator. North Carolina seeds were collected from plants growing in an irrigated gravel area at the Horticultural Crops Research Station, Castle Hayne, NC. In Virginia, doveweed plants were grown in containers for seed collection. Seeds were cleaned then stored at approximately 4C until use.

Preemergence herbicides used in these experiments were either labeled for use in container nurseries or under development for such uses. See Table 1 for a list of the herbicides, formulations and application rates used in these experiments. Granular herbicides were applied with a handheld shaker and liquid formulations were applied with a CO_2-pressurized backpack sprayer equipped with flat-fan nozzles and calibrated to deliver 280 liters·ha^{-1} (30 GPA) in North Carolina and 234 liters·ha^{-1} (25 GPA) in Virginia at 207 to 276 kPa (30 to 40 psi). All pots were irrigated following treatment and continued to receive approximately 1.5 cm (0.6 in) of overhead irrigation daily.

Each experiment was arranged in a randomized complete block design with four replications. Treatment plots within replications included three pots per treatment. Visual ratings were based on percent control of weed growth compared to the nontreated, where 0 = no control and 100 = 100% reduction in above-ground biomass. The total number of doveweed plants per plot was recorded. Data were subject to analysis of variance using Tukey's studentized range test (SAS Institute, Inc., Cary, NC) to evaluate location/year and treatment effects, and interactions. For each experiment, there was an observed treatment effect, location/year effect, and an interaction between treatment and location/year. Therefore, data for each location/year were analyzed separately. Data were subjected to analysis of variance and pairwise comparisons using Fisher's protected LSD test ($P \leq 0.05$) with and without the nontreated data. There were no differences between comparisons made with and without the nontreated data. Results from the nontreated plots were only included in the analysis and presentation of data from weed counts.

Broad-spectrum herbicide efficacy. Three tests were conducted to compare the efficacy of labeled rates of BroadStar 0.25G, OH2 3G, and Snapshot TG 2.5G (isoxaben + trifluralin). Experiments were conducted at the Hampton Roads Agricultural Research and Extension Center, Virginia Beach, VA, in 2005, at the Horticultural Crops Research Station, Castle Hayne, NC, in 2006, and at the North Carolina State University Horticultural Field Laboratory, Raleigh, NC, in 2007. Recommended labeled rates for herbicides used for this study were 0.42 kg ai·ha^{-1} (0.38 lb ai·A^{-1}) BroadStar, 3.3 kg ai·ha^{-1} (3 lb ai·A^{-1}) OH2, and 5.6 kg ai·ha^{-1} (5 lb ai·A^{-1}) Snapshot TG. In Virginia, pots were seeded and treated May 31, 2005. Percent weed control was visually evaluated, compared to the non-treated plots, 5 weeks after treatment (WAT). In Castle Hayne, pots were seeded April 19, 2006, and treated April 20, 2006. In Raleigh, NC, pots were treated June 22, 2007, and seeded June 27, 2007. In NC experiments, percent weed control was recorded approximately every two weeks between 4 and 10 WAT.

Labeled product comparison. Based on the large differences observed among herbicides from the broad-spectrum herbicide trials and because the only effective herbicide from these initial trials, BroadStar, was not at the time labeled in any formulation for use in landscapes or for over the top

Table 1. Preemergence herbicides, formulations and application rates included in the 2006 and 2007 experiments.

Herbicide	Active ingredient	Formulation[z]	Rate (kg ai·ha^{-1})	Rate (lb ai·A^{-1})	Year[y] 2006	Year[y] 2007
BroadStar[x]	flumioxazin	0.25 GR	0.42	0.38	X	X
Pennant Magnum	*s*-metolachlor	7.62 EC	2.8	2.5	X	X
Tower	dimethenamid-*p*	6 EC	1.68	1.5	X	X
Barricade	prodiamine	65 DF	0.84	0.75		X
			1.68	1.5	X	X
Dimension	dithiopyr	2 EW	0.56	0.5		X
Gallery	isoxaben	75 DF	1.12	1	X	X
OH2	oxyfluorfen + pendimethalin	3 GR	3.36	3	X	X
Pendulum	pendimethalin	2 GR or 60DG	2.24	2		X
			4.48	4	X	X
Regal O-O	oxyfluorfen + oxadiazon	3 GR	3.36	3	X	X
Ronstar	oxadiazon	2 GR	2.24	2	X	X
			4.48	4	X	X
Rout	oxyfluorfen + oryzalin	3 GR	3.36	3	X	X
Showcase	trifluralin + isoxaben + oxyfluorfen	2.5 GR	5.6	5	X	X
Snapshot TG	isoxaben + trifluralin	2.5 GR	2.8	2.5	X	X
			5.6	5	X	X
Surflan	oryzalin	4 AS or 85DF	2.24	2		X
			4.48	4	X	X
Number of experiments					1	2

[z]DG = water dispersible granule; DF = dry flowable, EC = emulsifiable concentrate, EW = emulsion, oil in water, GR = granule, AS = aqueous suspension. The formulation of Pendulum used in VA in 2006 was the 60DG; all other experiments used the 2G formulation. Surflan 4AS was used in the NC experiments whereas the 85DF formulation used in Virginia.

[y]Treatments marked with an 'X' were included in that year's experiment.

[x]The BroadStar formulation used in these studies was the original marketed form, designated as VC1453.

of herbaceous crops (2), the herbicide list was expanded to evaluate most herbicides labeled for use in nursery and landscape weed management. Herbicides, formulations and rates used in these studies are presented in Table 1. Herbicides included were: Barricade (prodiamine), BroadStar, Dimension (dithiopyr), Gallery (isoxaben), OH2, Pendulum (pendimethalin), Pennant Magnum (*s*-metolachlor), Regal O-O, Ronstar (oxadiazon), Rout, Showcase (oxyfluorfen + isoxaben + trifluralin), Snapshot TG, Surflan (oryzalin), and Tower (dimethenamid-*p*), which has been recently labeled for use in nurseries and landscapes (3). In the 2006 study, conducted in Virginia, herbicides were applied at the maximum manufacturer's recommended rates. In 2007 the treatment list was expanded to include low and high labeled rates of several herbicides and conducted in both North Carolina and Virginia. In 2006, pots were seeded and treated June 30th. Number of emerged doveweed plants was recorded 3 WAT and percent control was recorded 4 WAT. Because results from this study suggested significant differences in longevity of doveweed control between herbicides, the treatment to evaluation interval was extended in subsequent NC tests to 7 and 9 WAT, more typical of a nursery herbicide re-application interval. In 2007 in Virginia, pots were seeded and treated May 10th, and number of emerged seedlings was recorded 10 WAT. In Raleigh, pots were seeded May 31, 2007, and treated June 1 and 2, 2007. Percent control was recorded 7 and 9 WAT and number of emerged seedlings was recorded 9 WAT.

Results and Discussion

Broad-spectrum herbicide efficacy. In Virginia, doveweed was controlled ≥ 82% by BroadStar, whereas OH2 and Snapshot TG provided significantly less control (Table

Table 2. Preemergence control of doveweed with BroadStar, OH2, and Snapshot TG.

Herbicide[y]	Rate (kg ai·ha^{-1})	Rate (lb ai·A^{-1})	VA 2005[z] 5 WAT[x]	NC 2006 4 WAT	NC 2006 8 WAT	NC 2007 4 WAT	NC 2007 10 WAT
BroadStar	0.42	0.38	82a[w]	99a	95a	100a	95a
OH2	3.36	3	5b	55b	33b	35b	3b
Snapshot TG	5.6	5	10b	45b	13c	15b	0b

[z]VA 2005, NC 2006, NC 2007 designate locations, Virgina (VA) or North Carolina (NC), and year.

[y]Herbicide formulations used: BroadStar 0.25G (flumioxazin), OH2 3G (oxyfluorfen + pendimethalin), and Snapshot TG 2.5G (isoxaben + trifluralin).

[x]WAT = weeks after treatment

[w]Doveweed control was visually estimated on a percent scale where 0% = no control and 100% = total control. Evaluations are expressed as percent control relative to the non-treated plants; therefore, non-treated data were not included in the analysis. Means within columns followed by the same letter are not significantly different at P ≤ 0.05 using a Fisher's protected LSD test.

Table 3. Preemergence herbicide efficacy on doveweed — Virginia, 2006.

Treatment	Rate (kg ai·ha^{-1})	Rate (lb ai·A^{-1})	% Control[z] 4 WAT[x]	Weed count[y] 3 WAT
BroadStar	0.42	0.38	95a[w]	2h
Pennant Magnum	2.8	2.5	100a	0h
Tower	1.68	1.5	95a	1h
Barricade	1.68	1.5	12gh	45ab
Gallery	1.12	1	20efgh	45ab
OH2	3.36	3	35bcdef	21fg
Pendulum	4.48	4	22defgh	35bcd
Regal O-O	3.36	3	38bcde	32de
Ronstar	2.24	2	30cdefg	33cde
	4.48	4	40bcd	22efg
Rout	3.36	3	45bc	20g
Showcase	5.6	5	18fgh	44abc
Snapshot TG	2.8	2.5	5h	55a
	5.6	5	15gh	32def
Surflan	4.48	4	52b	18g
Nontreated	—	—	—	40bcd

[z]Percent control where 0% = no control and 100% = total control. Visual ratings were relative to the non-treated pots; therefore, data for the non-treated were omitted from these analyses.

[y]Average number of doveweed seedlings per experimental unit (three pots per treatment per replicate).

[x]Weeks after treatment (WAT)

[w]Means within columns followed by the same letter are not significantly different at $P \leq 0.05$ using a Fisher's protected LSD test.

2). Similarly, in North Carolina experiments doveweed control with Broadstar was 95 to 100%; control with OH2 and Snapshot was 3 to 55% and 0 to 45%, respectively. These data clearly demonstrated wide variation in doveweed susceptibility to preemergence herbicides labeled for container nursery crops.

Labeled product comparison. In the expanded 2006 and 2007 experiments, poor and variable control was observed for all treatments except BroadStar, Pennant Magnum, and Tower, which provided consistent preemergence control of doveweed (Tables 3 and 4). In VA in 2006, doveweed was controlled 95, 100, and 95% with BroadStar, Pennant Mag-

Table 4. Preemergence herbicide efficacy on doveweed — Virginia and North Carolina, 2007.

Treatment	Rate (kg ai·ha^{-1})	Rate (lb ai·A^{-1})	% Control[z] NC 7 WAT[x]	% Control[z] NC 9 WAT	Weed counts[y] NC 9 WAT	Weed counts[y] VA 10 WAT
BroadStar	0.42	0.38	98a[w]	96a	1f	18de
Pennant Magnum	2.8	2.5	100a	100a	0f	10e
Tower	1.68	1.5	100a	100a	0f	9e
Barricade	0.84	0.75	15efg	28de	15abc	25abcd
	1.68	1.5	68bc	68b	2ef	31abc
Dimension	0.56	0.5	10fg	8ef	14abcd	26abcd
Gallery	1.12	1	12efg	8ef	18ab	28abcd
OH2	3.36	3	28def	18ef	13abcd	20cde
Pendulum	2.24	2	12efg	5f	14abcd	33ab
	4.48	4	45cd	42cd	8de	18de
Regal O-O	3.36	3	35de	18ef	12bcd	33ab
Ronstar	2.24	2	20efg	18ef	10cd	23abcd
	4.48	4	60bc	55bc	4ef	36a
Rout	3.36	3	28def	28de	11cd	25abcd
Showcase	5.6	5	0g	0f	18a	21bcde
Snapshot TG	2.8	2.5	5fg	0f	19a	33abc
	5.6	5	18efg	8ef	14abcd	28abcd
Surflan	2.24	2	20efg	12ef	12bcd	27abcd
	4.48	4	70b	50bc	3ef	28abcd
Nontreated	—	—	—	—	14abcd	30abcd

[z]Visual ratings were based on percent control where 0% = no control and 100% = total control. Visual ratings were relative to the non-treated pots; therefore, data for the non-treated were omitted from these analyses.

[y]Average number of doveweed seedlings per experimental unit (three pots per treatment per replicate).

[x]Weeks after treatment (WAT).

[w]Means within columns followed by the same letter are not significantly different at $P \leq 0.05$ using a Fisher's protected LSD test.

num, and Tower, respectively, 4 WAT (Table 3). Number of plants per plot in Virginia Beach 3 WAT for BroadStar, Pennant Magnum, and Tower was 2, 0, and 1, respectively, compared to 40 per plot in the nontreated. At 10 WAT in the 2007 VA study, weed counts for BroadStar, Pennant Magnum, and Tower were 18, 10, and 9, respectively, compared to 30 plants per plot in the non-treated (Table 4).

Doveweed control with these treatments was similar in the NC experiment. In the 2007 NC experiment, doveweed control 9 WAT was 96%, 100%, and 100% with BroadStar, Pennant Magnum, and Tower, respectively (Table 4). Plant counts 9 WAT in NC demonstrated essentially complete control with these three herbicides.

Control of less than 45% for doveweed was observed with Regal O-O, Dimension, Gallery, and Rout. Of the remaining herbicides, there was greater control with increasing rates for Barricade, Pendulum, Ronstar, Snapshot TG, and Surflan, though these responses were variable between studies. For example, in the NC test, doveweed populations were reduced with increased rate of Barricade but not in the Virginia experiment. Similar trends were observed with the high rates of Pendulum, Ronstar, and Surflan. It should be noted that although doveweed populations were reduced, the growth and development of surviving plants was generally not inhibited. For this reason, visual control ratings in the NC experiment reflect a lower level of control than the plant count data may imply (Table 4).

BroadStar, Pennant Magnum, and Tower provided excellent control of doveweed. These results are consistent with previous reports for flumioxazin, metolachlor, and *s*-metolachlor for control of doveweed, tropical spiderwort and Asiatic dayflower in other cropping systems (1, 5, 9, 11, 16). In contrast to previous research (16), doveweed was not controlled by Rout. However, Stamps and Chandler reported similarly poor control of doveweed with OH2 and Regal O-O (16). Previous research reported control of dayflower with dithiopyr and prodiamine (9, 15); however, these herbicides did not control doveweed in this experiment. These results suggest doveweed may be less susceptible than dayflower to several preemergence herbicides and control may differ between container nurseries and field sites.

Data reported herein demonstrate the only preemergence herbicides labeled for nurseries and/or landscapes to provide consistent control of doveweed are BroadStar, Pennant Magnum, and Tower. However, each of these herbicides has been reported to cause some crop injury. Tender herbaceous perennials, tropical shrubs, and annual bedding plants are sensitive to damage from BroadStar (2). Pennant Magnum (14) and Tower (J.C. Neal, unpublished data) can damage tender new foliage and cause stunting in certain ornamentals during active growth, though injury may be temporary in many species. A granular herbicide containing dimethenamid-*p*, the active ingredient in Tower, has recently been labeled for use in nursery crops and landscapes under the trade name Freehand and may provide doveweed control with reduced potential for crop injury compared to Tower (12). When using these herbicides for control of doveweed, follow all label precautions to avoid crop damage.

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