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IRRIGATION INTERVAL AND HERBICIDE REDUCES DOLLARWEED (HYDROCOTYLE UMBELLATA) IN ST. AUGUSTINEGRASS (STENOTAPHRUM SECUNDATUM) TURF

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ABSTRACT

Dollarweed canopy cover is reduced in lawns of St. Augustinegrass by reducing irrigation frequency, but without herbicides cultural management does not provide acceptable weed reduction. Field studies were performed to assess the interaction of irrigation interval and postemergence broadleaf herbicides to reduce dollarweed in St. Augustinegrass turf, and to determine optimum combinations of irrigation interval and herbicide. Under daily irrigation, among atrazine (2-chloro-4-(ethylamine)-6- -s-triazine) at 2.24 kg ai ha^{-1}, Metsulfuron (Methyl 2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]amino]sulfonyl]benzoate) at 0.021 kg ai ha^{-1}, sulfosulfuron at 0.066 kg ai ha^{-1}, and their combinations, the most extended reduction was obtained from atrazine mixed with either metsulfuron or sulfosulfuron, (N-[[(4,6-dimeth-oxy-2-pyrimidinyl)amino]carbonyl]-2-(ehtylsulfonyl)imidazo{1,2-a]pyridine-3-sulfonamide) but dollarweed reduction was >85% only through 8 wk after initial treatment. Under delayed irrigation (2, 4, or 6-day irrigation interval) there were herbicide X irrigation interval interactions, and there was >85% reduction of dollarweed from some combinations of irrigation interval and herbicide. The most effective combinations were 6-d irrigation interval following sulfosulfuron application, and 4-d or 6-d irrigation interval following application of atrazine + sulfosulfuron.

Abbreviations: WAIT, wk after initial treatment; WAT, wk after treatment.; DAT, d after treatment.

Keywords: Cultural management, integrated pest management; lawns; optimum weed control.

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INTRODUCTION

Turfgrass cultural practices (mowing, irrigation, fertilization, cultivation, planting, and turfgrass selection) are infrequently reported as methods of weed reduction (Busey, 2003). There are few examples showing interaction of cultural management and herbicides. Smooth crabgrass [*Digitaria ischaemum* (Schreber) Schreber ex Muhlenb.] reduction with preemergence herbicides is appropriate when tall fescue (*Festuca arundinacea* Schreb.) is mowed at 3.2 or 5.5 cm, but when mowed at 8.8 cm crabgrass populations are low and do not need herbicide treatment (Dernoeden et al., 1993). Reduction of soil pH using elemental sulfur is comparable to the only effective herbicide, oxadiazon, in suppressing dandelion (*Taraxacum officinale* G. H. Weber ex Wiggers) in bermudagrass (*Cynodon* sp.) turf (Johnson and Burns, 1985). Tall mowing height (7 cm) in turf, predominantly Kentucky bluegrass (*Poa pratensis* L.) allows the fungal bioherbicide *Sclerotinia minor* Jagger to reduce dandelion for 6 wk, but close mowing height (3-5 cm) allows dandelion seedling recruitment due to lack of residual bioherbicide activity (Abu-Dieyeh and Watson, 2006).

St. Augustinegrass is the most widely used lawn species in Florida and dollarweed is a prevalent and serious broadleaf weed in St. Augustinegrass lawns. Atrazine has been the main postemergence broadleaf herbicide used in St. Augustinegrass turf in Florida since the late 1950s (White and Busey, 1987). Precautions to protect drinking water caused the U.S. Environmental Protection Agency in 2003 to reduce the allowable rate of atrazine applied as a liquid to 1.12 kg ai ha^{-1} in residential lawns, although higher rates are allowed in sod. Metsulfuron was used exclusively by the Scotts Miracle-Gro Company (Marysville, OH 43041, USA) in the early 1990s for postemergence broadleaf weed reduction as custom applications in St. Augustinegrass lawns in the U.S. (Erica Santella, The TruGreen Companies, personal communication). After being removed from the U.S. residential turf market in 1994, metsulfuron was reintroduced under different labeled brands in 2000. Sulfosulfuron was introduced in 2005 for broadleaf weed reduction in St. Augustinegrass.

As an alternative to herbicides, dollarweed populations are reduced in St. Augustinegrass turf by delaying irrigation, while populations of other weeds are reduced by reduced mowing height and increased fertilization rate (Busey and Johnston, 2006). Nevertheless, based on that 3-yr study, with no herbicides, no combination of cultural practices provides acceptable weed reduction in St. Augustinegrass. The objectives of this study were to assess the interaction of irrigation interval and postemergence broadleaf herbicide to reduce dollarweed in St. Augustinegrass, and to determine optimum combinations of irrigation interval and herbicide.

MATERIALS AND METHODS

Field experiments were conducted at the University of Florida Fort Lauderdale Research and Education Center in Davie, Broward County. Soil was Margate fine sand (hyperthermic, Mollic Psammaquent), 94% sand with pH 7.3, 13 mg P kg^{-1}, 41 mg K kg^{-1}, and 5.5% wt/vol organic matter. A full-sun field area was planted May 1999 with dollarweed rhizomes and interplanted January 2000 with plugs of 'Floratam' St. Augustinegrass. Dollarweed and St. Augustinegrass were grown together and managed to encourage the growth of both species. Following 3 yr of irrigation treatments from 2001 to 2003, the field area received daily irrigation from 2004 through 2005 to reestablish a uniform mixed population of dollarweed and St. Augustinegrass.

Daily Irrigation and Herbicides.

The experimental design was completely randomized, with plots 2.1 by 3.7 m, in four replications. Initially on March 3, 2006 atrazine at 2.24 kg ai ha^{-1} (Atrazine 4L Flowable Herbicide, SipCam Agro USA, Inc., 300 Colonial Center Parkway, Suite 230, Roswell, GA 30076), metsulfuron at 0.021 kg ai ha^{-1} (Manor Selective Herbicide, Nufarm Americas Inc., Burr Ridge, IL 60527-0866), and sulfosulfuron at 0.066 kg ai ha^{-1} (Certainty Turf Herbicide, Monsanto Company, St. Louis, MO 63167) were applied individually and in the three possible tank mix combinations. Atrazine, metsulfuron, and sulfosulfuron, were also applied individually with each of the other two herbicides applied again as “followed by” treatments to the same plots on March 17, 2006. Thus there were three unitary herbicide treatments, three binary tank mixtures, and six possible combinations of "followed by" treatments, and a nontreated check.

Herbicides were applied with a CO_2-pressurized backpack sprayer (Weed Systems, Inc., 154 Orange Lane Hawthorne, FL 32640) equipped with flat fan spray tip nozzles (TeeJet 11015, Spraying Systems Co., P. O. Box 7900, Wheaton, IL 60189-7900) with an underleaf banding spray tip nozzle on the outside of the boom to provide sharp definition of the borders of treated plots, and a 0.30-m nontreated strip between adjacent plots, at 814 L/ha spray volume. There was no rain, irrigation, or mowing during 48 h after treatment. Irrigation was resumed each night with 9 mm water to approximately replace the maximum St. Augustinegrass evapotranspiration reported for the area by Stewart and Mills (1967), and mowing was performed at 89 mm height once per wk, using a rotary mower. Dollarweed reduction was evaluated visually on multiple dates each wk through 70 DAT and was based on percent dollarweed canopy dead, 0 to 100%. Plots were simultaneously observed to visually evaluate St. Augustinegrass phytotoxicity but there was never an observable effect. Data were pooled by averaging as subplots in time, in intervals of 2 wk, and analyzed by ANOVA using SAS (SAS for Windows version 9.1, SAS Institute, Inc., 100 SAS Campus Drive, Cary, NC 27513-2414.).

Delayed Irrigation, Fertilization, and Herbicides.

The experimental design was randomized complete block, with separately zoned irrigation interval treatments in main plots 8.1 m X 8.1 m, in three replications. Irrigation intervals initiated April 20, 2006 were irrigated every 2, 4, and 6 d. Precipitation rate was 14.6 mm h^{-1} and irrigation coefficient of uniformity (Christiansen, 1942) was 83%. Irrigation main plots were subdivided into split plots, unfertilized vs. fertilized with 14.9 g N m^{-2} which was three times the amount recommended per application. The fertilizer source had a nutrient ratio of 26 N:2 P:13 K. Fertilization split plots were subdivided into three herbicide treatment split-split plots. Atrazine at 2.24 kg ai ha^{-1}, sulfosulfuron at 0.066 kg ai ha^{-1}, and a nontreated check, were split-split plot treatments. Plots were evaluated visually to estimate dollarweed reduction on multiple dates each wk through 67 DAT, and surviving dollarweed canopy cover was estimated visually at 12 WAT. Plots were simultaneously observed to visually evaluate St. Augustinegrass

Table 1. Dollarweed reduction by herbicides 2 to 10 wk after initial treatment (WAIT) under daily irrigation. Rates were atrazine at 2.24 kg/ha, metsulfuron at 0.021 kg/ha, and sulfosulfuron at 0.66 kg/ha. For herbicides followed by ("fb") a second herbicide, the second herbicide was applied 14 d after the first herbicide.

Herbicide treatment			Dollarweed reduction†								
			2 WAIT		4 WAIT		6 WAIT		8 WAIT		10 WAIT
			(%)								
Atrazine			18.1	c	68.7	c	81.5	bc	65.8	b	75
Metsulfuron			7.8	d	48.8	e	67.6	e	66.3	b	77.7
Sulfosulfuron			26.9	a	88.9	a	90.2	ab	74.5	ab	65.6
Atrazine	+	metsulfuron	28.8	a	93.0	a	96.7	a	85.8	ab	72.1
Atrazine	+	sulfosulfuron	24.2	ab	89.9	a	94.9	a	86.8	ab	66.7
Metsulfuron	+	sulfosulfuron	6.9	d	49.1	e	75.1	cde	80.0	ab	68.3
Atrazine	fb	metsulfuron	20.5	bc	77.5	b	96.7	a	87.8	ab	73.8
Metsulfuron	fb	atrazine	7.3	d	58.7	d	91.5	a	74.5	ab	68.1
Atrazine	fb	sulfosulfuron	18.7	c	76.5	b	96.9	a	97.0	a	86.9
Sulfosulfuron	fb	atrazine	4.4	de	50.3	e	95.1	a	69.3	b	52.5
Metsulfuron	fb	sulfosulfuron	5.6	d	51.1	e	77.2	cd	90.5	ab	90.4
Sulfosulfuron	fb	metsulfuron	3.6	de	40.6	f	72.5	de	79.8	ab	84.6
Nontreated check			0.0	e	9.1	g	15.3	f	25.5	d	37.9
Source of variation		**df**	**Mean squares‡**								
Herbicides		12	387.4	***	2273.8	***	1983.4	***	1276.2	***	850.8
Error		39	14.2		28.9		46.8		288.4		516.2

† Means in columns with a letter in common are not different by the prior-*F* LSD test (P=0.05).
‡ *** Mean square significant at $P < 0.001$.

phytotoxicity but there was never an observable effect. Data were pooled in 2-wk intervals and analyzed by ANOVA. The main plot treatment (irrigation) and split (fertilization) and split-split (herbicide) effects were analyzed as a split-split-plot experiment according to the design of Little and Hills (1972). Means were separated according to Fisher's Protected LSD, P = 0.05 (Littell et al. 1996) using the corresponding error mean squares.

Delayed Irrigation and Herbicides.

In a 2007 experiment the experimental design was randomized complete block, again with separately zoned irrigation interval main plots 8.1 m X 8.1 m, in four replications. Irrigation intervals initiated February 21, 2007 were irrigated every 2, 4, and 6 d. Irrigation main plots were each subdivided into four splits assigned randomly to herbicide split-plot treatments of atrazine at 2.24 kg ai ha^{-1}, sulfosulfuron at 0.066 kg ai ha^{-1}, atrazine + sulfosulfuron mixture, and a nontreated check. Plots were evaluated visually to estimate dollarweed reduction through 84 DAT, and surviving dollarweed canopy cover was estimated visually 14 WAT. In this and the next experiment there was no observed phytotoxicity to St. Augustinegrass. Data were pooled within 2-wk intervals and analyzed by ANOVA.

In a 2008 experiment the experimental design was randomized complete block with four replications. Irrigation intervals were initiated beginning February 26, 2008 every 2, 4, and 6 d. Irrigation main plots were each subdivided into four split plots assigned randomly to herbicide split-plot treatments of atrazine at 2.24 kg ai ha^{-1}, sulfosulfuron at 0.066 kg ai ha^{-1}, atrazine + sulfosulfuron mixture, and a nontreated check. Plots received rain 2 hr after treatment. Plots were evaluated visually to estimate dollarweed reduction through 46 DAT, and surviving dollarweed canopy cover was estimated visually 9-12 WAT and 14 WAT. Data were pooled within 2-wk intervals and analyzed by ANOVA.

RESULTS

Daily Irrigation and Herbicides.

There were highly significant differences (P < 0.01) among herbicide treatments from 2 to 8 wk after initial treatment (WAIT) (Table 1). By 10 WAIT, with the advance of warmer weather, there was natural decline of dollarweed in the nontreated check plots, and recovery of dollarweed in herbicide plots, so that treatment differences were no longer detectable.

Atrazine, metsulfuron, and sulfosulfuron applied individually reduced dollarweed from 2 to 8 WAIT, and the most reduction was observed 6 WAIT. Only sulfosulfuron reduced dollarweed >85%, 4 to 6 WAIT. Among single-application herbicide mixtures, only atrazine + sulfosulfuron and atrazine + metsulfuron caused >85% dollarweed reduction, from 4 to 8 WAIT.

Combined "followed by" treatments involving atrazine and either metsulfuron or sulfosulfuron always reduced dollarweed by >85% at 6 WAIT, and when atrazine was applied first and followed by a sulfonylurea herbicide (either metsulfuron or sulfosulfuron), dollarweed was reduced >85% through 8 WAIT. Dollarweed reduction from sulfonylurea herbicide combinations (metsulfuron followed by sulfosulfuron, and sulfosulfuron followed by metsulfuron) showed antagonism in the

Table 2. Dollarweed reduction in 2006 by irrigation, fertilization, and herbicides, 2 to 10 wk after treatment (WAT), and dollarweed canopy cover 12 WAT. Rates were atrazine at 2.24 kg/ha and sulfosulfuron at 0.66 kg/ha.

Management factor		Dollarweed reduction† 2 WAT		4 WAT		6 WAT		8 WAT		10 WAT		Dollarweed cover (12 WAT)	
		%											
Irrigation (I) Interval (I):													
2 days		38.5		35.7	b	33.6	b	22.6		20.6	b	52.2	
4 days		44.5		78.1	a	62.8	a	32.1		42.5	a	32.2	
6 days		58.5		97.2	a	80.2	a	45.2		47.5	a	24.1	
Fertilization:													
None		46.5		69.7		60.5		29.2		22.2	b	40.0	
Fertilized (F)		47.8		70.9		57.2		37.4		51.5	a	32.4	
Herbicide treatment:													
Atrazine		56.8	a	75.3	a	44.5	b	16.9	b	24.2	b	40.0	a
Sulfosulfuron		47.3	b	81.0	a	90.2	a	67.4	a	58.3	a	31.7	b
Nontreated check		37.5	c	54.7	b	41.8	b	15.7	b	28.1	b	36.8	ab
Source of variation	**df**	**Mean squares‡**											
Replicates	2	790.2		1593.4		862.2		515.0		2035.2		1322.4	
Irrigation (I)interval (I)	2	1895.1		17818.6	*	9986.7	*	2312.5		3697.7	*	3774.1	
Error a	4	2276.4		1344.9		977.9		483.2		418.5		585.9	
Fertilization rate (F)	1	22.7		19.6		146.7		906.5		11557.4	**	789.7	
I X F	2	149.2		29.2		107.0		478.2		142.1		3.8	
Error b	6	143.8		29.2		206.0		268.0		708.3		363.1	
Herbicides (H)	2	1669.3	***	3457.8	***	13286.0	***	15659.1	***	6297.7	***	313.7	*
I X H	4	168.8		1461.1	***	1216.2	***	2293.3	**	3214.4	***	449.3	**
F X H	2	29.6		9.1		50.1		565.7		994.9		11.1	
I X F X H	4	4.6		21.0		57.6		249.5		175.5		30.7	
Error c	24	104.8		151.6		110.5		541.9		455.8		81.9	

†For each management treatment factor, means in columns with a letter in common are not different by the prior-F LSD test (*P*=0.05).
‡ *, **, *** Mean square significant at P < 0.05, 0.01, or 0.001, respectively.

form of delayed response, and >85% reduction did not occur until 8 WAIT.

Delayed Irrigation, Fertilization, and Herbicides.

There were differences in dollarweed reduction among irrigation interval treatments at 4, 6, and 10 WAT (Table 2). In each case, the 4-d and 6-d irrigation intervals reduced dollarweed more than the 2-d irrigation interval, but the 6-d irrigation interval did not differ from the 4-d interval. Fertilization reduced dollarweed only in one observation period, 10 WAT. Herbicides reduced dollarweed in all observation periods, 2 to 10 WAT. Atrazine was more effective earlier, 2 WAT, than sulfosulfuron in reducing dollarweed. At 4 WAT atrazine and sulfosulfuron did not differ, and from 6 to 10 WAT sulfosulfuron reduced dollarweed more than atrazine, which did not differ from the nontreated check. Overall dollarweed reduction (not considering irrigation interval) was >85% only with sulfosulfuron, only at 6 WAT. There was strong irrigation interval X herbicide interaction 4 to 10 WAT, which is illustrated for treatment combinations at 10 WAT (Fig. 1a).

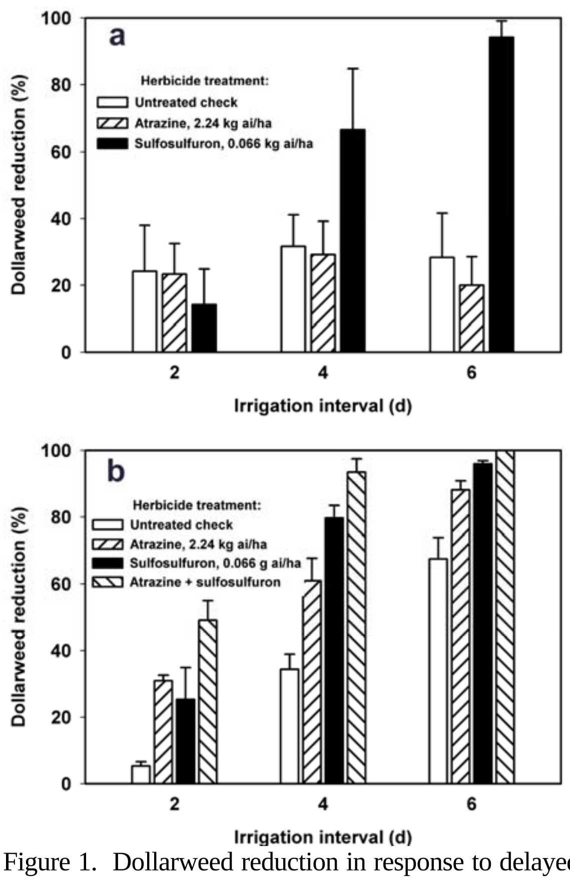

Figure 1. Dollarweed reduction in response to delayed irrigation interval and herbicide treatments, (a) 10 weeks after treatment, 2006 data and (b) 12 weeks after treatment, 2007 data. Error bars are standard errors.

Under the 2-d irrigation interval, no herbicide reduced dollarweed. Under the 4-d irrigation interval sulfosulfuron reduced dollarweed more than other treatments but no treatment reduced dollarweed >85%. Under the 6-d irrigation interval only sulfosulfuron reduced dollarweed >85%. Dollarweed canopy cover at 12 WAT was consistent with effects observed on dollarweed reduction, and although the irrigation effect was not significant, there was strong irrigation X herbicide interaction.

Delayed Irrigation and Herbicides.

In the 2007 study there were dollarweed effects from irrigation interval treatments at 4, 10, and 12 WAT (Table 3). The 6-d irrigation interval always reduced dollarweed more than the 2-d irrigation interval and at 4 and 12 WAT the 6-d irrigation interval reduced dollarweed more than the 4-d irrigation interval. There were differences in herbicide treatments across all observation periods, 2 to 12 WAT. Atrazine was more effective than sulfosulfuron earlier, 2 and 4 WAT, in reducing dollarweed, but from 6 to 12 WAT sulfosulfuron reduced dollarweed more than atrazine. While both atrazine and sulfosulfuron always reduced dollarweed to some degree, compared with the nontreated check, the atrazine + sulfosulfuron mixture always reduced dollarweed more than either atrazine or sulfosulfuron alone and provided >85% dollarweed reduction from 6 to 10

Table 3. Dollarweed reduction in 2007 study, by irrigation and herbicides, 2 to 12 wk after treatment (WAT) and dollarweed canopy cover 14 WAT. Rates were atrazine at 2.24 kg/ha and sulfosulfuron at 0.66 kg/ha.

Management		Dollarweed reduction†												Dollarweed cover	
		2 WAT		4 WAT		6 WAT		8 WAT		10 WAT		12 WAT		(14 WAT)	
		%													
Irrigation:															
2 days		23.0		44.8	b	59.7		64.1		48.1	b	27.7	c	55.5	a
4 days		21.3		45.6	b	61.4		68.3		70.9	a	67.1	b	29.6	b
6 days		23.0		49.4	a	62.6		73.4		81.4	a	87.9	a	15.0	c
Herbicide treatment:															
Atrazine		32.8	b	61.7	b	67.9	c	82.2	c	71.1	c	60.0	c	33.2	b
Sulfosulfuron		11.9	c	38.1	c	76.6	b	92.1	b	82.2	b	67.0	b	30.1	b
Atrazine + sulfosulfuron		45.0	a	82.4	a	99.4	a	96.5	a	91.7	a	80.8	a	18.2	c
Nontreated check		0.1	d	4.2	d	1.0	d	3.7	d	22.3	d	35.7	d	51.9	a
Source of variation	**df**	**Mean squares‡**													
Replicates	3	36.6		74.2		110.8		9.4		84.9		77.3		252.5	
Irrigation (I)	2	17.2		94.4	*	34.8		343.3		4659.8	**	14977.6	***	6739.6	***
Error a	6	13.7		13.9		53.0		103.8		197.3		171.4		145.1	
Herbicides (H)	3	4908.2	***	13501.4	***	21465.2	***	22921.1	***	11400.5	***	4274.7	***	2343.1	***
I X H	6	3.8		93.2	**	7.8		22.8		123.1		237.3	*	72.7	
Error b	27	15.0		26.2		59.4		32.1		58.7		76.0		56.8	

†For each management treatment factor, means in columns with a letter in common are not different by the prior-F LSD test *P*=0.05).

‡ *, **, *** Mean square significant at P < 0.05, 0.01, or 0.001, respectively.

WAT. There was herbicide X irrigation interval interaction 4 and 12 WAT, and this can be understood by inspecting treatment combinations (Fig. 1b). In the 2-d irrigation interval, no herbicide treatment reduced dollarweed >85%. In the 4-d irrigation interval only the atrazine + sulfosulfuron treatment reduced dollarweed >85%. In the 6-d irrigation interval any herbicide, atrazine, sulfosulfuron, or atrazine + sulfosulfuron, reduced dollarweed >85%. Dollarweed canopy cover at 14 WAT was consistent with dollarweed reduction, and there were strong effects from both irrigation interval and herbicide.

In the 2008 study there were no dollarweed effects from irrigation interval treatments until 8 WAT (Table 4), with the 6-d irrigation interval reducing dollarweed more than the 2-d or 4-d intervals. There were differences in herbicide treatments across all observation periods, 2 to 8 WAT. Atrazine was more effective than sulfosulfuron at 2 and 6 WAT, in reducing dollarweed, but by 8 WAT sulfosulfuron reduced dollarweed more than atrazine. While both atrazine and sulfosulfuron always reduced dollarweed to some degree, compared with the nontreated check, the atrazine + sulfosulfuron mixture always reduced dollarweed more than either atrazine or sulfosulfuron alone and provided >85% dollarweed reduction from 4 to 6 WAT. There was no herbicide X irrigation interval interaction. Dollarweed canopy cover at 9-12 WAT and 14 WAT was consistent with dollarweed reduction, and the irrigation effect persisted but the herbicide effect was no longer detectable at 14 WAT.

DISCUSSION

Under daily irrigation few herbicide treatments greatly reduced dollarweed for more than a short period.

Table 4. Dollarweed reduction in 2008 study, by irrigation and herbicides, 2 to 8 wk after treatment (WAT) and dollarweed canopy cover 9-12 WAT and 14 WAT. Rates were atrazine at 2.24 kg/ha and sulfosulfuron at 0.66 kg/ha.

Management		Dollarweed reduction†				Dollarweed cover	
		2 WAT	4 WAT	6 WAT	8 WAT	9-12 WAT	14 WAT
		%				%	
Irrigation interval:							
2 days		35.9	43.0	50.0	42.2 c	32.8 a	18.0 a
4 days		34.7	46.3	52.8	52.5 b	20.0 b	4.6 b
6 days		33.4	45.6	53.1	59.5 a	8.4 c	0.3 b
Herbicide treatment:							
Atrazine		25.0 c	41.7 c	68.3 b	58.9 c	21.5 b	14.4
Sulfosulfuron		40.8 b	49.6 b	52.5 c	66.9 b	15.4 b	14.3
Atrazine + sulfosulfuron		72.9 a	88.1 a	87.1 a	77.5 a	15.1 b	14.0
Nontreated check		0.0 d	0.4 d	0.0 d	2.2 d	29.7 a	20.7
Source of variation	**df**	**Mean squares‡**					
Replicates	3	36.6	180.7 *	372.7 *	292.4 *	231.6	221.0
Irrigation interval (I)	2	25.0	48.6	47.4	1210.8 ***	2382.5 ***	1364.0 *
Error a	6	46.5	28.1	38.4	43.5	85.0	165.8
Herbicides (H)	3	11185.2 ***	15518.2 ***	16807.5 ***	13589.5 ***	559.4 ***	25.7
I X H	6	5.6	16.6	37.7	163.3	29.4	47.9
Error b	27	46.0	59.5	120.2	70.7	64.0	97.2

†For each management treatment factor, means in columns with a letter in common are not different by the prior-F LSD test (P=0.05).

‡ *, *** Mean square significant at $P<0.05$ and $P < 0.001$, respectively.

The only herbicide treatments causing >85% dollarweed reduction for at least 8 wk under daily irrigation involved sulfonylurea herbicides, metsulfuron or sulfosulfuron, either combined in tank mixtures with atrazine or applied as part of a repeated application. Sulfosulfuron at 0.066 kg ai ha^{-1} was generally more effective than atrazine at 2.24 kg ai ha^{-1} in reducing dollarweed, which is encouraging because the U.S. EPA has reduced the allowable rate of atrazine applied as a liquid to 1.12 kg ai ha^{-1} in residential lawns.

Under delayed irrigation the effect of herbicide alone was again generally temporary or small but irrigation interval significantly reduced dollarweed ($P < 0.05$) in differing periods among years. Differences in rainfall explained the differences among years. In 2006, when there was 28 cm rain during the first 10 WAT, only one of nine irrigation X herbicide combinations reduced dollarweed >85%. In 2007, there was only 9 cm rain during the first 10 WAT, and 4 of 12 irrigation X herbicide combinations reduced dollarweed >85%. In 2008 there was 22 cm rain during the first 7 WAT, but during 8 to 12 WAT there was only 2 cm rain which explained the strong, late, 8 to 14 WAT, effect of irrigation interval. Both the 4- and 6-d irrigation intervals resulted in <10% dollarweed by 14 WAT. Dollarweed reduction was largest in the 4- and 6-day irrigation interval during dry years, 2007 and 2008.

Irrigation interval interacted with broadleaf herbicide in reducing dollarweed in St. Augustinegrass, most notably from 4 to 10 WAT in the 2006 experiment, and 4 WAT and 12 WAT in the 2007 experiment. The most effective combinations were 6-d irrigation interval following sulfosulfuron application, and 4-d or 6-d irrigation interval following application of atrazine + sulfosulfuron.

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