II. Effect of Pyridine and Sulfonylurea Admixtures on Virginia Buttonweed (*Diodia virginiana*) Control in Turf

Abstract: A common experiment was conducted at three locations with the objective of evaluating non-phenoxy herbicides for control of Virginia buttonweed and turfgrass tolerance. Variables included full and half rates of chlorsulfuron, metsulfuron, trifloxysulfuron, and fluroxypyr and all possible pair-wise tank admixtures were evaluated in the first study. When applied alone, the full-rates of these herbicides provided superior Virginia buttonweed control over the half-rates. However, the half-rate pair-wise admixtures were superior to the full-rate of trifloxysulfuron applied alone. At the McCall's location, only the pair wise admixtures that contained fluroxypyr provided excellent Virginia buttonweed control (> 90%) 1 month after treatment (MAT). However, treatments containing fluroxypyr at Gulf Shores injured 'Tifway' bermudagrass from 33 to 58% 2 weeks after treatment (WAT). Turfgrass tolerance varied across locations and with respect to species evaluated. Trifloxysulfuron applied to centipedegrass and St. Augustinegrass resulted in 37 to 68 and 10 to 55% injury, respectively. Other treatments provided unacceptable (> 30%) short-term injury, but recovery was rapid and symptoms were non-existent 2 MAT. A second common

experiment was conducted at three locations with the objective of evaluating single and double herbicide applications of chlorsulfuron, metsulfuron, trifloxysulfuron, fluroxypyr, triclopyr + diflufenzopyr, and triclopyr + clopyralid + diflufenzopyr. A single application of triclopyr + clopyralid + diflufenzopyr provided complete control of Virginia buttonweed without regrowth 15 WAT. Two applications of this treatment resulted in 68% injury to 'Palmetto' St. Augustinegrass and 44% injury to 'Tifway' bermudagrass 1 month after the second application. At all locations, the double application of fluroxypyr and triclopyr + diflufenzopyr significantly increased control to ≥ 86% 1 MAT. The double application of triclopyr + diflufenzopyr resulted in 45% injury to 'Palmetto' St. Augustinegrass. A single application of trifloxysulfuron injured centipedegrass (56%) and St. Augustinegrass (50%). Centipedegrass and zoysiagrass were the most tolerant to pyridine herbicides evaluated.

Nomenclature: Chlorsulfuron; diflufenzopyr; fluroxypyr; metsulfuron; trifloxysulfuron; triclopyr + diflufenzopyr; triclopyr + clopyralid + diflufenzopyr; common centipedegrass *Eremochloa ophiuroides* (Munro) Hack #[1]ERLOP; bermudagrass *Cynodon dactylon X C. transvaalensis* Burtt-Davey 'Tifway'; St. Augustinegrass *Stenotaphrum secundatum* Walt. Kuntze 'Palmetto', 'Raleigh' #STPSE; Virginia buttonweed *Diodia virginia* L. # DIQVI; zoysiagrass *Zoysia japonica* Steud 'Meyer' #ZOYMA

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[1] Letters following this symbol are a WSSA approved computer code from *Composite List of Weeds*, Revised 1989. Available only on computer disk from WSSA, 810 East 10th Street, Lawrence, KS 66044-8897.

Additional index words: CYNDA, ERLOP, STPSE, DIQVI, ZOYMA, herbicide application, herbicide rate, Virginia buttonweed regrowth.

Abbreviations: MAT, month after treatment; WAT weeks after treatment.

INTRODUCTION

Virginia buttonweed (*Diodia virginiana* L.) is a member of the tribe Spermacoceae within the Rubiacea family (Lewis and Oliver 1974). Originally, Virginia buttonweed was most commonly found in wet ditches, margins of streams, along roadsides, savannahs, ponds and marshes. However present habitats include lawns, golf courses, athletic fields, and sod farms (Dickens and Turner 1985b; Radford et al. 1981).

Virginia Buttonweed is a problematic weed in warm-season turfgrasses throughout the Southeastern U.S. and is considered the most troublesome turf weed in Alabama, Georgia, Louisiana, Mississippi, and Tennessee (Dickens and Turner 1985a; Dickens and Turner 1985b; Dowler 2000). It is difficult to control due to variable fecundity and adaptability. It can produce viable seed above and below ground along with extensive vegetative reproduction capabilities that helps to ensure survival (Baird et al. 1992; Dute et al. 1988).

Several preemergence-applied herbicides will provide adequate control of seedling Virginia buttonweed (Heering et al. 1987; Scott and Coats 1999). Present recommendations for postemergence control include multiple applications of two- and three-way mixes of auxin-type herbicides including several phenoxy carboxylic acids and dicamba. However, regrowth is common and the herbicide rates required for adequate control are frequently injurious to warm-season turf (Coats 1986; Duble et al. 1986; Jordan 1980; Jordan and Coats 1980; Scott and Coats 1998).

Pyridine herbicides include clopyralid, fluroxypyr, and triclopyr. These herbicides control many annual and perennial broadleaves in rangeland, pasture, and turf (Ahrens 1994; Ross and Lembi 1999). Data presented by Kelly and Coats (1998) concluded that clopyralid provided Virginia buttonweed control equivalent to dicamba, but had superior turfgrass tolerance. McGregor (1982) was able to achieve 95% control of Virginia buttonweed with triclopyr in greenhouse trials, but results were inconsistent in the field. A pre-packaged mixture of triclopyr + clopyralid provided the best control of Virginia buttonweed in trials evaluated by Klosterboer et al. (1999). Fluroxypyr has provided acceptable levels of control and warm-season turf tolerance (Kelly and Coats 2000; Staples and Walker 2001). Taylor et al. (2001) reported that a fluroxypyr + clopyralid tank mixture provided $\geq$ 83% control of Virginia buttonweed.

Diflufenzopyr, also of pyridine chemistry, has been evaluated as a synergist when mixed with various phenoxy carboxylic acid, benzoic acid, and pyridine herbicides. Diflufenzopyr increases the effectiveness of dicamba by inhibiting auxin transport thus allowing the accumulation of auxins and auxin-like herbicides in the meristematic regions of the plants. Numerically higher uptake of dicamba occurred when accompanied with diflufenzopyr compared to dicamba alone. However, when diflufenzopyr was applied alone at the evaluated rates, it did not have significant herbicidal activity (Sciumbato et al. 2000).

Sulfonylurea herbicides, such as chlorsulfuron, metsulfuron, and trifloxysulfuron, have been shown to control grasses, sedges, and broadleaf weeds in warm-season turf (Brecke and Unruh 2000; Brooks and Baumann 1995; Gaitan-Gaitan et al. 1994; Gannon and Yelverton 2001; Larocque and Christians 1985; Teuton et al. 2001; Williams et al. 2001). According to Kelly and Coats (2000), a single application of metsulfuron was equivalent to a single application of 2,4-D for controlling Virginia buttonweed. Virginia buttonweed is shown on the chlorsulfuron label, but valid research articles are not available.

Both pyridine and sulfonylurea herbicides have demonstrated effectiveness in controlling Virginia buttonweed in warm-season turf. It is a reasonable assumption that tank-mixed admixtures which include members of both herbicide groups may offer superior efficacy. However, Kelly and Coats (2000) found the addition of metsulfuron to 2,4-D did not increase Virginia buttonweed control over the two herbicides applied alone.

Admixtures of selected sulfonylurea and pyridine herbicides for control of Virginia buttonweed in warm-season turf was the focus of this research. Two separate studies were included. The first study evaluated Virginia buttonweed control and turfgrass tolerance with selected pyridine and sulfonylurea herbicides as influenced by herbicide admixtures and rate. The second study evaluated the same parameters but focused on single versus repeat applications of selected pyridine and sulfonylurea herbicides.

MATERIALS AND METHODS

General procedures. Field experiments were conducted at four locations during the spring and summer of 2001. Locations were: 1) Gulf Shores State Park Golf Course, Gulf Shores, Alabama (Gulf Shores); 2) Auburn University Turfgrass Research Unit, Auburn, Alabama (Auburn); 3) Frog Pond Sod Farm, Hurtsboro, Alabama (Frog Pond); and 4) McCall's Sod Farm, Southport, Florida (McCall's). The soil type found at each location was: 1) Newhan fine sandy loam (thermic, uncoated typic quartzipsamments); 2) Marvin sandy loam (fine-loamy, kaolinitic, thermic Typic Kanhapludults); 3) Springhill loamy sand (fine-loamy, kaolinitic, thermic Typic Kanhapludults); 4) Leon sand (Sandy, siliceous, thermic Aeric Alaquods). A randomized complete block design with 3 or 4 replicates was used at all locations. Individual plots were 1.2 m wide and ranged from 3 to 6 m in length. Treatments were applied using a CO_2 backpack sprayer attached to a push boom calibrated to deliver 280 L/ha at 213 Kpa. The boom consisted of four 6502 flat fan nozzles on a 25-cm spacing, and placed 35 cm above the turf surface. Cohort DC®[2] was applied with each treatment at a rate of 1.5 g/L of spray solution. Cohort DC® is an adjuvant consisting of a proprietary blend of polyethoxylated hydroxyl alkyl surfactants, encapsulated in organic nitrogen.

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[2] Cohort DC is manufactured by Helena Chemical Company 225 Schilling Blvd Collierville, TN 38017.

Virginia buttonweed control was evaluated at various intervals using a rating scale from 0 to 100 where 0 = no control and 100 = total control. Regrowth was measured using a relative scale of 0 to 5, where 0 was equivalent to no regrowth and 5 was equivalent to regrowth of non-treated plants. Turfgrass injury was evaluated when available using a scale from 0 to 100 where 0 = no injury and 100 = complete necrosis. Within this scale, 0-30% = slight, 31-60 = moderate, and 61-100 = severe injury and a rating > 30% was considered unacceptable.

Herbicide admixtures and rates. The pyridine herbicide fluroxypyr and the sulfonylurea herbicides chlorsulfuron, metsulfuron, and trifloxysulfuron were evaluated in identical studies at Gulf Shores, Auburn (Auburn with sod, Auburn without sod), and McCall's. Herbicides were applied alone at a full rate and a half rate. All possible two-way full-rate and half-rate admixtures were also applied.

Gulf Shores treatments were applied 3 May, 2001 to a natural infestation of Virginia buttonweed growing in an established 'Tifway' bermudagrass [*Cynodon. dactylon X C. transvaalensis* (Burtt-Davey)] fairway. Fertility was low and neither bermudagrass nor the Virginia buttonweed were very robust, therefore 24 kg N/ha from a 25-4-8 fertilizer was applied just prior to herbicide application. Supplemental irrigation was provided as needed and the area was mowed at 2.5 cm 3 times weekly.

The Auburn with sod location consisted of a natural and propagated Virginia buttonweed population. Propagated Virginia buttonweed plants were grown in a greenhouse and used to supplement the natural infestation to insure uniform density.

Each plot contained common centipedegrass [*Eremochloa ophiuroides* (Munro) Hack], 'Palmetto' St. Augustinegrass (*Stenotaphrum secundatum* Walt. Kuntze), 'Meyer' zoysiagrass (*Zoysia japonica* Steud), and 'Tifway' bermudagrass. These turfgrasses were established 1 year prior from 41 cm by 61 cm sections of sod. Test area was mowed at 5 cm and fertilized with 12-4-8 to achieve 24 kg N/ha monthly. Supplemental irrigation was available and applied as needed. Treatments were applied 1 July, 2001 when the majority of the Virginia buttonweed was flowering.

McCall's location contained the most severe Virginia buttonweed infestation. Treatments were applied on 6 July, 2001 to a harvestable 'Raleigh' St. Augustinegrass sod. The entire test area was mowed just prior to treatment application and weekly thereafter. Center-pivot irrigation was available, but not needed during the evaluation period due to excessive rainfall (> 410 mm in July).

Single and repeat herbicide applications. Three sulfonylurea herbicides and three pyridine herbicides were selected for evaluation. Single and repeat applications of the six herbicides were evaluated. The repeat application was applied 30 days after the initial. Two studies were conducted at Auburn and one at Frog Pond.

The Auburn without sod location contained a monoculture of Virginia buttonweed. The site was fumigated with metam-sodium (Vapam®) at 123 L of product per hectare and tarped the previous fall and seeded to perennial ryegrass for soil stability. Individual 1.2- by 6-m plots spaced on 1.2-m centers were treated with glufosinate at

0.84 kg ai/ha to provide a plant-free environment for transplanting the greenhouse-grown Virginia buttonweed plants.

Virginia buttonweed seed were collected from the Auburn University Turfgrass Research Unit in the fall of 2000. In early-March 2001, seeds were planted into 1-L styrofoam cups containing a 90:10 v/v mixture of sand and peat. They were allowed to grow in this environment for 55 days. These greenhouse-grown plants were then transplanted into the test area. Individual plots contained three plants spaced 1.5 m apart. Plants were allowed to grow 40 days prior to herbicide treatment. Fertility was maintained as previously described and supplemental irrigation was applied as needed to obtain at least 2.5 cm per week.

Treatments were applied 9 July, 2001 with a second application applied 9 August, 2001. At this time, all above ground portions of Virginia buttonweed plants were removed in plots receiving only one herbicide application. Above ground portions of plants that received a repeat application were removed 6 weeks after the second application (28 September, 2001).

Virginia buttonweed control was measured 14 days after treatment (DAT), 30 DAT, and monthly thereafter. For plots that received a single application, regrowth from the original rootstock was evaluated monthly after plant tissue removal. The second application remained on the plants for 6 weeks due to less than optimal temperatures for rapid Virginia buttonweed growth encountered in September. Plants that received a second application were allowed to regrow from 28 September, 2001 until evaluation on 2 November, 2001.

The Auburn with sod location consisted of a natural Virginia buttonweed population. Greenhouse-grown plants, as previously described were planted to supplement the natural infestation to insure uniform density. Each plot contained common centipedegrass, 'Palmetto' St. Augustinegrass, 'Meyer' zoysiagrass, and 'Tifway' bermudagrass. These turfgrass species were established 1 year prior. Blocks of sod (41 cm by 61 cm) of each of the four turfgrass species were randomly placed within each plot.

Treatments were applied July 9, 2001 when the majority of the Virginia buttonweed was flowering. Virginia buttonweed control and turfgrass injury was evaluated on the same interval as described for the Auburn with out sod location.

Treatments at the Frog Pond site were applied 22 August, 2001 to Virginia buttonweed growing in a sod-free environment. The test area was mowed 1 week prior to treatment application and again 1 month after treatment (MAT). Aside from this mowing, no other management practices were utilized resulting in low fertility. Supplemental irrigation was available from center-pivot systems and applied on an as needed basis.

Data analysis. Data were analyzed using mixed models analysis of variance techniques as implemented in the SAS® procedure mixed (Littell et al. 1996). Mixed models analysis has many advantages over the traditional generalized linear models

(GLM) technique. The mixed procedure uses an iterative restricted maximum likelihood approach to estimate model solutions. It is superior because it offers a way to handle violations of implicit assumptions. One assumption that is commonly violated in research trials is that all treatments have the same variance. This is clearly not the case because of the negative association between efficacy and error. In these studies, within treatment variances differed by as much as 368 times. Mixed models procedures are able to handle these situations because treatments can be grouped based on common error variances. Our approach was to first analyze a given dataset under the assumption of equal variances for all treatments and recording the magnitude of the model fit statistics. We then grouped treatments based on the size of the within treatment variance and repeated the analysis with these groupings using the 'REPEATED / GROUP=VARGRP' statement within SAS® PROC MIXED, where VARGRP represents a number from 1 to the total number of treatments. If the second analysis resulted in better-fit statistics, this model was then chosen for the final analysis. The result of this type of refined analysis is that (a) only probability values are printed without either Type I or Type III sums of squares, and (b) treatment means are reported with different standard errors. Linear contrasts were used to determine significance of differences among treatments. A treatment by location interaction was revealed and data will be discussed by location.

RESULTS AND DISCUSSION

Herbicide admixtures and rates. Virginia buttonweed control among the three locations was least variable across all herbicide treatments at the Gulf Shores location. Control at this location ranged from a low of 51% for the half rate of fluroxypyr to a high of 86% for the full rates of chlorsulfuron alone and chlorsulfuron + trifloxysulfuron. In general, Virginia buttonweed control ranged from most to least with the following groupings: full rate admixtures > single herbicide full rates = half rate admixtures > single herbicide half rates, Table II. 1.

Virginia buttonweed control at the Auburn location ranged from a low of 0 for the half rate of fluroxypyr to a high of 95% for the full rates of chlorsulfuron + fluroxypyr admixture. Control in general ranged from most to least at Auburn with the following groupings: full rate admixtures > single herbicide full rates = half rate herbicide admixtures > single herbicide half rates, Table II. 1.

Virginia buttonweed control at McCall's ranged from a low of 19% for the half rate of trifloxysulfuron to a high of 95% for the full rate admixture of metsulfuron + fluroxypyr. Virginia buttonweed control was most to least with the following groupings at McCall's: full rate admixtures > half rate admixtures > single herbicide full rates > single herbicide half rates. Full rate admixtures provided control that ranged from 82 to 99%. However, this same level of control was achieved with all half-rate admixtures that contained fluroxypyr and trifloxysulfuron + chlorsulfuron, Table II. 1.

Turfgrass species were not the same at all locations. Injury to Tifway bermudagrass 2 WAT at the Gulf Shores location was unacceptable with all treatments that contained fluroxypyr. Injury for fluroxypyr treatments ranged from 33% for the half-rate admixture of chlorsulfuron + fluroxypyr to a high of 58% for the full rate of fluroxypyr alone and the trifloxysulfuron + fluroxypyr admixture, Table II. 2. Tifway injury 1 MAT was still unacceptable for all treatments that received the full rate of fluroxypyr. Previous research by Staples and Walker at Auburn showed no problem with fluroxypyr injury to Tifway bermudagrass. However, bermudagrass regrowth potential at Gulf Shores was much less than at the Auburn location. Kelly and Coats (2000) reported similar injury levels when fluroxypyr was applied to common bermudagrass. However, in their study, injury had receded to acceptable levels by 1 MAT, while at 1 MAT at Gulf Shores injury to Tifway bermudagrass was still unacceptable.

Injury to St. Augustinegrass at McCall's 1 MAT was unacceptable for all treatments that contained the full rate of trifloxysulfuron. The full-rate admixture of trifloxysulfuron + chlorsulfuron or metsulfuron or fluroxypyr averaged 55% injury while trifloxysulfuron at the full rate alone averaged 40% injury.

Injury to centipedegrass at the Auburn location was unacceptable with any treatment contained trifloxysulfuron. Injury was as high as 68% 1 MAT with admixtures that contained trifloxysulfuron + metsulfuron or chlorsulfuron or fluroxypyr. However, only trifloxysulfuron + chlorsulfuron produced unacceptable (40%) injury to St. Augustinegrass at the Auburn location, Table II. 2. Turf injury evaluations at the Auburn location 2 MAT continued to show excessive injury to centipedegrass with treatments containing trifloxysulfuron, but injury to the St. Augustinegrass had reached acceptable levels, Table II. 3.

Brecke and Unruh (2000) evaluated trifloxysulfuron for use in warm-season turfgrass. They determined that injury to St. Augustinegrass resulting from trifloxysulfuron treatments was unacceptable and cultivar dependent. They also concluded that trifloxysulfuron was non-injurious to either zoysiagrass or bermudagrass at all evaluated rates. Teuton et al. (2001) further confirmed the earlier findings of Brecke and Unruh by achieving excellent tolerance of 'TifEagle' bermudagrass to multiple rates and applications of trifloxysulfuron.

Single and repeat herbicide applications. Results from the Auburn without sod location showed 93% control of Virginia buttonweed 1 MAT with a single application of Confront® + diflufenzopyr. All other single-application treatments produced unacceptable control that ranged from 30 to 61%. When treatments were repeated and evaluated 1 month later, significant improvement in Virginia buttonweed control was observed, Table II. 4. Regrowth data showed that no regrowth of Virginia buttonweed plants treated with a single or repeat application of Confront® + diflufenzopyr or with fluroxypyr repeated, Table II. 5.

At the Auburn location with sod, results were similar to the Auburn without sod location. Single and repeat application of Confront® + diflufenzopyr provided 96 and

99% control, respectively. Triclopyr + diflufenzopyr applied twice averaged 95% control but the repeat application of fluroxypyr averaged only 78%, Table II. 4.

Data collected from the Frog Pond location again showed that Confront + diflufenzopyr provided near complete control of Virginia buttonweed and fluroxypyr applied twice averaged 93% control. However, different results were obtained with some treatments. Chlorsulfuron provided 91 and 99% control with single and repeat application, respectively while triclopyr + diflufenzopyr provided 43 and 75% control with the single and repeat application, respectively, Table II. 4.

Turfgrass injury (Auburn with sod location) varied with turf species. Herbicides that produced unacceptable injury to common centipedegrass included: 1) single and repeat trifloxysulfuron; 2) repeat chlorsulfuron. St. Augustinegrass could not tolerate single applications of: 1) trifloxysulfuron; 2) triclopyr + diflufenzopyr; 3) Confront® + diflufenzopyr or any repeat application except fluroxypyr. Unacceptable injury to Meyer zoysiagrass and Tifway bermudagrass was not evident with any herbicide treatment in a single or repeat application, Table II. 6.

From this research, the herbicide treatment that provided excellent control of Virginia buttonweed with a single application was Confront® + diflufenzopyr. The four warm-season turfgrasses evaluated could easily tolerate one application of this treatment without loosing aesthetic appeal. Two applications of other herbicides were needed to obtain higher levels of control, but the resulting turfgrass injury would render these treatments unacceptable.

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Table II. 1 . Virginia buttonweed control as affected by herbicide and herbicide admixtures applied at full and half rates (kg active/ha) at 3 locations; 1 month after treatment.

				Gulf Shores			Auburn			McCall's		
Herbicide	Rate	Supplement	Rate	%Control	SE	*P* > 0	%Control	SE	*P* > 0	%Control	SE	*P* > 0
Metsulfuron	0.06	None		84	2.5	*	42	1.6	*	44	2.3	*
Trifloxysulfuron	0.04	None		71	3.4	*	28	2.6	*	26	2.7	*
Chlorsulfuron	0.28	None		86	1.9	*	77	2.6	*	74	2.3	*
Fluroxypyr	0.28	None		66	3.4	*	20	1.6	*	79	1.1	*
Metsulfuron	0.03	None		79	1.3	*	10	2.6	*	23	1.1	*
Trifloxysulfuron	0.02	None		68	2.8	*	3	3.4	NS	19	2.0	*
Chlorsulfuron	0.14	None		78	1.9	*	25	2.6	*	35	2.3	*
Fluroxypyr	0.14	None		51	4.4	*	0	2.6	NS	21	2.7	*
Metsulfuron	0.06	Trifloxysulfuron	0.04	76	1.9	*	87	4.2	*	82	1.6	*
Metsulfuron	0.06	Chlorsulfuron	0.28	79	3.7	*	85	2.6	*	86	2.0	*
Metsulfuron	0.06	Fluroxypyr	0.28	82	3.4	*	88	2.6	*	99	1.1	*
Trifloxysulfuron	0.04	Chlorsulfuron	0.28	86	4.4	*	83	2.6	*	85	1.6	*
Trifloxysulfuron	0.04	Fluroxypyr	0.28	81	2.8	*	81	4.2	*	97	0.9	*
Chlorsulfuron	0.28	Fluroxypyr	0.28	81	3.4	*	95	2.6	*	98	1.1	*
Metsulfuron	0.03	Trifloxysulfuron	0.02	79	2.5	*	25	3.4	*	38	4.0	*
Metsulfuron	0.03	Chlorsulfuron	0.14	73	2.5	*	15	2.6	*	70	1.6	*
Metsulfuron	0.03	Fluroxypyr	0.14	79	3.7	*	30	2.6	*	98	1.6	*
Trifloxysulfuron	0.02	Chlorsulfuron	0.14	78	2.5	*	74	2.6	*	83	2.3	*
Trifloxysulfuron	0.02	Fluroxypyr	0.14	76	3.4	*	30	2.4	*	90	1.6	*
Chlorsulfuron	0.14	Fluroxypyr	0.14	79	2.5	*	70	2.6	*	97	1.6	*

Table II. 1. continued.

	Gulf Shores			Auburn			McCall's		
Contrast	EST.	SE	*P* > 0	EST.	SE	*P* > 0	EST.	SE	*P* > 0
Metsulfuron full rate vs. half-rate	5	2.2	*	32	2.8	*	21	2.3	*
Trifloxysulfuron full rate vs. half-rate	4	4.0	NS	25	4.1	*	8	3.2	*
Chlorsulfuron full rate vs. half-rate	9	1.9	*	52	3.5	*	39	3.1	*
Fluroxypyr full rate vs. half-rate	15	5.3	*	20	2.8	*	58	2.7	*
Trifloxysulfuron + Metsulfuron full rate vs. half-rate	-3	2.6	NS	62	5.3	*	44	4.2	*
Chlorsulfuron + Metsulfuron full rate vs. half-rate	6	4.1	*	70	3.5	*	16	2.3	*
Fluroxypyr + Metsulfuron full rate vs. half-rate	3	4.7	NS	58	3.5	*	1	1.6	NS
Trifloxysulfuron + Chlorsulfuron full rate vs. half-rate	9	4.8	NS	8	3.5	*	-8	2.6	*
Trifloxysulfuron + Fluroxypyr full rate vs. half-rate	5	4.0	NS	51	4.7	*	8	1.4	*
Chlorsulfuron + Fluroxypyr full rate vs. half-rate	3	3.8	NS	25	3.5	*	2	1.6	NS
Metsulfuron full rate vs. mixtures half-rate	21	7.9	*	55	6.5	*	-74	7.9	*
Trifloxysulfuron full rate vs. mixtures half-rate	-19	10.4	*	-44	8.7	*	-141	9.1	*
Chlorsulfuron full rate vs. mixtures half-rate	30	5.6	*	71	8.5	*	-38	7.1	*
Fluroxypyr full rate vs. mixtures half-rate	-35	10.7	*	-70	6.0	*	-47	3.2	*

Table II. 2. Warm-season turfgrass injury following one application of the listed herbicides and rates (kg active/ha), 2001

				Gulf Shores						Auburn						McCall's		
				2 WAT[a]			1 MAT[b]			1 MAT						1 MAT		
				Tifway Bermudagrass						Centipedegrass			Palmetto St. Augustinegrass			Raleigh St. Augustinegrass		
Herbicide	Rate	Supplement	Rate	% Injury	SE	$P > 0$	% Injury	SE	P > 0	% Injury	SE	$P > 0$	% Injury	SE	$P > 0$	% Injury	SE	P > 0
Metsulfuron	0.06	None		28	2.7	*	17	2.5	*	0	1.7	NS	0	1.7	NS	17	4.9	*
Trifloxysulfuro	0.04	None		16	0.9	*	15	2.7	*	37	1.7	*	13	3.2	*	40	3.7	*
Chlorsulfuron	0.28	None		17	3.1	*	19	2.9	*	0	1.7	NS	13	1.7	*	29	7.5	*
Fluroxypyr	0.28	None		58	0.9	*	42	3.7	*	0	1.7	NS	0	1.7	NS	21	4.7	*
Metsulfuron	0.03	None		5	1.8	*	0	2.7	NS	0	1.7	NS	0	1.7	NS	8	5.4	NS
Trifloxysulfuro	0.02	None		16	1.8	*	23	2.9	*	44	2.7	*	10	3.2	*	26	5.4	*
Chlorsulfuron	0.14	None		21	0.9	*	15	2.5	*	3	1.7	*	10	3.2	*	22	6.2	*
Fluroxypyr	0.14	None		34	5.6	*	20	2.9	*	0	1.7	NS	0	1.7	*	27	4.9	*
Metsulfuron	0.06	Trifloxysulfuro	0.04	22	3.1	*	15	2.7	*	68	1.7	*	23	3.2	*	41	5.4	*
Metsulfuron	0.06	Chlorsulfuron	0.28	25	2.7	*	16	2.7	*	8	1.7	*	28	1.7	*	34	3.7	*
Metsulfuron	0.06	Fluroxypyr	0.28	57	3.1	*	43	2.9	*	18	4.4	*	10	1.7	*	32	3.7	*
Trifloxysulfuro	0.04	Chlorsulfuron	0.28	20	3.1	*	20	2.7	*	45	2.7	*	40	3.2	*	55	6.2	*
Trifloxysulfuro	0.04	Fluroxypyr	0.28	58	0.9	*	48	3.7	*	51	1.7	*	22	3.2	*	39	5.4	*
Chlorsulfuron	0.28	Fluroxypyr	0.28	56	0.9	*	38	2.9	*	2	1.7	NS	18	3.2	*	26	6.2	*
Metsulfuron	0.03	Trifloxysulfuro	0.02	23	1.8	*	15	4.4	*	47	6.7	*	15	3.2	*	30	5.4	*
Metsulfuron	0.03	Chlorsulfuron	0.14	19	2.7	*	15	2.9	*	5	2.7	NS	12	3.2	*	28	4.9	*
Metsulfuron	0.03	Fluroxypyr	0.14	38	4.8	*	24	2.5	*	0	1.7	NS	0	1.7	NS	21	4.9	*
Trifloxysulfuro	0.02	Chlorsulfuron	0.14	19	4.8	*	10	2.5	*	68	1.7	*	25	1.7	*	34	7.5	*
Trifloxysulfuro	0.02	Fluroxypyr	0.14	33	5.6	*	19	2.7	*	68	1.7	*	13	3.2	*	32	3.4	*
Chlorsulfuron	0.14	Fluroxypyr	0.14	43	1.8	*	23	2.7	*	0	1.7	NS	3	3.2	NS	20	4.9	*

[a] WAT = weeks after treatment.

[b] MAT = months after treatment.

Table II. 2 Continued.

	Gulf Shores						Auburn						McCall's		
	2 WAT			1 MAT			1 MAT						1 MAT		
	Tifway Bermudagrass						Centipedegrass			St. Augustinegrass			St. Augustinegrass		
Contrast	Est.	SE	P > 0	Est.	SE	P > 0	Est.	SE	P > 0	Est.	SE	P > 0	Est.	SE	P > 0
Metsulfuron full rate vs. half-rate	23	3.1	*	17	1.7	*	0	2.3	NS	0	2.4	NS	10	3.6	*
Trifloxysulfuron full rate vs. half-rate	1	1.7	NS	-9	2.2	*	-8	3.2	*	3	4.5	NS	14	4.9	*
Chlorsulfuron full rate vs. half-rate	-4	3.1	NS	4	2.0	NS	-3	2.4	*	3	3.6	NS	7	6.8	NS
Fluroxypyr full rate vs. half-rate	25	5.6	*	22	3.3	*	0	2.3	NS	0	2.4	NS	-6	6.8	NS
Trifloxysulfuron + Metsulfuron full rate vs. half-rate	0	3.5	NS	1	3.9	NS	22	6.9	NS	8	4.5	NS	11	7.7	NS
Chlorsulfuron + Metsulfuron full rate vs. half-rate	6	3.7	NS	1	2.2	NS	3	3.2	NS	17	3.6	*	6	6.8	NS
Fluroxypyr + Metsulfuron full rate vs. half-rate	19	5.7	*	19	2.0	*	18	4.7	*	10	2.4	NS	11	6.8	NS
Trifloxysulfuron + Chlorsulfuron full rate vs. half-rate	2	5.7	NS	10	1.7	*	-23	3.2	*	15	3.6	*	22	9.6	*
Trifloxysulfuron + Fluroxypyr full rate vs. half-rate	24	5.6	*	29	3.1	*	-17	2.4	*	8	4.5	NS	7	3.6	NS
Chlorsulfuron + Fluroxypyr full rate vs. half-rate	13	1.7	*	15	2.2	*	2	2.4	NS	15	4.5	*	5	6.8	NS
Metsulfuron full rate vs. mixtures half-rate	4	9.7	NS	-3	5.0	NS	-52	8.9	*	-27	7.0	*	-28	15.2	NS
Trifloxysulfuron full rate vs. mixtures half-rate	-26	7.7	*	0	5.8	NS	-73	8.8	*	-13	10.7	NS	23	15.3	NS
Chlorsulfuron full rate vs. mixtures half-rate	-29	10.8	*	9	5.7	NS	-73	6.1	*	0	6.9	NS	6	20.8	NS
Fluroxypyr full rate vs. mixtures half-rate	61	7.7	*	61	8.7	*	-68	5.8	*	-17	7.0	*	-10	19.7	NS

Table II. 3. Auburn with sod location, 2001. Warm-season turfgrass injury from respective herbicides, pair-waise combinations and rates (kg active/ha).

				2 Months After Treatment					
				Centipedegrass			St. Augustinegrass		
Herbicide	Rate	Supplement	Rate	% Injury	SE	$P > 0$	% Injury	SE	$P > 0$
Metsulfuron	0.06	None		5	2.9	NS	0	1.7	NS
Trifloxysulfuron	0.04	None		40	5.8	*	20	2.8	*
Chlorsulfuron	0.28	None		3	3.3	NS	18	1.7	*
Fluroxypyr	0.28	None		0	2.6	NS	2	1.7	NS
Metsulfuron	0.03	None		2	1.7	NS	0	1.7	NS
Trifloxysulfuron	0.02	None		52	4.4	*	3	3.5	NS
Chlorsulfuron	0.14	None		3	2.9	*	15	2.8	*
Fluroxypyr	0.14	None		0	2.6	NS	2	1.7	NS
Metsulfuron	0.06	Trifloxysulfuron	0.04	58	1.7	*	23	3.5	*
Metsulfuron	0.06	Chlorsulfuron	0.28	8	3.3	*	18	1.7	*
Metsulfuron	0.06	Fluroxypyr	0.28	5	2.9	NS	2	1.7	NS
Trifloxysulfuron	0.04	Chlorsulfuron	0.28	62	4.4	*	31	3.5	*
Trifloxysulfuron	0.04	Fluroxypyr	0.28	60	9.9	*	10	2.8	*
Chlorsulfuron	0.28	Fluroxypyr	0.28	2	1.7	NS	13	3.5	*
Metsulfuron	0.03	Trifloxysulfuron	0.02	35	2.9	*	15	2.8	*
Metsulfuron	0.03	Chlorsulfuron	0.14	2	1.7	NS	10	2.8	*
Metsulfuron	0.03	Fluroxypyr	0.14	0	2.6	NS	0	1.7	NS
Trifloxysulfuron	0.02	Chlorsulfuron	0.14	48	1.7	*	24	2.8	*
Trifloxysulfuron	0.02	Fluroxypyr	0.14	55	2.9	*	17	1.7	*
Chlorsulfuron	0.14	Fluroxypyr	0.14	3	3.3	NS	10	2.8	*

Table II. 3 Continued.

	2 Months After Treatment					
	Centipedegrass			St. Augustinegrass		
Contrast	EST.	SE	P > 0	EST.	SE	P > 0
Metsulfuron full rate vs. half-rate	3	3.3	NS	0	2.4	NS
Trifloxysulfuron full rate vs. half-rate	-12	7.3	NS	17	4.5	*
Chlorsulfuron full rate vs. half-rate	0	2.8	NS	3	3.3	NS
Fluroxypyr full rate vs. half-rate	0	3.6	NS	0	2.4	NS
Trifloxysulfuron + Metsulfuron full rate vs. half-rate	23	3.3	*	8	4.5	NS
Chlorsulfuron + Metsulfuron full rate vs. half-rate	7	3.7	NS	8	3.3	*
Fluroxypyr + Metsulfuron full rate vs. half-rate	5	3.9	NS	2	2.4	NS
Trifloxysulfuron + Chlorsulfuron full rate vs. half-rate	13	4.7	*	7	4.5	NS
Trifloxysulfuron + Fluroxypyr full rate vs. half-rate	5	10.4	NS	-7	3.3	*
Chlorsulfuron + Fluroxypyr full rate vs. half-rate	-2	3.7	NS	3	4.5	NS
Metsulfuron full rate vs. mixtures half-rate	-22	9.6	*	-25	6.8	*
Trifloxysulfuron full rate vs. mixtures half-rate	-18	17.9	NS	4	9.5	NS
Chlorsulfuron full rate vs. mixtures half-rate	-43	10.8	*	11	7.0	NS
Fluroxypyr full rate vs. mixtures half-rate	-58	9.2	*	-22	6.2	*

Table II. 4. Virginia buttonweed control as affected by herbicides applied either as a single full rate or the full rate followed by a full rate 1 month after respective treatment.

		Application				
		Single		Repeat		Contrast[a]
Location/Herbicide	Rate	% Control	SE	% Control	SE	P > 0
Auburn without sod	kg a/ha[b]					
Metsulfuron	0.04	33	4.4	51	13	NS
Chlorsulfuron	0.28	61	2.3	79	8	NS
Trifloxysulfuron	0.04	42	2.3	46	6	NS
Fluroxypyr	0.28	30	4.4	86	5	*
Triclopyr + Diflufenzopyr[c]	0.47	61	2.3	92	3	*
Confront[d] + Diflufenzopyr	0.84	93	2.3	100	3	NS
Auburn with sod						
Metsulfuron	0.04	16	2.6	67	2.6	*
Chlorsulfuron	0.28	64	2.6	75	2.6	*
Trifloxysulfuron	0.04	16	3.5	49	1.4	*
Fluroxypyr	0.28	18	2.6	78	3.5	*
Triclopyr + Diflufenzopyr	0.47	28	4.3	95	1.4	*
Confront + Diflufenzopyr	0.84	96	1.4	99	0.3	NS
Frog Pond						
Metsulfuron	0.04	51	8.0	71	1.5	NS
Chlorsulfuron	0.28	91	1.5	99	1.5	*
Trifloxysulfuron	0.04	53	1.5	71	1.5	*
Fluroxypyr	0.28	68	6.0	93	1.5	*
Triclopyr + Diflufenzopyr	0.47	43	4.8	75	1.5	*
Confront + Diflufenzopyr	0.84	99	1.5	99	1.5	NS

[a]Contrast of 1 vs 2 applications.

[b]kg a/ha is active ingredient either acid equivalent or active ingredient per hectare.

[c]Diflufenzopyr applied at 0.14 kg ae/ha.

[d]Confront is a 3:1 ratio prepackaged mixture of triclopyr + clopyralid.

Table II. 5. Virginia buttonweed regrowth after single or repeat herbicide applications at the given rates (kg ai or ae/ha) at 11 and 7 weeks after removal of above ground plant tissue; Auburn without sod, 2001.

		Application						
		Single			Repeat			Contrast[a]
Treatment	Rate	Regrowth	SE	P > 0	Regrowth	SE	P > 0	P > 0
Metsulfuron	0.04	5[c]	0.4	*	2	0.4	*	*
Chlorsulfuron	0.28	4	0.4	*	1	0.4	*	*
Trifloxysulfuron	0.04	4	0.4	*	2	0.4	*	*
Fluroxypyr	0.28	2	0.4	*	0	0.4	NS	*
Triclopyr + Diflufenzopyr[d]	0.47	4	0.4	*	1	0.4	NS	*
Confront[e] + Diflufenzopyr	0.84	0	0.4	NS	0	0.4	NS	NS

[a]Contrast of 1 application vs 2 applications.

[b] Regrowth rated 15 and 11 weeks after first and second application, respectively.

[c]Regrowth scale 0-5. 0 = no regrowth; 5 = regrowth equivilent to non-treated.

[d]Diflufenzopyr applied at 0.14 kg ae/ha.

[e]Confront is a 3:1 ratio prepackage-mix of triclopyr + clopyralid.

Table II. 6. Turfgrass injury as affected by herbicides applied either as a single full rate or the full rate followed by a full rate 1 month after initial treatment (MAIT); Auburn with sod.

		Single application[a]			Repeat application[b]			
		1 MAIT			2 MAIT			Contrast[c]
Treatment/Turfgrass	Rate	Injury	SE	$P > 0$	Injury	SE	$P > 0$	$P > 0$
Common Centipedegrass	--kg active/ha--	%			%			
Metsulfuron	0.04	5	0.9	NS	27	4.1	*	*
Chlorsulfuron	0.28	4	0.9	NS	33	4.1	*	*
Trifloxysulfuron	0.04	56	3.3	*	84	2.9	*	*
Fluroxypyr	0.28	0	0.9	NS	6	1.9	*	NS
Triclopyr + Diflufenzopyr[d]	0.47	3	2.4	NS	9	1.9	*	NS
Confront[e] + Diflufenzopyr	0.84	1	0.9	NS	5	1.9	*	NS
Palmetto St. Augustinegrass								
Metsulfuron	0.04	6	3.0	NS	37	2.1	*	*
Chlorsulfuron	0.28	19	5.9	NS	58	9.2	*	*
Trifloxysulfuron	0.04	50	5.0	*	79	3.2	*	*
Fluroxypyr	0.28	19	3.0	*	25	6.2	*	NS
Triclopyr + Diflufenzopyr	0.47	56	5.0	*	45	3.6	*	NS
Confront + Diflufenzopyr	0.84	61	2.0	*	68	7.8	*	NS
Meyer Zoysiagrass								
Metsulfuron	0.04	0	1.2	NS	15	6.5	NS	NS
Chlorsulfuron	0.28	1	1.2	NS	21	5.3	*	NS
Trifloxysulfuron	0.04	0	1.2	NS	11	3.8	NS	NS
Fluroxypyr	0.28	1	1.3	NS	1	1.3	NS	NS
Triclopyr + Diflufenzopyr	0.47	4	2.2	NS	0	2.2	NS	NS
Confront + Diflufenzopyr	0.84	4	2.2	NS	1	1.3	NS	NS
Tifway Bermudagrass								
Metsulfuron	0.04	0	2.0	NS	10	3.5	NS	NS
Chlorsulfuron	0.28	0	2.0	NS	14	1.3	*	*
Trifloxysulfuron	0.04	1	2.6	NS	15	2.1	*	*
Fluroxypyr	0.28	4	2.6	NS	5	2.9	NS	NS
Triclopyr + Diflufenzopyr	0.47	9	5.3	NS	13	5.2	NS	NS
Confront + Diflufenzopyr	0.84	16	1.3	*	44	5.6	*	*

[a]Treatments were applied 9 July, 2001 and evaluated 1 month later.

[b]Repeat application was applied 9 August, 2001 1 month after initial and re-evaluated in 1 month.

[c]Contrast of a single application vs. repeat application.

[d]Diflufenzopyr applied at 0.14 kg ae/ha.

[e]Confront is a 3:1 ratio prepackage-mix of triclopyr + clopyralid.