IV. Virginia Buttonweed (*Diodia virginiana*) Response to Herbicides Supplemented with Dicamba + Diflufenzopyr or Diflufenzopyr

Abstract: A series of field experiments were conducted in 2000 and 2001 to determine if acceptable levels of Virginia buttonweed control and turfgrass tolerance could be obtained with a single herbicide application.

The first two experiments were designed to determine if adding clopyralid or clopyralid + diflufenzopyr to dicamba, 2,4-D + 2,4-DP, chlorsulfuron, fluroxypyr, triclopyr, trifloxysulfuron, and metsulfuron increased control of Virginia buttonweed over herbicides without clopyralid or clopyralid + diflufenzopyr. The addition of clopyralid increased control with these herbicides; however, the further addition of diflufenzopyr did not always increase control. The third experiment examined the effects of combining variable pyridine herbicide rates with variable rates of diflufenzopyr for Virginia buttonweed control. Treatments were triclopyr + clopyralid (3:1 ratio) and fluroxypyr + clopyralid (2:1 ratio) at two rates alone, and in combination with diflufenzopyr. There was no difference in the two rates of diflufenzopyr evaluated, but the presence of diflufenzopyr was significant. Diflufenzopyr is presently marketed in a prepackaged mixture with dicamba. Therefore, a fourth experiment was designed to determine if dicamba + diflufenzopyr could replace diflufenzopyr in tank-mixes and

maintain equivalent Virginia buttonweed control. Dicamba + diflufenzopyr could replace diflufenzopyr and when tank mixed with metsulfuron provided higher levels of control than metsulfuron + diflufenzopyr.

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

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

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

INTRODUCTION

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 produces viable seed both above and below ground and has extensive vegetative reproduction capabilities (Baird et al. 1992; Dute et

[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.

al. 1988). Present recommendations for postemergence control of Virginia buttonweed include multiple applications of two- and three-way mixtures of auxin-type herbicides. While short-term control can be obtained with these treatments, unacceptable turf injury is common (Coats 1986; Jordan 1980).

Pyridine herbicides (clopyralid, fluroxypyr, and triclopyr) control many annual and perennial broadleaf species in rangeland, pasture, and turf (Ahrens 1994; Ross and Lembi 1999). These herbicides may have potential to control Virginia buttonweed and provide less injury to warm-season turfgrass. McGregor (1982) reported 95% control of Virginia buttonweed with triclopyr in greenhouse trials, but results were inconsistent in the field. Triclopyr + clopyralid provided the best control of Virginia buttonweed in trials evaluated by Klosterboer et al. (1999). Fluroxypyr has been shown to provide acceptable weed control and warm-season turf tolerance (Kelly and Coats 2000; Staples and Walker 2001). Taylor et al. (2001) reported that fluroxypyr + clopyralid provided $\geq$ 83% control of Virginia buttonweed. Kelly and Coats (1998) concluded that clopyralid provided control equivalent to dicamba, but demonstrated superior turfgrass tolerance. Synergism has been observed when the auxin-type herbicides were tank-mixed with pyridine carboxylic acids (Kelly 1994; Hamilton et al. 1972).

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 evaluated rates, it did not have significant herbicidal activity (Sciumbato et al. 2000).

Some sulfonylurea herbicides have been shown effective against Virginia buttonweed in warm-season turf. Dickens et al. (1991) reported that metsulfuron at 0.067 kg ai/ha and 2,4-DP at 2.24 kg ai/ha provided the best control of Virginia buttonweed. The combination of these two herbicides were no more effective than either applied alone. Metsulfuron applied at 0.042 kg ai/ha is a recommended treatment for Virginia buttonweed control in Texas (Duble 1999). Kelly and Coats (2000) showed metsulfuron produced 65% control 1 month after treatment (MAT) and 56% 2 MAT. Control was not increased with the addition of 2,4-D. In both studies control decreased over time and it was not clear whether this reduction was due to regrowth of treated plants and/or re-infestation from seeds.

Previous research as outlined above has demonstrated that worthwhile, but not fully acceptable, activity against Virginia buttonweed is available from various sulfonylurea and pyridine herbicides; as well as from other hormone disruptive-type herbicides that are currently used in warm-season turf. We hypothesize that the desired level of control combined with acceptable turfgrass tolerance may be found in various combinations and/or sequential programs using selected members of the aforementioned groups. A series of four experiments were conducted to test this hypothesis with each experiment having separate objectives.

MATERIALS AND METHODS

General procedures. Studies were conducted in 2000 and 2001 at three locations in Alabama. Locations included the Auburn University Turfgrass Research Unit in Auburn (Auburn), Frog Pond Sod Farm in Hurtsboro (Frog Pond), and Beck's Turf Farm in Tuskegee (Beck's). A randomized complete block design was used with all studies with plots 1.2 m wide and length varying from 3 m to 6 m. All treatments were applied using a CO_2-pressurized backpack sprayer with four 6502 flat fan nozzles calibrated to deliver 280 L/ha at 213 Kpa.

Data collection included Virginia buttonweed control and turf tolerance (where available). Weed control was evaluated using a rating scale from 0 to 100 where 0 = no control and 100 = total control. Turfgrass injury was evaluated using a scale from 0 to 100 where 0 = no injury and 100 = death. Within this scale, 0-30% = slight, 31-60 = moderate, and 61-100 = severe injury and a rating > 30% was considered unacceptable.

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 herbicide 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 this study, within treatment variances differed by as much as 400 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 from1 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.

Auburn 1. This experiment was conducted in 2000 to determine if adding clopyralid or clopyralid + diflufenzopyr to dicamba, 2,4-D + 2,4-DP, chlorsulfuron, fluroxypyr, trifloxysulfuron, and metsulfuron increase control of Virginia buttonweed and response of turfgrasses. The experimental area contained a natural population of Virginia buttonweed, but was supplemented with greenhouse-grown plants to ensure a more uniform population. The soil is a Marvin sandy loam (fine-loamy, kaolinitic, thermic Typic Kanhapludults) with 1% organic matter and pH 6.0.

A 41- by 61-cm piece of common centipedegrass [*Eremochloa ophiuroides* (Munro) Hack], 'Palmetto' St. Augustinegrass (*Stenotaphrum secundatum* Walt. Kuntze), 'Meyer' zoysiagrass (*Zoysia japonica* Steud), and 'Tifway' bermudagrass (*Cynodon dactylon X C. transvaalensis* Burtt-Davey) sod was planted in each 1.2- by 6-m plot 10 June, 2000. Placement of sod was random within each of the four replications. Virginia buttonweed control and turfgrass injury were evaluated 4 and 8 weeks after treatment (WAT). These turfgrasses were established 2 months prior to treatment. The test area was mowed at a 5-cm height and supplemental irrigation was applied (6.4 mm 3 times weekly) in the absence of rainfall. Herbicide treatments were considered whole plots and turfgrass species were subplots. Treatments were applied 14 August, 2000.

Beck's 1. This experiment was only conducted in 2001 on a Hyatt loamy sand (fine-loamy, siliceous, active, thermic Typic Endoaqualts) soil that contained 1% organic matter, and pH 6.0. Objective was to determine if Virginia buttonweed control as obtained from the currently used, postemergence-applied herbicides could be enhanced by adding clopyralid, diflufenzopyr, or a mixture of the two. Herbicides included dicamba, 2,4-D+2,4-DP, UHS-302 (MCPA, fluroxypyr, and clopyralid in a 10:2:1 ratio) and triclopyr applied alone at their normal use rate (X rate), ¾ X, ¾ X plus tank-mixed with clopyralid or diflufenzopyr, and ¾ X tank-mixed with clopyralid plus diflufenzopyr. Treatments were applied 18 May, 2001 to Virginia buttonweed growing along a shallow drainage ditch and were not subjected to mowing. Virginia buttonweed control was evaluated 4 and 8 WAT.

Beck's 2. This study was conducted on a Hyatt loamy sand (fine-loamy, siliceous, active, thermic Typic Endoaqualts) soil to determine if Virginia buttonweed control with pyridine mixtures could be enhanced with the addition of diflufenzopyr. Treatments were triclopyr + clopyralid (3:1 ratio) and fluroxypyr + clopyralid (2:1 ratio) applied alone at two rates, and in combination with diflufenzopyr. Treatments were applied on 22 August, 2001 to Virginia buttonweed growing along and in a shallow drainage ditch. Virginia buttonweed control was evaluated 4 and 6 WAT.

Frog Pond and Beck's 3. These studies were conducted in 2001 to determine if dicamba + diflufenzopyr[2] could replace diflufenzopyr in tank-mixes and maintain equivalent Virginia buttonweed control.

The Frog Pond location was on a Springhill loamy sand (fine-loamy, kaolinitic, thermic Typic Kanhapludults) soil. Treatments were applied 22 August, 2001 and the area was mowed at 6 cm 1 week prior to treatment and again 1 MAT. Supplemental irrigation was available from center-pivot systems and applied as needed. Virginia buttonweed control was evaluated 3 and 6 WAT.

At Beck's, treatments were applied 24 August, 2001 to Virginia buttonweed

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[2] Distinct, BASF Corp., Research Triangle Park, NC 27709.

growing along a shallow drainage ditch on a Hyatt loamy sand (fine-loamy, siliceous,

active, thermic Typic Endoaqualts) soil. Virginia buttonweed control was evaluated 4 and 6 WAT.

Auburn 2 and 3. These studies were conducted in 2001 to determine if including dicamba + diflufenzopyr in pyridine tank-mixes would allow reduction of the pyridine herbicide components and increase turfgrass tolerance.

Auburn 2 within the Auburn University Turfgrass Research Unit contained a Marvin sandy loam with 1% organic matter and pH 6.0. This area was fumigated spring 2000 with methyl bromide at 896 kg product/ha. A 41- by 61-cm piece of common centipedegrass, 'Palmetto' St. Augustinegrass, 'Meyer' zoysiagrass, and 'Tifway 419' bermudagrass sod was planted on 10 June, 2000. Placement of sod was random within each of the two replications. Virginia buttonweed seed were sown between the middle two pieces of sod in each replication. The sod and Virginia buttonweed were allowed to grow for the reminder of 2000. Herbicide treatments were considered whole plots and turfgrass species were the subplots. Turfgrass injury was evaluated using the previously described scale. Treatments were applied 22 September, 2001 and both Virginia buttonweed control and turf injury were rated 2 and 5 WAT.

Auburn 3 within the Auburn University Turfgrass Research Unit; Virginia buttonweed seed was collected in the fall of 2000 and stored in a controlled environment (7 C and 42% relative humidity) for 3 months. Seeds were sown March 2001 into a

90:10 sand:peat growth media where they were subjected to wetting and drying cycles for 5 days to stimulate germination. Individual seedlings were transplanted into 1-L styrofoam cups containing the aforementioned growth media. Seedlings were grown for 55 days in a greenhouse environment (21-32 C) and watered 4 times daily. Biweekly, each cup received 50 ml of a solution containing 4 ml/L of 20-10-20. Previous observations of growth of Virginia buttonweed seedlings in the above greenhouse environment demonstrated that perennial rhizomes were present 6 weeks after emergence.

The site was fumigated with metam sodium (Vapam® @ 128 L of product/ha) and tarped the previous fall and seeded to perennial ryegrass (*Lolium perenne* L.) 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.

Three holes with an in-row spacing of 1.5 m were created with a putting green cup cutter in individual plots that contained the dessicated perennial ryegrass. Virginia buttonweed plants grown as previously described were removed from the styrofoam cups and the entire contents of one cup placed into a hole. Each plant received 100 ml of the 4 ml/L 20-10-20 fertilizer solution. In the absence of rain, irrigation was applied to achieve 6.4 mm per week and plants were allowed to grow for 40 days prior to herbicide treatment. Treatments were arranged in a four herbicide by two applications factorial and placed in a randomized complete block design with two replications. Appropriate non-treated controls were also included in each block. Treatments were applied 22 September, 2001 and Virginia buttonweed control was evaluated 2 and 5 WAT.

RESULTS AND DISCUSSION

Auburn 1. Virginia buttonweed control ranging from 75 to 85% was obtained 4 WAT with fluroxypyr, chlorsulfuron, and trifloxysulfuron with or without additives (Table IV. 1). The addition of clopyralid to either 2,4-D + 2,4-DP, dicamba, or dicamba + diflufenzopyr increased control significantly from 33, 58, 33% to 82, 78, and 76%, respectively. The further addition of diflufenzopyr to tank-mixes containing clopyralid did not significantly increase control. A significant increase in control was not observed when clopyralid or clopyralid + diflufenzopyr was added to chlorsulfuron, fluroxypyr, or trifloxysulfuron. Chlorsulfuron and trifloxysulfuron provided the highest levels of control when applied alone 8 WAT. Fluroxypyr was unaltered by the additives.

Unacceptable (>30%) St. Augustinegrass and centipedegrass injury was observed for trifloxysulfuron 4 and 8 WAT (Table IV. 2). 'Meyer' zoysiagrass or 'Tifway' bermudagrass did not show injury symptoms at either rating date, thus the data is not included. This data is similar to the findings of Brecke and Unruh (2000). They reported unacceptable injury to St. Augustinegrass and no injury to zoysiagrass and hybrid bermudagrass with rates of trifloxysulfuron ranging from 0.024 to 0.10 kg ai/ha. Teuton et al. (2001) reported excellent tolerance of 'TifEagle' bermudagrass to multiple applications of trifloxysulfuron, but St. Augustinegrass injury was variable and cultivar dependent.

Beck's 1. Virginia buttonweed control ranged from 16 to 35% 4 WAT and near zero 8 WAT for all treatments when applied without the clopyralid, diflufenzopyr or clopyralid + diflufenzopyr additives (Table IV. 3). In general, a betterment in Virginia buttonweed control was observed when herbicides were applied with the clopyralid additive, but did not exceed 56%. When diflufenzopyr replaced clopyralid, there was a general betterment in Virginia buttonweed control, but only triclopyr combination produced near acceptable results (79%) 8 WAT. Herbicides receiving both clopyralid and diflufenzopyr additives showed a betterment in Virginia buttonweed control and two herbicide treatments produced control above 70%: 1) UHS 302 = 73 and 71% 4 and 8 WAT; triclopyr = 83 and 81% for the respective WAT. Percent Virginia buttonweed control in this study was low and can be attributed in part to large, unmowed weeds without turfgrass competition. However, data do illustrate that clopyralid and/or diflufenzopyr can be used to enhance efficacy of pyridine herbicides against Virginia buttonweed.

Beck's 2. All treatments provided ≥ 83% control of Virginia buttonweed (Table IV. 4). The presence of diflufenzopyr increased control levels of both rates of triclopyr + clopyralid and the lower rate of fluroxypyr + clopyralid to 99% 4 WAT. Triclopyr + clopyralid and fluroxypyr + clopyralid applied alone provided 83 to 92% control respectively, 6 WAT. The addition of diflufenzopyr increased all treatments to ≥ 97%

control. Rates of diflufenzopyr evaluated were not significantly different when applied with either herbicide.

Frog Pond and Beck's 3. At the Frog Pond location, tank-mixtures provided better control than triclopyr (49%), triclopyr + clopyralid (90%), or metsulfuron (60%) applied alone 3 WAT (Table IV. 5). Triclopyr + dicamba + diflufenzopyr provided 99% control and was superior to triclopyr + diflufenzopyr (87%). Addition of dicamba + diflufenzopyr to metsulfuron provided 96% control and was significantly better than metsulfuron + diflufenzopyr (66%). Excellent control (≥90%) was obtained with fluroxypyr, triclopyr + clopyralid and fluroxypyr + clopyralid applied alone and with either dicamba + diflufenzopyr or diflufenzopyr.

All treatments except triclopyr applied alone provided ≥ 91% control of Virginia buttonweed 2 weeks after the second application. Dicamba + diflufenzopyr added to triclopyr and metsulfuron provided higher levels (99%) of control than diflufenzopyr (90 and 94%) added to these two herbicides.

At Beck's all herbicide mixtures except triclopyr + clopyralid provided greater Virginia buttonweed control 3 WAT than herbicides applied alone. Triclopyr + clopyralid provided ≥ 90% control applied alone, with dicamba + diflufenzopyr, or diflufenzopyr. Dicamba + diflufenzopyr and diflufenzopyr provided equivalent control as tank-mix components with all treatments except metsulfuron. Metsulfuron + dicamba + diflufenzopyr provided 88% control and was superior to metsulfuron + diflufenzopyr that provided only 60%.

With the exception of triclopyr + clopyralid, herbicide mixtures containing fluroxypyr provided better Virginia buttonweed control 6 WAT than individual herbicides applied alone. Metsulfuron + dicamba + diflufenzopyr was better than metsulfuron + diflufenzopyr resulting 87 and 73% control, respectively. There was no difference detected when triclopyr, fluroxypyr, triclopyr + clopyralid, or fluroxypyr + clopyralid was tank-mixed with either dicamba + diflufenzopyr or diflufenzopyr.

Inspection of data at both locations revealed that triclopyr + clopyralid, fluroxypyr + clopyralid, and fluroxypyr provided equivalent control of Virginia buttonweed when mixed with either diflufenzopyr or dicamba + diflufenzopyr. Herbicide mixtures that included diflufenzopyr always provided better control than metsulfuron applied alone. Greater enhancement of metsulfuron was realized when mixed with dicamba + diflufenzopyr rather than just diflufenzopyr.

Auburn 2 and 3. At both locations, dicamba + diflufenzopyr combinations with fluroxypyr + clopyralid or triclopyr + clopyralid provided better control than dicamba + diflufenzopyr applied alone (Table IV. 6). There was no significant difference in Virginia buttonweed control with fluroxypyr + clopyralid or triclopyr + clopyralid in combination with dicamba + diflufenzopyr where both treatments provided $\geq$ 94% control.

For Auburn 2, fluroxypyr + clopyralid + dicamba + diflufenzopyr injured St. Augustinegrass 39 and 18% 3 and 6 WAT, respectively (Table IV. 6). Turfgrass injury resulting from triclopyr + clopyralid + dicamba + diflufenzopyr was < 8% for all cultivars. Dicamba + diflufenzopyr applied alone at all rates did not result in any turfgrass injury.

Through these experiments we were able to identify herbicide combinations that produced excellent control of Virginia buttonweed and acceptable warm-season turfgrass injury levels with a single application. Though diflufenzopyr is not herbicidally active at the rates used, consistent improvement in control of Virginia buttonweed was obtained when mixed with triclopyr or fluroxypyr.

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Table IV. 1. Effects of adding clopyralid or clopyralid + diflufenzopyr to selected herbicides for Virginia buttonweed control, Auburn 2000.

	Treatment			4 WAT			8 WAT		
Herbicide	Rate	Clopyralid[a]	Diflufenzopyr[b]	Control	SE	$P > 0$	Control	SE	$P > 0$
	kg a/ha[c]			%			%		
Dicamba	0.28	---	---	58	1.3	*	53	1.7	*
Trifloxysulfuron	0.04	---	---	75	4.8	*	83	1.7	*
2,4-D + 2,4-DP	0.28 + 0.28	---	---	33	3.1	*	55	2.9	*
Fluroxypyr	0.28	---	---	82	1.3	*	87	1.7	*
Dicamba + diflufenzopyr[d]	0.28	---	---	33	3.1	*	52	1.7	*
Chlorsulfuron	0.28	---	---	85	1.3	*	91	0.7	*
None		Yes	---	43	1.3	*	63	1.7	*
Dicamba	0.28	Yes	---	78	1.3	*	68	1.5	*
Trifloxysulfuron	0.04	Yes	---	79	1.3	*	75	2.9	*
2,4-D + 2,4-DP	0.28 + 0.28	Yes	---	82	3.1	*	73	1.7	*
Fluroxypyr	0.28	Yes	---	87	1.3	*	92	1.5	*
Dicamba + diflufenzopyr	0.28	Yes	---	76	1.3	*	78	1.7	*
Chlorsulfuron	0.28	Yes	---	83	3.1	*	80	2.9	*
None		Yes	Yes	42	1.3	*	53	1.7	*
Dicamba	0.28	Yes	Yes	77	1.3	*	82	1.7	*
Trifloxysulfuron	0.04	Yes	Yes	72	1.3	*	73	1.7	*
2,4-D + 2,4-DP	0.28 + 0.28	Yes	Yes	77	1.3	*	83	1.7	*
Fluroxypyr	0.28	Yes	Yes	89	1.3	*	94	2.1	*
Dicamba + diflufenzopyr	0.28	Yes	Yes	80	1.3	*	85	1.7	*
Chlorsulfuron	0.28	Yes	Yes	81	1.3	*	85	0.3	*
None		---	Yes	3	1.3	*	20	2.9	*
Non-treated		---	---	0	1.3	NS	23	1.7	*

Table IV. 1 continued.

Contrast	Est.	SE	P > 0	Est.	SE	P > 0
Dicamba alone vs dicamba with supplements	38	3.1	*	43	4.0	*
Dicamba with supplement 1 vs with supplement 2	0	1.8	NS	14	2.2	*
Trifloxysulfuron alone vs trifloxysulfuron with supplements	1	9.7	NS	-18	4.7	*
Trifloxysulfuron with supplement 1 vs with supplement 2	-7	1.8	*	-2	3.3	NS
2,4-D+2,4-DP alone vs 2,4-D+2,4-DP with supplements	92	7.0	*	47	6.2	*
2,4-D+2,4-DP with supplement 1 vs with supplement 2	-5	3.3	NS	10	2.4	*
Fluroxypyr alone vs fluroxypyr with supplements	11	3.1	*	13	4.2	*
Fluroxypyr with supplement 1 vs with supplement 2	1	1.8	NS	2	2.5	NS
Distinct alone vs distinct with supplements	89	6.4	*	60	4.1	*
Distinct with supplement 1 vs distinct with supplement 2	4	1.8	*	7	2.4	*
Chlorsuluron alone vs chlorsulfuron with supplements	-6	4.2	NS	-16	3.2	NS
Chlorsuluron with suppl. 1 vs chlorsulfuron with suppl. 2	-3	3.3	NS	5	2.9	NS

[a] Clopyralid applied at 0.28 kg ae/ha.

[b] Diflufenzopyr applied at 0.17 kg ae/ha.

[c] Rate reported as kg of active (acid equivalent or active ingredient).

[d] Distinct is a prepackaged mix of dicamba and diflufenzopyr in a 2.5:1 ratio.

Table IV. 2. Turfgrass response to adding clopyralid + diflufenzopyr to selected herbicides for Virginia buttonweed control, Auburn 2000.

				4 WAT						8 WAT					
				Centipedegrass			St. Augustinegrass			Centipedegrass			St. Augustinegrass		
Herbicide	Rate	Clopyralid[a]	Diflufenzopyr[b]	Injury	SE	$P > 0$	Injury	SE	$P > 0$	Injury	SE	$P > 0$	Injury	SE	$P > 0$
	kg a/ha[c]			%			%			%			%		
Dicamba	0.28	---	---	0	2.6	NS	0	1.5	NS	0	1.1	NS	0	1.1	NS
Trifloxysulfuron	0.04	---	---	43	3.7	*	48	1.5	*	62	1.5	*	60	1.1	*
2,4-D+2,4-DP	0.28 + 0.28	---	---	3	1.7	NS	3	1.7	NS	0	1.1	NS	0	1.1	NS
Fluroxypyr	0.28	---	---	13	4.4	*	0	1.5	NS	0	1.1	NS	0	1.1	NS
Distinct[d]	0.28	---	---	8	1.7	*	0	1.5	NS	0	1.1	NS	0	1.1	NS
Chlorsulfuron	0.28	---	---	22	6.7	*	5	5.0	*	23	1.7	*	23	1.7	*
None	---	Yes	---	0	2.6	NS	0	1.5	NS	0	1.1	NS	0	1.1	NS
Dicamba	0.28	Yes	---	3	3.3	NS	0	1.5	NS	0	1.1	NS	0	1.1	NS
Trifloxysulfuron	0.04	Yes	---	47	3.3	*	37	6.7	*	58	1.7	*	33	1.5	*
2,4-D+2,4-DP	0.28 + 0.28	Yes	---	3	3.3	NS	0	1.5	NS	12	1.7	*	13	1.7	*
Fluroxypyr	0.28	Yes	---	3	1.7	NS	0	1.5	NS	15	2.9	*	7	1.7	*
Distinct[d]	0.28	Yes	---	3	1.7	NS	0	1.5	NS	3	1.7	NS	0	1.1	NS
Chlorsulfuron	0.28	Yes	---	10	5.0	NS	0	1.5	NS	25	2.9	*	28	1.7	*
None	---	---	Yes	0	2.6	NS	2	1.7	NS	0	1.1	NS	0	1.1	NS
Dicamba	0.28	---	Yes	7	6.7	NS	2	1.7	NS	23	1.7	*	3	1.7	*
None	---	Yes	Yes	3	3.3	NS	0	1.5	NS	18	1.7	*	15	2.9	*
Dicamba	0.28	Yes	Yes	13	1.7	*	5	2.9	NS	18	1.7	*	5	2.9	*
Trifloxysulfuron	0.04	Yes	Yes	38	1.7	*	40	2.9	*	47	1.0	*	44	2.3	*
2,4-D+2,4-DP	0.28 + 0.28	Yes	Yes	2	1.7	NS	2	1.7	NS	18	1.7	*	15	2.9	*
Fluroxypyr	0.28	Yes	Yes	15	7.6	NS	0	1.5	NS	20	2.3	*	10	2.9	*
Distinct[d]	0.28	Yes	Yes	13	6.7	NS	5	2.9	NS	28	1.7	*	8	1.7	*
Chlorsulfuron	0.28	Yes	Yes	7	1.7	*	2	1.7	NS	28	1.5	*	13	1.7	*
Non-treated	---	---	---	0	2.6	NS	0	1.5	NS	0	1.1	NS	0	1.1	NS

Table IV. 2 continued.

	4 WAT						8 WAT					
	Centipedegrass			St. Augustinegrass			Centipedegrass			St. Augustinegrass		
Contrast	Est.	SE	P > 0	Est.	SE	P > 0	Est.	SE	P > 0	Est.	SE	P > 0
Dicamba alone vs 1 and 2 suppl	17	6.4	*	5	4.5	NS	18	2.9	*	5	3.9	NS
Dicamba with suppl 1 vs with suppl 2	10	3.7	*	5	3.3	NS	18	2.0	*	5	3.1	NS
Trifloxysulfuron alone vs 1and2 suppl	0	8.3	NS	-19	7.8	*	-19	3.5	*	-43	3.6	*
Trifloxysulfuron with suppl 1 vs with suppl 2	-8	3.7	*	3	7.3	NS	-11	1.9	*	12	2.7	*
2,4-D+2,4-DP alone vs 1and 2 suppl	-2	5.0	NS	-5	4.0	NS	30	3.2	*	28	4.0	*
2,4-D+2,4-DP with suppl 1 vs with suppl 2	-2	3.7	NS	2	2.3	NS	7	2.4	*	2	3.3	NS
Fluroxypyr alone vs 1and 2 suppl	-8	11.8	NS	0	3.8	NS	69	4.3	*	17	4.0	*
Fluroxypyr with suppl 1 vs with suppl 2	12	7.8	NS	0	2.2	NS	39	3.7	*	3	3.3	NS
Distinct alone vs 1and 2 suppl	0	7.6	NS	5	4.5	NS	32	3.2	*	8	3.1	*
Distinct with suppl 1 vs with suppl 2	10	6.9	NS	5	3.3	NS	25	2.4	*	8	2.0	*
Chlorsulfuron alone vs 1and 2 suppl	-27	14.3	NS	-8	10.3	NS	6	4.6	NS	-5	4.1	NS
Chlorsulfuron with suppl 1 vs with suppl 2	-3	5.3	NS	2	2.3	NS	3	3.2	NS	-15	2.4	*

[a] Clopyralid applied at 0.28 kg acid equivalent/ha.

[b] Diflufenzopyr applied at 0.17 kg acid equivalent/ha.

[c] Rate reported as kg of active/ha (kg a/ha is acid equivalent for all herbicides except chlorsulfuron and trifloxysulfuron which is active ingredient).

[d] Distinct is a prepackaged mix of dicamba and diflufenzopyr in a 2.5:1 ratio.

Table IV. 3. Postemergence additives to enhance herbicidal control of Virginia buttonweed control at Beck's, 2001.

Treatment				4 WAT			8 WAT		
Base	Rate[a]	Clopyralid[b]	Diflufenzopyr[c]	% Control	SE	$P > 0$	% Control	SE	$P > 0$
Dicamba	0.28	---	---	20	2.0	*	0	1.4	NS
2,4-D+2,4-DP[d]	1.12	---	---	26	2.4	*	4	2.4	NS
UHS-302[e]	1.12	---	---	35	2.0	*	5	2.9	NS
Triclopyr	0.63	---	---	21	2.4	*	0	1.4	NS
Dicamba	0.21	---	---	16	2.4	*	0	1.4	NS
2,4-D+2,4-DP	0.84	---	---	26	2.4	*	0	1.4	NS
UHS-302	0.84	---	---	28	3.2	*	0	1.4	NS
Triclopyr	0.47	---	---	28	3.2	*	0	1.4	NS
None	---	Yes	---	18	3.2	*	3	2.5	NS
Dicamba	0.21	Yes	---	33	3.2	*	0	1.4	NS
2,4-D+2,4-DP	0.84	Yes	---	56	2.4	*	36	2.4	*
UHS-302	0.84	Yes	---	36	2.4	*	21	1.3	*
Triclopyr	0.47	Yes	---	31	2.4	*	23	1.3	*
None	---	---	Yes	0	1.4	*	3	2.5	NS
Dicamba	0.21	---	Yes	55	2.0	*	3	2.5	NS
2,4-D+2,4-DP	0.84	---	Yes	45	2.0	*	16	2.4	*
UHS-302	0.84	---	Yes	43	3.2	*	60	2.0	*
Triclopyr	0.47	---	Yes	73	2.7	*	79	3.1	*
None	---	Yes	Yes	18	1.4	*	5	2.9	NS
Dicamba	0.21	Yes	Yes	61	4.3	*	46	2.4	*
2,4-D+2,4-DP	0.84	Yes	Yes	60	2.0	*	45	2.9	*
UHS-302	0.84	Yes	Yes	73	1.4	*	71	1.3	*
Triclopyr	0.47	Yes	Yes	83	1.4	*	81	1.3	*
Non-treated	---	---	---	0	1.7	NS	0	1.4	NS

Table IV. 3 continued.

	4 WAT			8 WAT		
Contrast	Est.	SE	P > 0	Est.	SE	P > 0
Herbicide vs. non-treated	905	58.0	*	500	44.9	*
Clopyralid vs. dicamba	-1	6.0	NS	5	4.7	NS
Clopyralid + dicamba vs. others	-502	55.5	*	-385	43.0	*
Dicamba vs. others	-55	12.1	*	-9	9.4	NS
2,4-D + 2,4-DP vs. triclopyr	-6	8.6	NS	3	6.6	NS
UHS vs. triclopyr	14	4.9	*	5	3.8	NS
Dicamba vs. clopyralid mixtures	-26	8.6	*	-80	6.6	*
2,4-D + 2,4-DP vs. pyridine/clopyralid mixtures	45	6.0	*	29	4.7	*
UHS vs. triclopyr + clopyralid	5	3.5	NS	-1	2.7	NS
Clopyralid mixtures vs high rate of herbicides alone	59	7.0	*	80	5.4	*
Dicamba vs. diflufenzopyr mixtures	4	8.6	NS	-148	6.6	*
2,4-D + 2,4-DP vs. pyridine + diflufenzopyr mixtures	-26	6.0	*	-106	4.7	*
UHS vs. triclopyr + diflufenzopyr	-31	3.5	*	-19	2.7	*
Diflufenzopyr mixtures vs high rate of herbicides alone	118	7.0	*	158	5.4	*
Dicamba vs. diflufenzopyr + clopyralid mixtures	-31	8.6	*	-59	6.6	*
2,4-D + 2,4-DP vs. pyridine with diflufenzopyr + clopyralid	-35	6.0	*	-63	4.7	*
UHS vs. triclopyr + diflufenzopyr + clopyralid	-10	3.5	*	-10	2.7	*
Diflufenzopyr + clopyralid mixtures vs high rate of herbicid	179	7.0	*	244	5.4	*

[a]Rate = kg acid equivalent/ha.

[b]Clopyralid applied at 0.28 kg acid equivalent/ha.

[c] Diflufenzopyr applied at 0.17 kg acid equivalent/ha.

[d]2,4-D + 2,4-DP 1:1 ratio

[e]UHS-302 is a 10:2:1 ratio prepackage mixture of MCPA, fluroxypyr, and clopyralid, respectively.

Table IV. 4. Diflufenzopyr enhancement of pyridine-base tank mixtures for Virginia buttonweed control at Beck's 2001.

Treatment				Virginia Buttonweed					
				4 WAT			6 WAT		
Base	Rate[a]	Supplement	Rate	% Control	SE	P > 0	% Control	SE	P > 0
Triclopyr + Clopyralid[b]	0.84			89	0.3	*	92	1.7	*
Triclopyr + Clopyralid	0.56			84	2.4	*	86	2.5	*
Triclopyr + Clopyralid	0.84	Diflufenzopyr	0.14	99	0.5	*	99	0.7	*
Triclopyr + Clopyralid	0.84	Diflufenzopyr	0.28	99	0.3	*	99	0.7	*
Triclopyr + Clopyralid	0.56	Diflufenzopyr	0.14	99	0.5	*	98	0.7	*
Triclopyr + Clopyralid	0.56	Diflufenzopyr	0.28	99	0.5	*	99	0.3	*
Fluroxypyr + Clopyralid[c]	0.28			99	0.3	*	87	1.7	*
Fluroxypyr + Clopyralid	0.19			91	0.5	*	83	0.7	*
Fluroxypyr + Clopyralid	0.28	Diflufenzopyr	0.14	99	0.5	*	99	0.3	*
Fluroxypyr + Clopyralid	0.28	Diflufenzopyr	0.28	99	0.3	*	99	0.3	*
Fluroxypyr + Clopyralid	0.19	Diflufenzopyr	0.14	99	0.3	*	97	2.5	*
Fluroxypyr + Clopyralid	0.19	Diflufenzopyr	0.28	99	0.3	*	99	0.3	*
Non-treated				0	0.5	NS	0	0.7	NS

[a]Rate reported in kg acid equivalent/ha

[b]Triclopyr and clopyralid in a 3:1 ratio.

[c]Fluroxypr and clopyralid in a a 2:1 ratio.

Table IV. 5. Two locations where dicamba + diflufenzopyr versus diflufenzopyr alone 3 and 6 weeks after treatment (WAT) for enhancing Virginia buttonweed control with selected tank mixtures.

				Frog Pond						Beck's					
				3 WAT			6 WAT			3 WAT			6 WAT		
Herbicide	Rate[a]	Supplement	Rate	% Control	SE	$P > 0$	% Control	SE	$P > 0$	% Control	SE	$P > 0$	% Control	SE	$P > 0$
Triclopyr	0.63			49	3.3	*	48	2.5	*	87	2.3	*	82	4.6	*
Fluroxypyr	0.28			97	0.8	*	99	0.3	*	85	1.0	*	90	2.3	*
Metsulfuron	0.06			60	3.3	*	91	1.3	*	48	2.3	*	55	5.2	*
Triclopyr + Clopyralid[b]	0.84			90	2.1	*	94	2.5	*	90	3.1	*	91	1.3	*
Fluroxypyr + Clopyralid[c]	0.42			97	1.1	*	94	2.5	*	81	2.3	*	87	5.2	*
Dicamba + Diflufenzopyr	0.56			93	2.1	*	98	0.9	*	90	1.0	*	89	2.3	*
Triclopyr	0.63	Diflufenzopyr	0.14	87	1.1	*	90	2.5	*	98	1.0	*	94	2.3	*
Fluroxypyr	0.28	Diflufenzopyr	0.14	98	0.8	*	99	0.3	*	96	1.0	*	96	1.3	*
Metsulfuron	0.06	Diflufenzopyr	0.14	66	2.1	*	94	0.3	*	60	2.3	*	73	5.2	*
Triclopyr + Clopyralid	0.84	Diflufenzopyr	0.14	99	0.2	*	99	0.3	*	98	1.0	*	99	1.3	*
Fluroxypyr + Clopyralid	0.42	Diflufenzopyr	0.14	99	0.2	*	99	0.3	*	98	1.0	*	99	1.3	*
Triclopyr	0.63	Dicamba + diflufenzopyr	0.56	99	0.2	*	99	0.3	*	96	1.0	*	98	1.3	*
Fluroxypyr	0.28	Dicamba + diflufenzopyr	0.56	98	0.2	*	97	2.5	*	98	1.0	*	92	2.3	*
Metsulfuron	0.06	Dicamba + diflufenzopyr	0.56	96	2.1	*	99	0.3	*	88	3.5	*	87	2.3	*
Triclopyr + Clopyralid	0.84	Dicamba + diflufenzopyr	0.56	99	0.2	*	100	0.3	*	99	1.0	*	99	1.3	*
Fluroxypyr + Clopyralid	0.42	Dicamba + diflufenzopyr	0.56	99	0.2	*	99	0.3	*	97	1.0	*	99	1.3	*

Table IV. 5 continued.

	Frog Pond Sod Farm						Beck's Sod Farm					
	3 WAT			6 WAT			3 WAT			6 WAT		
Contrast	Est.	SE	P-value	Est.	SE	P-value	Est.	SE	P-value	Est.	SE	P-value
Triclopyr vs mixtures	-88	6.8	*	-94.500	5.689	*	-20.750	4.712	*	-27.750	9.542	*
Triclopyr Distinct vs. Diflufenzopyr	12	1.1	*	9.000	2.556	*	-1.250	1.374	NS	3.750	2.606	NS
Fluroxy vs mixtures	-1	1.8	NS	1.500	2.614	NS	-23.750	2.335	*	-8.750	5.235	NS
Fluroxy Distinct vs. Diflufenzopyr	1	0.8	NS	-2.500	2.556	NS	1.250	1.348	NS	-3.750	2.606	NS
Metsulfuron vs. mixtures	-42	7.3	*	-10.250	2.530	*	-52.000	6.149	*	-50.750	11.802	*
Metsulfuron Distinct vs. Diflufenzopyr	29	3.0	*	4.750	0.387	*	28.000	4.183	*	13.250	5.655	*
Confront vs. mixtures	-19	4.2	*	-10.250	5.097	NS	-16.250	6.277	NS	-15.250	3.135	*
Confront Distinct vs. Diflufenzopyr	0	0.3	NS	0.250	0.387	NS	0.250	1.348	NS	0.250	1.810	NS
Starcom vs. mixtures	-4	2.2	NS	-10.250	5.097	NS	-33.250	4.712	*	-23.250	10.516	*
Starcom Distinct vs. Diflufenzopyr	0	0.3	NS	0.250	0.387	NS	-1.250	1.374	NS	0.250	1.810	NS

[a]Rate reported in kg active/ha

[b]Triclopyr and clopyralid is prepackaged as Confront in a 3:1 ratio.

[c]Fluroxypyr + clopyralid is a tank mixture at 2:1 ratio.

[d]Dicamba + diflufenzopyr is prepackaged as Distinct in a 2.5:1 ratio.

Table IV. 6. Dicamba + diflufenzopyr as partial replacement of pyridine components of tank mixtures for increased turf tolerance and control of Virginia buttonweed.

				Location 1						Location 2					
Herbicide	Rate	Supplement	Rate	3 WAT	SE	$P > 0$	6 WAT	SE	$P > 0$	3 WAT	SE	$P > 0$	6 WAT	SE	$P > 0$
	- kg ae/ha-		- kg ae/ha-	% Control			% Control			% Control			% Control		
Dicamba + Diflufenzopyr[a]	0.56	Fluroxypyr + Clopyralid[b]	0.34	88	1.8	*	99	1.3	*	92	2.5	*	99	0.8	*
Dicamba + Diflufenzopyr	0.56	Triclopyr + Clopyralid[c]	0.45	89	1.8	*	94	1.3	NS	83	2.5	*	95	0.8	*
Dicamba + Diflufenzopyr	0.56			58	1.8	*	78	1.3	NS	38	2.5	*	82	0.8	*
Non-treated				0	1.8	NS	0	1.3	NS	0	2.5	NS	0	0.8	NS

				Location 1											
				Centipedgrass						St. Augustinegrass					
Herbicide		Supplement		3 WAT	SE	$P > 0$	6 WAT	SE	$P > 0$	3 WAT	SE	$P > 0$	6 WAT	SE	$P > 0$
				% Injury			% Injury			% Injury			% Injury		
Dicamba + Diflufenzopyr	0.56	Fluroxypyr + Clopyralid	0.34	8	1.3	*	1	0.9	NS	39	3.8	*	18	1.3	*
Dicamba + Diflufenzopyr	0.56	Triclopyr + Clopyralid	0.45	0	1.3	NS	9	3.3	*	8	3.8	NS	0	1.3	NS
Dicamba + Diflufenzopyr	0.56			0	1.3	NS	1	0.9	NS	0	3.8	NS	0	1.3	NS
Non-treated				0	1.3	NS	8	6.0	NS	0	3.8	NS	0	1.3	NS
				Zoysiagrass						Bermudagrass					
Dicamba + Diflufenzopyr	0.56	Fluroxypyr + Clopyralid	0.34	0	1.2	NS	0	1.2	NS	8	1.3	*	0	2.0	NS
Dicamba + Diflufenzopyr	0.56	Triclopyr + Clopyralid	0.45	0	1.2	NS	0	1.2	NS	0	1.3	NS	0	2.0	NS
Dicamba + Diflufenzopyr	0.56			0	1.2	NS	0	1.2	NS	0	1.3	NS	0	2.0	NS
Non-treated				0	1.2	NS	2	2.2	NS	0	1.3	NS	0	2.0	NS

[a] 2.5:1 ratio.

[b] 2:1 ratio.

[c] 3:1 ratio.