HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

The use of any trade name in this article does not imply an endorsement of the equipment, product or process named, nor any criticism of any similar products that are not mentioned.

Pansy Tolerance to Preemergence Herbicides[1]

James E. Altland[2], Charles H. Gilliam[3], J. Raymond Kessler Jr.[4], Elizabeth M. Wallace[2], and Amy M. Riggs[5]
Department of Horticulture
Auburn University, AL 36849

Abstract

Three studies were conducted to determine tolerance of pansy cultivars to preemergence applied herbicides. In the first two studies, three cultivars were evaluated for tolerance. In the first study plants were small at the time of treatment [5 cm (2 in) in height]. Herbicides that caused no injury or shoot dry weight (SDW) reduction of 'Crystal Bowl True Blue' and 'Maxim Orange' were Corral (pendimethalin) and Pennant (metholachlor). With 'Imperial Antique Shades', only Pennant 5G caused no injury or SDW reduction. In the second study, with larger transplants [12 to 15 cm (5 to 6 in) in height], the same three pansy cultivars appeared more tolerant of applied herbicides. With 'Crystal Bowl True Blue' only Rout 3G and Pendulum 60WDG caused injury and reduced SDW, while with 'Maxim Orange' those two plus Ronstar caused injury or SDW reduction. 'Imperial Antique Shades' again was the most sensitive cultivar with five herbicides causing injury or SDW reduction. In the third study, two cultivars, 'Bingo' and 'Majestic Giant', were treated with 11 herbicides. Corral, Treflan, and Factor caused no injury to either cultivar.

Index words: weed control, annual bedding plants, fall bedding plants.

Herbicides used in this study: Rout 3G, (oxyfluorfen), [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4 (trifluoromethyl) benzene + (oryzalin), 3, 5-dinitro-N_4, N_4-dipropylsulfanilamide]; Surflan 4AS (oryzalin); Corral 2.68G, Pendulum 2G, and Pendulum 60WDG (pendimethalin), N- (1-ethylpropyl)-3, 4 dimethyl-2, 6-dinitrobenzenamine; Ronstar 2G (oxadiazon), 3-[2, 4 dichloro-5- (methylethoxy) phenyl]-5-(1,1-dimethyl ethyl) -1, 3, 4- oxadiazol-2-(3H)-one; Factor 65WDG and RegalKade 0.5G (prodiamine) N_3,N_3-Di-n-propyl-2, 4-dinitro-6-(trifluoromethyl)-m- phenylenediamine; Regal 0-0 (oxyfluorfen+oxadiazon); Regal Star 1.2G (prodiamine + oxadiazon); Gallery 75DF (isoxaben), N-[3-(1-ethyl-1 methylpropyl)-5-isoxazolyl]-2, 6-dimethoxybenzamide: Treflan 5G (trifluralin), 2, 6-dinitro-N, *N*-dipropyl-4-(trifluoromethyl) benzenamine; Snapshot 2.5TG (trifluralin + isoxaben); Stakeout 0.1G [dithiopyr, (Monsanto 15179)] (S, S-Dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3, 5- pyridinedicarbothioate); Pennant 5G and 7.8E (metolachlor), 2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide; Princep 4L (simazine), 2-chloro-4, 6-bis(ethylamino)-s-triazine; Manage 50 WP (halosulfuron) methyl 5-{[(4,6-dimethoxy-2-pyrimidinyl) amino] carbonylaminosulfonyl} -3-chloro-1-methyl-1-*H*-pyrazol-4-carboxylate.

Species used in this study: pansy (*Viola* x *wittrockiana* Gams. 'Crystal Bowl True Blue', 'Maxim Orange', 'Imperial Antique Shades', 'Bingo', and 'Majestic Giant').

Significance to the Nursery Industry

There is an increasing trend for using annual bedding plants to provide season-long color in commercial and residential landscapes. Pansies (*Viola sp.*) provide color throughout the fall, winter, and early spring, depending on local climate, and are among the most widely planted fall annuals. Weed control through use of preemergence herbicides is common among many landscape professionals. However, most research regarding bedding plant tolerance to preemergence herbicides has focused on summer annuals. The following data show the herbicides Corral 2.68G, Treflan 5G, RegalKade 0.5G, Regal Star 1.2G, and Factor 65DG did not injure any of the container-grown pansies evaluated; while Rout 3G, Pendulum 60WDG, Surflan 4AS, Gallery 75DF, and Princep 4L caused severe injury or shoot dry weight reductions, and should not be used over pansies in the landscape. Pansy tolerance to other herbicides varied.

Introduction

Weed control in newly-planted annual beds can be difficult and time consuming. There is a current industry trend for increasing use of annual bedding plants to provide season-long color in commercial landscapes. In the southern United States, this may be accomplished by planting summer annuals in the spring, followed by cool season crops like pansies in the fall. While weed control is a problem in most annual flowering beds throughout the year, most weed control research has focused on summer annuals. Fretz (4) compared eight herbicides on 15 annual bedding plants with varying results. Plant injury was least with trifluralin, which injured three of the 15 bedding plants tested. Gilbertz and Johnson (5) evaluated 13 herbicides on six commonly used annual bedding plant species and reported that plant response varied by herbicide, rate applied, and in some cases the year applied. In other work (6), four bedding plant species were evaluated for injury with prodiamine and oxadiazon. Growth of all four species decreased with increasing prodiamine rate, while oxadiazon was non-injurious to any species. Thetford et al. (8) compared several herbicides on eight summer annual species and demonstrated that several granular preemergence herbicides were safe on ageratum, celosia, geranium, impatiens and marigold. However, limited information is available on fall planted herbaceous plants (7). Pansy is one of the most widely planted fall annuals (2) in the southern United States and may provide color from October through May. During this time, several winter annual weeds are problems in the landscape. Little information is available on pansy tolerance to preemergence herbicides. The objective of this study was to determine pansy tolerance to selected preemergence herbicides.

Materials and Methods

Experiment 1. Uniform 48-cell pack liners (about 5 cm (2 in) in height) of three pansy (*Viola* x *wittrockiana* Gams.)

[1]Received for publication February 16, 2001; in revised form May 29, 2001.

[2]Graduate Research Assistant.

[3]Professor of Horticulture.

[4]Associate Professor.

[5]Undergraduate student.

cultivars ('Crystal Bowl True Blue', 'Maxim Orange' and 'Imperial Antique Shades') were potted in 2.8 liter (3 quart) containers on September 22, in a 6:1 pine bark:sand medium amended per m^3 (yd^3) with 8.3 kg (14 lb) of Osmocote 17N–3.1P–10K (17–7–12) (Scotts Co., Marysville, OH), 2.97 kg (5 lb) of dolomitic limestone, and 0.9 kg (1.5 lb) of Micromax (Scotts Co.). Plants were placed under 47% shade and watered as needed with overhead irrigation. On September 27, the following herbicides were applied: Southern Weed Grass (currently labeled as Corral 2.68G (pendimethalin)) (Scotts Co., Greensboro, NC) at 4.5 kg ai/ha (4 lb ai/A), Pennant 5G (metolachlor) (Novartis Crop Protection Inc., Greensboro, NC) at 4.5 kg ai/ha (4 lb ai/A), Ronstar 2G (oxadiazon) (Aventis ES, Montvale, NJ) at 4.5 kg ai/ha (4 lb ai/A), Rout 3G (oxyfluorfen + oryzalin) (Scotts Co.) at 3.4 kg ai/ha (3 lb ai/A), Stakeout 0.1G (dithiopyr) (Rohm and Haas, Philadelphia, PA) at 1.1 kg ai/ha (1 lb ai/A), Snapshot 2.5TG (isoxaben + trifluralin) (Dow AgroSciences, Indianapolis, IN) at 2.7 kg ai/ha (2.5 lb ai/A), Factor 65WDG (prodiamine) (Novartis Crop Protection Inc.) at 2.2 kg ai/ha (2.0 lb ai/A), Pendulum 60WDG (pendimethalin) (BASF, Research Triangle Park, NC) at 4.5 kg ai/ha (4 lb ai/A), Surflan 4AS (oryzalin) (Dow AgroSciences) at 4.5 kg ai/ha (4 lb ai/A), Pennant 7.8E (metolachlor) (Novartis Crop Protection Inc.) at 4.5 kg ai/ha (4 lb ai/A), and Manage 50WP (halosulfuron) (Monsanto Co., St. Louis, MO) at 0.07 kg ai/ha (0.063 lb ai/A). A hand weeded control treatment was also included. Granular herbicides were applied with a hand held shaker and spray herbicides were applied using a CO_2 backpack sprayer with a single 8004 flat fan nozzle calibrated to deliver 187 liters/ha (20 gal/A) at 235 kPa (34 psi). Immediately after application plants were watered with overhead irrigation (0.6 cm (0.25 in)). The experimental design was a randomized complete block within a cultivar, with four replications of four plants each. Plant

Table 1. Effects of selected hebicides on growth and injury of three pansy cultivars; Experiment 1.

Herbicide	Rate (kg ai/ha)	Injury[z] 15 DAT	Injury[z] 30 DAT	Injury[z] 60 DAT	Injury[z] 150 DAT	Dry weight (g) 60 DAT	Dry weight (g) 150 DAT
		'Crystal Bowl True Blue'					
Corral 2.68G	4.5	1.1	1.4	1.3	1.3	7.1	18.6
Pennant 5G	4.5	1.1	1.1	1.0	1.0	10.0	25.4
Ronstar 2G	4.5	2.3*	2.1*	1.5	1.3	5.6	19.2
Rout 3G	3.4	3.4*	3.9*	3.8*	3.5*	1.4*	6.2*
Stakeout 0.1G	1.1	1.7	2.6*	2.3*	2.8*	5.5	7.2*
Snapshot 2.5TG	2.8	1.9*	2.3*	1.6	1.8	5.5	22.1
Factor 65WDG	2.3	1.7	1.7	1.4	2.0	4.7	13.0
Pendulum 60WDG	4.5	1.8*	3.0*	3.6*	4.3*	2.7*	1.3*
Surflan 4AS	4.5	1.7	2.3*	3.2*	4.4*	4.5	0.4*
Pennant 7.8E	4.5	1.2	1.1	1.1	1.5	10.4	22.1
Manage 50WP	0.1	2.6*	3.3*	3.4*	3.1*	2.0*	6.5*
Control		1.2	1.1	1.1	1.1	6.6	21.5
		'Maxim Orange'					
Corral 2.68G	4.5	1.2	1.3	1.2	1.3	9.4	23.6
Pennant 5G	4.5	1.3	1.2	1.2	2.1	9.5	20.9
Ronstar 2G	4.5	2.2*	2.4*	2.1*	2.8*	5.5*	10.9*
Rout 3G	3.4	3.7*	4.2*	4.5*	4.9*	0.5*	0.4*
Stakeout 0.1G	1.1	1.6*	2.3*	2.1*	2.8*	4.0*	9.7*
Snapshot 2.5TG	2.8	2.3*	2.6*	2.0	1.8	2.8*	18.6
Factor 65WDG	2.3	1.4	1.7	1.5	2.1	5.2*	16.5
Pendulum 60WDG	4.5	2.2*	3.1*	3.8*	3.6*	1.6*	4.6*
Surflan 4AS	4.5	1.6*	2.6*	3.1*	3.8*	2.9*	3.0*
Pennant 7.8E	4.5	1.4	1.3	1.1	1.9	9.6	19.2
Manage 50WP	0.1	2.8*	3.1*	2.9*	2.6	2.3*	8.4*
Control		1.1	1.3	1.3	1.6	8.7	20.5
		'Imperial Antique Shades'					
Corral 2.68G	4.49	1.1	1.6	1.2	1.3	6.6 *	22.5
Pennant 5G	4.49	1.1	1.5	1.1	1.1	7.6	25.5
Ronstar 2G	4.49	3.0 *	3.4 *	3.8 *	2.8 *	0.5 *	9.3 *
Rout 3G	3.37	3.7 *	4.4 *	4.6 *	4.9 *	0.3 *	0.1 *
Stakeout 0.1G	1.12	1.8 *	2.6 *	2.6 *	2.6 *	1.7 *	8.8 *
Snapshot 2.5TG	2.81	1.8 *	2.4 *	2.5 *	2.4 *	3.4 *	14.0 *
Factor 65WDG	2.25	1.7 *	2.6 *	2.3 *	2.4 *	2.5 *	10.6 *
Pendulum 60WDG	4.49	1.9 *	3.2 *	3.9 *	3.9 *	1.1 *	1.3 *
Surflan 4AS	4.49	1.6 *	2.9 *	3.7 *	4.3 *	1.7 *	1.1 *
Pennant 7.8E	4.49	1.3	1.6	1.4	1.0	6.0 *	25.4
Manage 50WP	0.07	3.0 *	3.6 *	3.9 *	3.3 *	0.9 *	3.2 *
Control		1.0	1.4	1.2	1.3	8.8	24.3 *

[z]Injury rated on a scale from 1–10 where 1 = no injury and 10 = plant death.

*Significantly different from non-treated controls (Dunnett's: $\alpha = 0.05$).

injury was rated at 15, 30, 60, and 150 days after treatment (DAT) on a scale of 1 to 10 where 1 = no injury and 10 = plant death. Shoot dry weight (SDW) data were collected at 60 and 150 DAT by sampling two plants per replication at each date.

Experiment 2. This study was conducted similarly to Experiment 1 with minor exceptions. Pansies had grown an additional 2 months in the 48-cell packs and were 12 to 15 cm (4 to 6 in) in height. Plants were potted on November 15 and treated on November 21. Data collected included: plant injury rating at 15, 30, 60, 90, and 120 DAT, and SDW at 120 DAT.

Experiment 3. This study was conducted with two cultivars of pansy, 'Bingo' and 'Majestic Giant'. Plants 8 to 12 cm (2 to 4 in) tall were potted in 2.8 liter (3 quart) containers in January in a similar potting medium to that used in Experiment 1. Plants were placed under 47% shade after potting and treated on January 20 with the following herbicides: Ronstar 2G at 4.5 kg ai/ha (4.0 lb ai/A), RegalKade 0.5G (prodiamine) (Regal Chemical Co., Alpharetta, GA) at 1.1 kg ai/ha (1.0 lb ai/A), Regal Star 1.2G (prodiamine + oxadiazon) (Regal Chemical Co.) at 2.7 kg ai/ha (2.5 lb ai/A), Treflan 5G (trifluralin) (Lesco, Strongsville, OH) at 4.5 kg ai/ha (4.0 lb ai/A), Snapshot 2.5TG at 3.4 kg ai/ha (3.0 lb ai/A), Corral 2.68G (pendimethalin) (Scotts Co.) at 3.4 kg ai/ha (3.0 lb ai/A), Surflan 4AS at 3.4 kg ai/ha (3.0 lb ai/A), Factor 65WDG at 1.1 kg ai/ha (1.0 lb ai/A), Pendulum 60WDG at 3.4 kg ai/ha (3.0 lb ai/A), Gallery 75DF (isoxaben) (Dow AgroSciences) at 1.1 kg ai/ha (1.0 lb ai/A), and Princep 4L (simazine) (Novartis Crop Protection Inc) at 1.1 kg ai/ha (1.0 lb ai/A). A hand weeded control treatment was also included. At 15, 30, 60, and 90 DAT, plant injury was rated on

Table 2. Effects of selected herbicides on growth and injury of three pansy cultivars; Experiment 2.

Herbicide	Rate (kg ai/ha)	Injury[z] 15 DAT	30 DAT	60 DAT	120 DAT	Dry weight (g)
		'Crystal Bowl True Blue'				
Corral 2.68G	4.5	1.8	1.8	2.4	1.2	16.6
Pennant 5G	4.5	1.9	2.0	2.1	1.0	16.9
Ronstar 2G	4.5	2.3	2.4	2.5	1.0	15.0
Rout 3G	3.4	2.3	2.5*	3.3*	1.5	9.3
Stakeout 0.1G	1.1	1.7	1.8	2.7	1.0	16.1
Snapshot 2.5TG	2.8	1.8	2.1	2.6	1.1	12.5
Factor 65WDG	2.3	2.0	1.9	2.6	1.0	14.9
Pendulum 60WDG	4.5	1.9	2.0	3.3*	1.4	10.8
Surflan 4AS	4.5	1.8	1.9	2.5	1.1	12.0
Pennant 7.8E	4.5	1.9	1.8	2.1	1.0	17.0
Manage 50WP	0.1	1.8	1.8	2.6	1.1	13.4
Control		1.9	1.9	2.1	1.3	16.9
		'Maxim Orange'				
Corral 2.68G	4.5	1.6	1.7	2.3	1.1	12.8
Pennant 5G	4.5	1.9	1.4	1.6	1.0	14.1
Ronstar 2G	4.5	2.4	2.7*	3.3*	2.4*	7.3
Rout 3G	3.4	2.6*	3.1*	3.8*	3.3*	3.5
Stakeout 0.1G	1.1	1.9	1.9	2.7	1.2	9.4
Snapshot 2.5TG	2.8	1.9	1.7	2.8	1.6	11.5
Factor 65WDG	2.3	1.8	1.8	2.8	1.6	8.6
Pendulum 60WDG	4.5	1.9	2.1	3.5*	2.2	3.8
Surflan 4AS	4.5	1.9	1.8	2.3	1.1	9.4
Pennant 7.8E	4.5	1.9	1.8	2.4	1.5	10.3
Manage 50WP	0.1	2.1	2.1	2.7	1.1	10.5
Control		2.1	1.9	2.3	1.1	12.6
		'Imperial Antique Shades'				
Corral 2.68G	4.5	1.9	1.6	3.0	1.1	12.4
Pennant 5G	4.5	2.0	1.8	2.6	1.1	16.1
Ronstar 2G	4.5	2.6*	2.0	3.5*	1.9	9.8
Rout 3G	3.4	2.6*	2.7*	3.7*	2.5*	7.0
Stakeout 0.1G	1.1	2.0	1.9	2.7	1.0	15.4
Snapshot 2.5TG	2.8	1.9	1.9	3.0	1.3	13.1
Factor 65WDG	2.3	2.3*	2.1	3.5*	1.5	9.3
Pendulum 60WDG	4.5	2.4*	2.2*	3.6*	2.6*	5.4
Surflan 4AS	4.5	1.7	1.6	2.4	1.1	13.1
Pennant 7.8E	4.5	1.9	1.9	2.8	1.3	16.3
Manage 50WP	0.1	2.1*	2.0	3.3*	1.5	10.6
Control		1.4	1.5	2.5	1.0	16.8

[z]Injury rated on a scale from 1–10 where 1 = no injury and 10 = plant death.

*Significantly different from non-treated controls (Dunnett's: $\alpha = 0.05$).

Table 3. Effect of selected herbicides on growth and injury of two pansy cultivars; Experiment 3.

Herbicide	Rate (kg ai/ha)	'Bingo' Injury[z] 15 DAT	30 DAT	60 DAT	90 DAT	Dry weight (g)	Flower[y] number
Ronstar 2G	4.5	1.7*	2.0*	1.4	1.2	14.7	13.9
Regal Kade 0.5G	1.1	1.6*	1.6	1.3	1.0	13.2	7.3
Regal Star 1.2G	2.7	1.4*	1.9	1.6	1.2	12.3	12.8
Treflan 5G	4.5	1.0	1.1	1.7	1.2	12.2	10.8
Snapshot 2.5TG	3.4	1.0	1.3	1.4	1.7	13.7	11.9
Corral 2.68G	3.4	1.0	1.0	1.3	1.1	13.3	11.3
Surflan 4AS	3.4	1.0	1.2	1.8	3.3*	7.5*	3.7*
Factor 65WDG	1.1	1.0	1.0	1.2	1.0	11.3	8.6
Pendulum 60WDG	3.4	1.0	1.5	2.4*	3.1*	7.8*	8.3
Gallery 75DF	1.1	1.2	3.9*	6.4*	4.3*	4.8*	3.5*
Princep 4L	1.1	1.0	8.4*	10.0*	10.0*	0.0*	0.0*
Control		1.0	1.1	1.1	1.0	12.8	11.1
		'Majestic Giant'					
Ronstar 2G	4.5	2.0*	2.5*	2.8	1.3	10.4	13.0
Regal Kade 0.5G	1.1	1.8*	1.8	1.5	1.0	13.7	15.8
Regal Star 1.2G	2.7	2.1*	2.7*	2.2	1.5	6.9	11.0
Treflan 5G	4.5	1.1	1.6	1.9	1.9	6.5	10.7
Snapshot 2.5TG	3.4	1.2	2.2	2.9	4.3*	3.1*	7.5*
Corral 2.68G	3.4	1.0	1.4	1.4	1.7	10.0	12.9
Surflan 4AS	3.4	1.0	1.4	1.8	3.8*	4.1*	6.6*
Factor 65WDG	1.1	1.0	1.7	1.6	1.1	11.8	13.4
Pendulum 60WDG	3.4	1.0	2.3*	3.9*	5.3*	1.6*	3.8*
Gallery 75DF	1.1	1.5*	4.2*	5.7*	4.2*	3.7*	5.2*
Princep 4L	1.1	1.1	7.4	8.9*	6.1*	1.3*	2.2*
Control		1.1	1.4	1.5	1.0	10.2	14.3

[z]Injury rated on a scale from 1–10 where 1 = no injury and 10 = plant death.

[y]Data were square root transformed prior to analysis; actual data are reported.

*Significantly different from non-treated controls (Dunnett's: $\alpha = 0.05$).

a 1 to 10 scale where 1 = no injury and 10 = plant death. At 90 DAT, flower numbers were counted and shoot dry weights were recorded.

Data were analyzed with analysis of variance. Injury ratings higher than non-treated controls, or SDW and flower numbers lower than non-treated controls were determined using Dunnett's one-tailed t test ($\alpha = 0.05$) (Table 3). Flower numbers were square root transformed prior to analysis to normalize the error terms, actual data are reported in Table 3.

Results and Discussion

Experiment 1. Herbicides that caused no injury or SDW reduction of 'Crystal Bowl True Blue' and 'Maxim Orange' were: Corral 2.68G and Pennant 5G and 7.8E (Table 1). Factor 65WDG was safe on both cultivars, except it reduced SDW of 'Maxim Orange'. With 'Imperial Antique Shades', only Pennant 5G caused no injury or SDW reduction during the study; however, Corral 2.68G and Pennant 7.8E caused slight, but significant, SDW reduction at 60 DAT. There were differences in cultivar response to herbicide application. For example, at 60 DAT, 12 herbicides reduced SDWs of 'Imperial Antique Shades', 10 reduced SDWs of 'Maxim Orange', and only four reduced SDWs of 'Crystal Bowl True Blue'. Herbicides causing the greatest injury were: Surflan 4AS, Pendulum 60WDG, and Rout 3G. Of these herbicides, both Surflan 4AS and Pendulum 60WDG are labeled for use on pansy. With these two herbicides, SDW reduction at 150 DAT ranged from 78% to 98%. Rout 3G can injure several summer annuals (8), while Surflan 4AS can injure marigold and zinnias (4). Pansies were small at the time of treatment (about 5 cm (2 in) in height), which may have affected their response to applied herbicides; they appeared to be more sensitive than those in those subsequent studies. Derr and Salihu (3) reported plant size at the time of treatment may be a factor in stunting caused by preemergence herbicides, with larger plants being more tolerant. This concurs with other postemergence weed control research, where larger weeds were more difficult to control than smaller weeds (1, 9).

Experiment 2. Plants were older and larger at the time of treatment than those in Experiment 1 and tended to be more tolerant of herbicides. For example, with 'Crystal Bowl True Blue', only Rout 3G and Pendulum 60WDG caused injury and reduced SDW (Table 2). With 'Maxim Orange', no herbicide caused injury or SDW reduction except Ronstar 2G, Rout 3G, and Pendulum 60WDG which reduced pansy shoot dry weights by 42%, 72%, and 70% respectively, similar to Experiment 1. 'Imperial Antique Shades' again appeared the most sensitive with five herbicides (Ronstar 2G, Rout 3G, Factor 65WDG, Pendulum 60WDG, and Manage 50WP) causing injury or SDW reduction. All other herbicides at the rates applied were safe for use on 'Imperial Antique Shades'.

Experiment 3. Herbicides causing no injury to 'Bingo' were Treflan 5G, Snapshot 2.5TG, Corral 2.68G, and Factor

65WDG. Slight injury occurred initially with Ronstar 2G, RegalKade 0.5G, and Regal Star 1.2G; however, plants grew past these injury symptoms after 30 days and were similar to control plants thereafter. Herbicides causing both plant injury and SDW reduction (% compared to non-treated controls) were: Surflan 4AS (41%), Pendulum 60WDG (39%), Gallery 75DF (63%), and Princep 4L (100%). Surflan 4AS and Pendulum 60WDG injury symptoms were not apparent until 90 and 60 DAT, respectively, and were characterized by plant stunting (Table 3). All 'Bingo' treated with Princep 4L died.

Treflan 5G, Corral 2.68G and Factor 65WDG caused no injury or SDW reduction of 'Majestic Giant'. 'Majestic Giant' SDW was reduced by the same four herbicides that reduced 'Bingo' SDW plus Snapshot 2.5TG; SDW reduction ranged from 60% with Surflan 4AS to 87% when Princep 4L was applied. With both cultivars, flower number generally followed the trend exhibited by SDW data. In addition, initial injury occurred with Ronstar 2G, RegalKade 0.5G, and Regal Star 1.2G; however, plants grew past injury symptoms and had similar injury ratings and SDW compared to the non-treated control plants by the end of the experiment.

In Experiments 1 and 2, pendimethalin was applied as two different formulations (Corral 2.68G and Pendulum 60WDG). Contrast analysis was used to directly compare the two formulations (data not shown). In Experiment 1, at all dates and for every measured parameter, Corral 2.68G was less injurious than Pendulum 60WDG. In Experiment 2, Corral 2.68G caused less injury than Pendulum 60WDG in most cases, and caused less SDW reduction in each case. The data indicate that granular pendimethalin (Corral 2.68G) is safer than spray-applied water dispersible granules (Pendulum 60WDG). In Experiment 3, prodiamine was applied as two different formulations (RegalKade 0.5G and Factor 65WDG). Only at 15 DAT was RegalKade 0.5G more injurious than Factor 65WDG. From 30 DAT through the termination of the study, plants treated with the two formulations of prodiamine were similar, and therefore formulation is not considered as important when using prodiamine for weed control in pansy compared to pendimethalin.

In conclusion, five herbicides currently on the market, Corral 2.68G, Treflan 5G, RegalKade 0.5G, Regal Star 1.2G, and Factor 65WDG, did not injure any of the container-grown pansy cultivars evaluated. Factor 65WDG is included in the group even though injury occurred with one of five cultivars in one experiment, most likely because the rate used in the first two experiments was higher than the normal use rate and the treated plants were small. Likewise, RegalKade 0.5G with the same active ingredient as Factor 65WDG (prodiamine) and Regal Star 1.2G are included because they only caused injury early in Experiment 3, which was not apparent by the end of the experiment. Thus, for landscape use four granular herbicides and one spray applied herbicide appear to be safe for use on pansy. These data also show that pansy cultivars vary in their tolerance to herbicides. Ronstar 2G and Snapshot 2.5TG caused slight injury to some but not all cultivars included. Herbicides causing severe injury or SDW reduction that should not be used include: Rout 3G, Pendulum 60WDG, Surflan 4AS, Gallery 75DF, and Princep 4L. In addition, Pennant 5G was safe on all three cultivars in the first test, and while not currently marketed, opportunity exists for a company to obtain and market this product.

Literature Cited

1. Altland, J.E., C.H. Gilliam, J.H. Edwards, G.J. Keever, J.R. Kessler, and D.J. Eakes. 2000. Effect of bittercress size and Gallery rate on postemergence bittercress control. J. Environ. Hort. 18:128–132.

2. Bailey, D.A. 1996. Commercial pansy production. North Carolina Cooperative Extension Service Information Leaflet 521.

3. Derr, J.E. and S. Salihu. 1996. Preemergence herbicide effects on nursery crop root and shoot growth. J. Environ. Hort. 14:210–213.

4. Fretz, T.A. 1976. Herbicide performance on transplanted annual bedding plants. HortScience 11:110–111.

5. Gilbertz, D.A. and B.J. Johnson. 1987. Response of bedding plants and weeds to herbicides. J. Environ. Hort. 5:158–162.

6. Henderson-Cole, J.C. and M.A. Schnelle. 1993. Effects of prodiamine and oxadiazon on growth of bedding plants and ground covers. J. Environ. Hort. 11:17–19.

7. Scheutt, J. and J.E. Klett. 1989. Preemergent weed control in container-grown herbaceous perennials. J. Environ. Hort. 7:14–16.

8. Thetford, M., C.H. Gilliam, and J.D. Williams. 1995. Granular preemergence applied herbicides influence annual bedding plant growth. J. Environ. Hort. 13:97–103.

9. Trammell, C.A., M.R. Bartes, R.L. Nichols, H.E. Shepherd, and F.R. Taylor. 1986. Lactofen efficacy related to weed size at the time of application. Proc. Southern Weed Sci. Soc. pp 97.