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Effect of 2,4-D and Triclopyr on Annual Bedding Plants[1]

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Abstract

Greenhouse trials were conducted to evaluate annual flower response to simulated drift of Weedar 64 (dimethylamine salt of 2,4-D) and Turflon Amine (triethylamine salt of triclopyr). Mature annual flowers responded differently to low concentrations of Weedar 64 and Turflon. The order for species from most sensitive to least sensitive was petunia > begonia = marigold = pansy = statice > geranium = impatiens = rose periwinkle = salvia. Rates less than 128 g ae/ha (0.11 lb ae/A) caused only slight injury. Injury was expressed in reduced flower production and callus. Turflon suppressed flowering 19% more than Weedar 64. Both herbicides reduced flowering at rates greater than 100 g/ha (0.088 lb/A).

Index words: triclopyr, 2,4-D, spray drift.

Chemicals used in this study: Weedar 64, (dimethylamine salt of 2,4-D), (2,4-dichlorophenoxy)acetic acid; Turflon Amine, (triethylamine salt of triclopyr), [(3, 5, 6-trichloro-2-pyridinyl)oxy] acetic acid.

Species used in this study: begonia, (*Begonia* x *semperflorens—cultorum* Hort.) 'Espresso Rose' and 'Party White'; geranium, (*Pelargonium* x *hortorum* Bailey) 'Cardinal and Pink Orbit'; impatiens (*Impatiens Wallerana* Hook.) 'Bright Eye','Accent Coral', 'Accent Apricot' and 'Accent White'; marigold, (*Tagetes erecta* L.) 'Perfection Gold', 'Bonanza Mixture' and 'Legend Yellow' and (*Tagetes patula* L.) 'Boy O'Boy'; pansy (*Viola* x *Wittrockiana* L.) 'Majestic Mixture'; petunia (*Petunia* x *hybrida* Hort. Vilm.) 'Daddy Mixture', 'Supercascade Lilac', 'Simply Madness' and 'Red Madness'; salvia (*Salvia farinacea* Benth.) 'Empire Lilac'; statice (*Limonium sinuatum* (L.) Mill.) 'Regal Mixed Colors'; and rose periwinkle (*Catharanthus roseus* (L.) G. Don) 'Pretty In Pink' and 'Bright Eye'.

Significance to the Nursery Industry

Auxin-like herbicides are applied postemergence to control broadleaf weeds in turfgrass and along roadsides with sensitive ornamentals nearby. Low concentrations of these herbicides can cause variable injury symptoms to many ornamentals (3, 6, 13). With annuals, the order of species sensitivity from most sensitive to least sensitive was petunia > begonia = marigold = pansy = statice > geranium = impatiens = rose periwinkle = salvia. A herbicide comparison study showed petunia was more sensitive to Turflon than Weedar 64, whereas marigold was moderately sensitive to both herbicides, and impatiens was moderately tolerant to both herbicides. Injury symptoms were expressed as general growth suppression, reduced flower production, and callus formation. Careful examination will be important for proper diagnosis of injury from herbicide drift to mature annual flowers.

Introduction

The lawn care industry and the Department of Transportation in Iowa frequently apply Weedar 64 (dimethylamine salt of 2,4-D) and Turflon Amine (triethylamine salt of triclopyr) postemergence to control broadleaf weeds in turfgrass and along roadsides with sensitive ornamentals nearby. Ries, (13) showed that low concentrations of these herbicides can cause noticeable injury symptoms. Lee and Bewick (10) reported that with many annual broadleaf weeds, susceptibility to auxin-like herbicides decreases with age and after fruiting, there is a period of minimum susceptibility. This suggests that annual flowers may have minimum drift injury from these herbicides because most are in an early flowering stage when transplanted into the landscape.

Wolfe (14) showed that during a spray application, some spray droplets drift from the intended target. Spray drift effects from plant growth regulator herbicides are well documented for numerous agricultural crops including soybean (*Glycine max*) (12), sunflower (Helianthus annuus) (7), alfalfa, (Medicago sativa) (2), sweet clover (Melilotus officinalis) (8), rapeseed (Brassica napus) (5), and various vegetable crops (9, 11). However, limited research has been directed towards describing injury symptoms to annuals from herbicide drift or to quantifying herbicide rates that cause damage. Feucht (6) described injury symptoms from various postemergence herbicides to several tree species. Al-Khatib et al. (3, 4) also described sweet cherry (Prunus avium) and roses (Rosa dilecta) response to simulated drift from selected postemergence herbicides. However, the response of annual flowers to 2,4-D type herbicides at simulated drift rates has not been reported.

The objectives of this study were to determine the susceptibility of several annual flowers to Weedar 64 and Turflon and to describe herbicide injury symptomology on these annual species.

Materials and Methods

Screening study. A preliminary greenhouse study was conducted with nine annual flower species: begonia (*Begonia* x *semperflorens—cultorum* Hort. 'Espresso Rose' and 'Party White'), geranium (*Pelargonium* x *hortorum* L. Bailey 'Cardinal and Pink Orbit'), impatiens (*Impatiens Wallerana* Hook 'Bright Eye' and 'Accent White'), marigold (*Tagetes erecta* L. 'Perfection Gold' and *Tagetes patula* L. 'Boy O'Boy'), pansy (*Viola* x *Wittrockiana* L. 'Majestic Mixture'), petunia (*Petunia* x *hybrida* Hort. Vilm. 'Daddy Mixture' and 'Red Madness'), salvia (*Salvia farinacea* L. 'Empire Lilac'), statice (*Limonium sinuatum* (L.) Mill. 'Regal Mixed

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Colors'), and rose periwinkle (*Catharanthus roseus* (L.) G. Don. 'Pretty In Pink' and 'Bright Eye'). Seeds were germinated under mist in a vermiculite medium. Seedlings at the two-true-leaf stage were transplanted into plastic D1206 compacks (A. H. Hummert Seed Co., St. Louis, MO) filled with a 1:2:2 (by vol) Canisteo clay loam (Fine loamy, mixed (calcareous), mesic Typic Haplaquolls), peat, and perlite medium. About 3 weeks later, the seedlings were transplanted into 500-cm^3 (30.5-in^3) pots filled with the same medium. Each pot contained a single plant. Plants were watered as needed and fertilized weekly with a 20N–4.3P–8.6K (20–10–20) soluble fertilizer diluted to 200 ppm N. Greenhouse temperature was maintained at a 24/17C (75/63F) day/night, and natural lighting was supplemented with high-pressure sodium lights at 250 µE/sq cm/s (11 µmol/sq ft/s) photosynthetic photon flux density and adjusted for a 15-hour day length.

A moving nozzle spray chamber equipped with a single 8001E (TeeJet even fan nozzle tip, Spraying Systems Co., Wheaton, IL) nozzle was used to apply herbicides to mature plants in full flower. The CO_2-pressurized sprayer delivered 234 liter/ha (25 gal/A) of spray solution at 225 kPa (33 psi). Turflon was applied at 2, 8, 32, 128, and 512 g ae/ha (0.0019, 0.0063, 0.031, 0.11, and 0.46 lb ae/A) and Weedar 64 was applied at 1, 4, 16, 64, and 256 g ae/ha (0.00063, 0.0038, 0.013, 0.056, and 0.23 lb ae/A). Control plants were sprayed with water only. Injury observations were recorded for 4 weeks at 4 day intervals after application. Visual injury ratings were taken 4 and 8 weeks after treatment (WAT). Ratings were based on 0 = no injury and 100 = plant death. Plant injury increased with time for herbicide rates greater than 100 g/ha; therefore, only the final injury evaluation was used.

Herbicide comparison study. A greenhouse study was conducted with impatiens (*Impatiens wallerana* Hook) 'Bright Eye', 'Accent Coral' and 'Accent Apricot', marigold, (*Tagetes erecta* L.) 'Bonanza Mixture' and 'Legend Yellow', and petunia (*Petunia* x *hybrida* Hort. Vilm.) 'Supercascade Lilac' and 'Simply Madness' to compare Weedar 64 and Turflon phytotoxicity. Germination, transplanting, growing conditions, and spray applications were identical to those previously described. Herbicides were applied to mature plants at the early flowering stage. Turflon and Weedar 64 were applied at 25, 50, 100, and 125 g/ha (0.025, 0.044, 0.088, and 0.11 lb/A).

Observations were recorded at 3 day intervals. Herbicide injury ratings and flower counts were recorded weekly. Plants were harvested at the soil surface 4 WAT, and fresh and dry weights recorded.

The experiments were conducted as a randomized complete blocks with three replications. Both studies were repeated, and results were combined upon confirmation of homogeneity of variances. Cultivars within a species responded similarly to herbicide treatments; thus, data were combined for each species. All data were subjected to analysis of variance, and means were separated by Fisher's protected least significant difference procedure ($P < 0.05$) where appropriate. Visual injury ratings were analyzed as percentages and as transformed (arcsin $\sqrt{x}$) percentages. The transformation did not affect results; thus, untransformed data were presented.

Results and Discussion

Screening study. Annual flower species response to herbicide and rate were species specific (Table 1). Petunia was the most sensitive species and exhibited greater sensitivity to Turflon than to Weedar 64 (data not shown). Injury from 256 g/ha (0.23 lb/A) Weedar 64 was similar to that from 2 g/ha (0.0019 lb/A) Turflon. Petunias receiving 2 g/ha (0.0019 lb/A) Turflon exhibited slight stem epinasty by 7 days after treatment (DAT), whereas plants receiving at least 128 g/ha (0.11 lb/A) exhibited wilting of open flowers, flower stalk epinasty, and leaf cupping 1 DAT, which progressed to shoot tip necrosis by 7 DAT. Flower production was also reduced 67% by both herbicides (data not shown).

Begonia was also sensitive to Turflon at 128 g/ha (0.11 lb/A) or more and to Weedar 64 at 256 g/ha (0.23 lb/A). Herbicide rates less than 100 g/ha produced slight leaf cupping or leaf strapping symptoms.

Marigold responded variably to herbicide treatments. Turflon at 512 g/ha (0.46 lb/A) killed all plants, whereas

Table 1. Visually observed injury to annual flowers as affected by 2,4-D and Turflon applications, 8 weeks after treatment[z]. Experiment 1.

Herbicide	Rate	Petunia	Begonia	Marigold	Statice	Pansy	Impatiens	Geranium	Vinca	Salvia
	g ae/ha (lb ae/A)	%								
Weedar 64	1 (0.00063)	20	10	18	17	10	10	12	12	13
	4 (0.0038)	28	12	23	13	10	13	15	13	10
	16 (0.013)	18	15	15	15	10	10	10	10	10
	64 (0.056)	20	10	20	17	10	10	10	10	10
	256 (0.23)	32	47	47	55	43	18	13	30	18
LSD (0.05)		7	7	12	10	4	10	5	6	3
Turflon	2 (0.03)	32	10	10	10	15	12	10	10	10
	8 (0.10)	43	15	10	10	10	10	10	10	15
	32 (0.50)	45	10	32	13	17	12	18	15	12
	128 (1.80)	87	78	23	57	22	22	20	27	10
	512 (7.30)	100	93	100	68	98	72	97	72	78
LSD (0.05)		9	7	11	9	8	12	7	5	8

[z]Visual ratings were based on 0 = no injury and 100 = plant death.

Table 2. Visually observed injury to petunia, marigold and impatiens and the number of open flowers as affected by Weedar 64 and Turflon[z].

Herbicide	Rate	Petunia				Marigold				Impatiens			
		7 DAT[y]		28 DAT		7 DAT		28 DAT		7 DAT		28 DAT	
	g ae/ha (lb ae/A)	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.
Weedar 64	25 (0.025)	12	2.8	10	5.0	7	1.5	18	1.5	1	2.0	2	12.5
	50 (0.044)	16	3.0	15	6.5	5	1.8	10	2.3	1	1.3	2	14.8
	100 (0.088)	18	2.8	13	7.3	7	1.8	37	1.8	5	1.3	5	14.7
	125 (0.11)	23	1.3	38	3.2	20	1.3	56	1.7	6	0.6	6	13.3
Turflon	25 (0.025)	15	1.3	33	3.8	6	1.7	14	1.3	2	2.2	2	14.5
	50 (0.044)	18	0.8	43	2.0	8	1.7	25	0.8	4	1.5	3	15.0
	100 (0.088)	30	0.0	85	0.0	13	1.5	32	0.3	3	1.5	8	12.8
	125 (0.11)	28	0.5	95	0.0	38	2.2	73	0.2	6	1.8	7	13.0
LSD (0.05)		4	1.0	10	2.2	8	NS	19	1.0	4	0.7	NS	NS

[z]Visual ratings were based on 0 = no injury and 100 = plant death

[y]DAT = days after treatment.

Weedar 64 at 256 g/ha (0.23 lb/A) caused epinasty, stem callus formation, and flower deformation.

Pronounced injury to statice was not observed until the use of at least 128 g/ha (0.11 lb/A) of Turflon or 256 g/ha (0.23 lb/A) of Weedar 64. All plants remained alive 8 WAT. Injury symptoms consisted of leaf wilt, leaf necrosis, and slight epinasty of the flower stalk for plants that bolted.

Pansy injury was not evident at rates below 512 g/ha (0.46 lb/A) of Turflon or 256 g/ha (0.23 lb/A) Weedar 64. These rates also reduced flower production. Slight flower stalk epinasty occurred at lower herbicide rates but was not easy to identify because of the plant's growth habit. Pansy injury symptoms included general growth suppression and slight cupping of the youngest leaves.

Impatiens, geranium, rose periwinkle, and salvia responded similarly to Turflon and Weedar 64. Only Turflon at 512 g/ha (0.46 lb/A) produced pronounced injury symptoms. Geranium was the most sensitive of the four species and impatiens was the least sensitive. Several geranium plants died by 8 WAT, whereas leaf wilt and marginal chlorosis were observed with impatiens. Vinca symptoms resembled water stress, consisting of downward leaf rolling and plant wilt. Symptoms on the salvia consisted of slight flower stem epinasty and leaf wilt. Flowering decreased for all four species as Weedar 64 or Turflon rates increased.

Herbicide comparison study. Petunia, marigold, and impatiens responded differently to the two herbicides but was similar to injury occurring in experiment 1 (Table 2).

Floral production by each species differed, depending on the herbicide and rate applied (Table 2). The average number of inflorescences produced by petunias and marigolds decreased as herbicide rates increased, whereas impatiens were not affected. Petunias treated with Turflon averaged less than two flowers/plant at 28 DAT compared with more than five flowers/plant for those treated with Weedar 64 (LSD = 2). Marigold flowering at 28 DAT was reduced by 99% when Turflon was compared with Weedar 64. Turflon and Weedar 64 suppressed petunia and marigold flower development throughout the study, whereas impatiens recovered by 28 DAT (Fig. 1). Plants treated with Turflon initiated

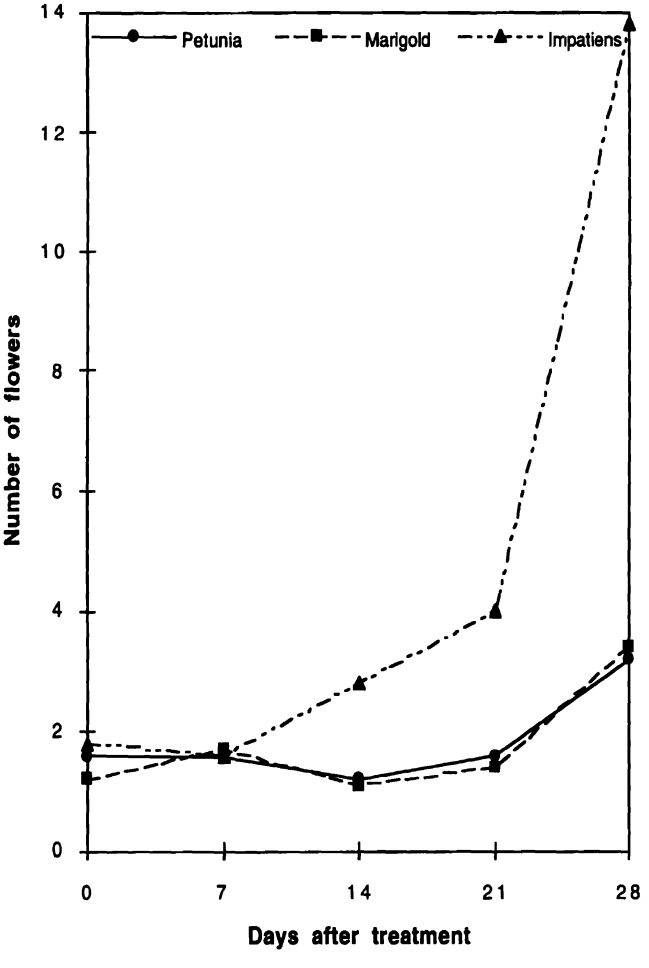

Fig 1. Effect of time after herbicide application on the flowering of petunia, marigold, and impatiens. Each point represents the pooled average for all Weedar 64 and Turflon treatments.

Table 3. Inflorescences and dry weights of petunia, marigold, and impatiens as affected by Weedar 64 and Turflon, 28 DAT.

		Herbicide		
	Rate	Weedar 64	Turflon	Mean
Flowers	g ae/ha (lb ae/A)	---------- % ----------		
	25 (0.025)	79	74	77a[z]
	50 (0.044)	86	67	77a
	100 (0.088)	77	34	56b
	125 (0.11)	59	43	51b
	Mean	75a	54b	
Dry weight	g ae/ha (lb ae/A)	---------- % ----------		
	25 (0.025)	104	92	98a
	50 (0.044)	97	85	91ab
	100 (0.088)	93	74	84b
	125 (0.11)	87	77	82b
	Mean	95a	82b	

[z]Means within a column or row followed by the same letter do not differ significantly at the LSD 0.05 probablility level.

19% less inflorescences than did Weedar 64-treated plants (Table 3). Turflon and Weedar 64 applied at 100 g/ha (0.088 lb/A) or more reduced floral initiation by about 50% compared with untreated plants and by almost 30% compared with plants treated with less than 100 g/ha (0.088 lb/A).

Dry weights decreased with increasing herbicide rate (Table 3). Turflon restricted dry-matter accumulation 16% more than Weedar 64. Plants treated with 25 g/ha (0.025 lb/A) of Weedar 64 accumulated 4% more dry matter than untreated plants. This increase indicated that growth was stimulated. Similar growth stimulation has been reported by Hemphill and Montgomery (9) with potatoes and by Ahmad et al., (1) with chrysanthemums (*Chrysanthemum* x *morifolium*).

These studies showed that mature annual flowers respond differently to Weedar 64 and Turflon. The order for species sensitivity from most sensitive to least sensitive in the screening study was petunia > begonia = marigold = pansy = statice > geranium = impatiens = rose periwinkle = salvia. The herbicide comparison study showed that petunias were more sensitive to Turflon than Weedar 64, that marigolds were moderately sensitive to both herbicides, and that impatiens were moderately tolerant to both herbicides. Injury symptoms were mainly general growth suppression, reduced flower production, and decreased asthetics because of callus formation. Therefore, if herbicide drift allegations include mature annual flowers, careful examination will be important for proper diagnosis.

(*Ed. note:* This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.)

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