Herbicide Combinations for Control of Prostrate Spurge in Container-Grown Landscape Plants[1]

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Abstract

Studies were conducted in 1989 and 1990 to evaluate combinations of herbicides for control of prostrate spurge (*Euphorbia humistrata* Engelm. ex. Gray) in container-grown landscape plants. In 1989, the combination of Ronstar 2G [oxadiazon (2.24 kg/ha) (2.0 lb/A)] with Surflan 40 AS [oryzalin (2.24 kg/ha) (2.0 lb/A] or Barricade 65 WG [prodiamine (2.24 kg/ha) (2.0 lb/A)] resulted in 95% or better control of prostrate spurge. Combinations of Ronstar 2G [oxadiazon (2.24 kg/ha) (2.0 lb/A)] and Pennant 5G [metalochlor (4.48 kg/ha) (4.0 lb/A] or Rout 3G [oxyfluorfen (2.24 kg/ha) (2.0 lb/A) plus oryzalin (1.12 kg/ha) (1.0 lb/A)] controlled more than 80% of the weeds after 12 weeks in 1989. Some herbicide treatments containing oryzalin and pendimethalin reduced the root grade of *Rhododendron* cv. 'Stewartsonian' and *Ilex crenata* Thunb. 'Helleri' in 1990. Herbicide treatments in the 1990 study had no effect on growth parameters of *Juniperus chinensis* L. 'Pfitzeriana Glauca'. Rout (oxyfluorfen plus oryzalin) was the only herbicide in the 1990 study which reduced the number of prostrate spurge plants per pot in all three landscape species after 10 weeks. Dry weight of prostrate spurge was reduced approximately 3.6× when Rout was used on 'Stewartsonian' azalea. Improved prostrate spurge control due to certain herbicide combinations did not result in increased foliar growth indices of the species used in this study. Dinitroanaline herbicides should be tested further for crop phytotoxicity and potential prostrate spurge control.

Index words: herbicides, container production, prostrate spurge

Herbicides used in this study: Barricade (prodiamine), [2,4-dinitro-N^3,N^3-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine]; Devrinol (napropamide), [*N*,*N*-diethyl-2-(1naphthalenyloxy)propan-amide]; Goal (oxyfluorfen), 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoro-methyl) benzene; OH-2 (oxyfluorfen) plus (pendimethalin), *N*-(1-ethylopropyl)-3,4-dimethyl-2,6-dinitrobenzenamine; Pennant (metalochlor), 2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide; Ronstar (oxadiazon), 3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one]; Rout (oxyfluorfen), 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene, plus (oryzalin); Surflan (oryzalin), [4-(dipropylamino)-3,5-dinitrobenzenesulfonamide].

Weed species used in this study: prostrate spurge (*Euphorbia humistrata* Engelm. ex. Gray).

Species used in this study: 'Helleri' holly (*Ilex crenata* Thunb. 'Helleri'); Blue Pfitzer juniper (*Juniperus chinensis* L. 'Pfitzerana Glauca'); 'Stewartsonian' azalea (*Rhododendron* cv. 'Stewartsonian').

Significance to the Nursery Industry

Prostrate spurge is a major weed and difficult to control in container-grown landscape plants in the southeastern United States. Combinations of herbicides offer the potential of an increased weed control spectrum. Dinitroanaline herbicides [Surflan (oryzalin) (2.0 lb/A), pendimethalin (1.0 lb/A) and Barricade (prodiamine) (2.0 lb/A)] in combination with other herbicides [Ronstar (oxadiazon) (2.0 lb/A) and Goal (oxyfluorfen) (2.0 lb/A)] adequately controlled prostrate spurge for a 10 to 12 week period. Improved control of prostrate spurge 10 weeks after treatment had no effect on shoot growth of the landscape species evaluated. The potential for reduced shoot growth during the growing season caused by reductions in root grade due to herbicide treatment should be weighed against herbicide efficacy. Further testing of herbicide combinations for weed control and phytotoxicity on other landscape species is warranted.

[1]Received for publication June 3, 1991; in revised form November 8, 1991. A joint contribution of the University of Georgia and U.S. Department of Agriculture, Agricultural Research Service, Coastal Plain Experiment Station, Tifton, GA 31793.

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Introduction

Prostrate spurge, next to yellow nutsedge (*Cyperus esculentus* L.), is considered the most difficult weed to control in container-grown plant materials (3). One prostrate spurge plant per container will limit the growth of azaleas (1). Ronstar is commonly used in container-grown plant production, but does not effectively control prostrate spurge (2). Combinations of Ronstar with other herbicides increased control of several weed species (2, 4). Herbicide combinations showed variable results for the control of prostrate spurge in container-grown *Ilex crenata* 'Compacta' (7). The objectives of this study were to evaluate several herbicide combinations for control of prostrate spurge and to determine phytotoxicity to three species of container-grown landscape plants.

Materials and Methods

Experiments were conducted at the Coastal Plain Experiment Station, Tifton, GA in 1989 and 1990 to evaluate combinations of herbicides for control of prostrate spurge. On June 27, 1989, prostrate spurge seeds were broadcast over 2.8 liter (1 gal) black plastic containers filled with a mixture of milled pine bark and river sand (2:1 by vol)

amended with 6.0 kg/m^3 (10 lbs/yd^3) 18N-2.6P-9.9K (18-6-12) slow release fertilizer (Osmocote, Grace/Sierra), 3.0 kg/m^3 (5.0 lbs/yd^3) dolomitic limestone and 0.15 kg/m^3 (0.25 lbs/yd^3) minor element mix (Perk, Vigoro). Herbicides were applied on June 27, 1989. The treatments were an untreated control; Ronstar 2G at 4.48 kg ai/ha (4.0 lb ai/A); Ronstar 2G plus Devrinol 5G at 3.36 kg ai/ha each (3.0 lb ai/A); Ronstar 2G plus Surflan 4 FL at 2.24 kg ai/ha each (2.0 lb ai/A); Ronstar 2G plus Goal 1.6 EC at 2.24 kg ai/ha (2.0 lb ai/A) and 1.12 kg ai/ha (1.0 lb ai/A); Ronstar 2G plus Pennant 5G at 2.24 kg ai/ha (2.0 lbs ai/A) and 4.48 kg ai/ha (4.0 lbs ai/A); Ronstar 2G plus Barricade 65 WG at 2.24 kg ai/ha each (2.0 lbs ai/A); and Rout 3G (oxyfluorfen plus oryzalin) at 2.24 kg ai/ha (2.0 lbs ai/A) and 1.12 kg ai/ha (1.0 lbs ai/A). Granular formulations were broadcast over the pots using pre-weighed herbicide aliquots and a hand-held shaker jar. Liquid formulations were sprayed over the pots in 187 l/ha (20 gpa) of solution using a CO_2 pressurized sprayer equipped with flat fan nozzles (Tee Jet, LF3). Irrigation at 1.3 cm (0.5 in) was applied daily to the containers using solid-set overhead irrigation. All treatments were replicated four times with three containers per replication in a randomized complete block design.

Visual weed control ratings were recorded every two weeks in 1989. Number of prostrate spurge plants per pot were counted at weeks 2, 6 and 8 after treatment. Shoot fresh weights of prostrate spurge were determined at the termination of the experiment, 12 weeks after treatment. Data were analyzed using analysis of variance and means separated using Duncan's multiple range test (P = 0.05).

Ilex crenata 'Helleri' and *Juniperus chinensis* 'Pfitzerana Glauca' liners were potted in 2.8 l (1 gal) containers in March, 1990 using the same potting medium formulation as used in 1989. *Rhododendron* 'Stewartsonian' liners were potted in 2.8 l (1 gal) containers on June 28, 1990. The potting medium for 'Stewartsonian' azalea was milled pine bark and river sand (4:1 by vol) amended with 0.9 kg/m^3 (1.5 lbs/yd^3) Micromax. Osmocote 18N-2.6P-9.9K (18-6-12) was top dressed on the azaleas at 0.9 kg N/m^3 (1.5 lbs N/yd^3). Herbicide treatments were applied and prostrate spurge seeds were broadcast over the containers on July 10, 1990. The treatments were an untreated control; Ronstar 2G at 4.48 kg ai/ha (4.0 lbs ai/A); Rout 3G (oxyfluorfen plus oryzalin) at 2.24 kg ai/ha (2.0 lbs ai/A) and 1.12 kg ai/ha (1.0 lbs ai/A); OH-2 (oxyfluorfen plus pendimethalin) at 2.24 kg ai/ha (2.0 lbs ai/A) and 1.12 kg ai/ha (1.0 lbs ai/A); Ronstar 2G plus Surflan 40 AS at 2.24 kg ai/ha (2.0 lbs ai/A); and Ronstar 2G plus Pennant 5G at 2.24 kg ai/ha (2.0 lbs ai/A) and 4.48 kg ai/ha (4.0 lbs ai/A). Granular formulations were broadcast over the containers while liquid formulations were applied with a CO_2 backpack sprayer at 187 liters/ha (20 gpa) of solution. Irrigation at 1.3 cm (0.5 in) was applied daily to the pots using solid-set irrigation. Pots were placed on container beds pot-to-pot. All treatments were replicated four times with three containers per replication in a randomized complete block design.

Number of prostrate spurge plants per pot and phytotoxicity ratings were determined every two weeks. Growth index (height × width × width/3), root grade (1 to 5 where 1 = 0 to 20%, 2 = 21 to 40%, 3 = 41 to 60%, 4 = 61 to 80%, and 5 = 81 to 100% white roots covering root ball surface); final plant dry weight and final spurge plant dry weight were determined on September 18, 1990, 10 weeks after treatment. Data were analyzed using an analysis of variance and means separation using a Waller-Duncan k-ratio t-test. Only significant (P=0.05) differences among treatments will be discussed unless otherwise stated.

Results and Discussion

Weed Control. For the containers not planted with landscape species in 1989, only the combination treatments of Ronstar plus Surflan or Barricade exceeded 95% control of prostrate spurge after 12 weeks (Table 1). The combination treatments of Ronstar plus Pennant and Rout also controlled more than 80% of the weeds after 12 weeks. Ronstar alone controlled less than 80% of the prostrate spurge after two weeks whereas Ronstar plus Devrinol and Ronstar plus Goal controlled less than 80% of prostrate spurge after six weeks. Certain dinitroanaline herbicides such as Barricade have low solubilities and have shown potential for providing persistent weed control in porous media formulations found in the production of container-grown nursery stock (6). Combinations of Ronstar with Surflan and Barricade increased broadleaf weed control in container-grown plants compared to Ronstar alone (2).

The numbers of prostrate spurge plants per pot in 1989 for the untreated check and Ronstar alone treatments were greater than Rout or the combinations of Ronstar plus Pennant, Surflan, or Barricade at six and eight weeks after treatment (Table 2). The same was true for prostrate spurge shoot fresh weight determined 12 weeks after treatment.

In 1990, Rout was the only herbicide treatment which reduced the number of spurge plants per pot in all landscape

Table 1. Percentage weed control ratings of prostrate spurge for a 12 week period after treatment (June 27 to September 22, 1989).

Treatment	Formulation	Rate (kg/ha)	Weeks after treatment					
			2	4	6	8	10	12
Untreated control	—	—	0 c[z]	0 c	0 d	0 c	0 d	0 f
Ronstar	2G	4.48	77 b	75 b	75 c	63 b	43 c	43 e
Ronstar + Devrinol	2G + 5G	3.36 + 3.36	88 ab	85 ab	80 c	74 b	50 bc	38 e
Ronstar + Surflan	2G + 40 AS	2.24 + 2.24	100 a	100 a	99 a	99 a	84 a	98 a
Ronstar + Goal	2G + 1.6 EC	2.24 + 1.12	98 a	85 ab	80 c	76 b	75 ab	55 cd
Ronstar + Pennant	2G + 5G	2.24 + 4.48	100 a	99 a	97 ab	93 a	89 a	88 ab
Ronstar + Barricade	2G + 65.0 WG	2.24 + 2.24	99 a	98 a	100 a	98 a	95 a	99 a
Rout (oryzalin + oxyfluorfen)	3G	1.12 + 2.24	100 a	97 a	97 ab	96 a	91 a	83 b

[z]Means in a column followed by the same letter are not different (P=0.05) according to Duncan's multiple range test.

Table 2. Number of prostrate spurge plants per pot 2, 6, and 8 weeks after treatment and fresh weight of prostrate spurge shoots 12 weeks after treatment (June 27 to September 22, 1989).

Treatment	Formulation	Rate (kg/ha)	Weeks after treatment 2 No. prostrate spurge plants/pot	6 No. prostrate spurge plants/pot	8 No. prostrate spurge plants/pot	12 Spurge fresh wt. (g)
Untreated control	—	—	65 a[z]	106 a	127 a	24.67 a
Ronstar	2G	4.48	18 b	36 b	52 bc	10.75 b
Ronstar + Devrinol	2G + 5G	3.36 + 3.36	13 b	31 b	72 bc	7.60 bc
Ronstar + Surflan	2G + 40 AS	2.24 + 2.24	2 b	4 c	5 d	0.02 c
Ronstar + Goal	2G + 1.6 EC	2.24 + 1.12	10 b	22 bc	32 cd	4.73 bc
Ronstar + Pennant	2G + 5G	2.24 + 4.48	2 b	6 c	18 d	1.00 c
Ronstar + Barricade	2G + 65.0 WG	2.24 + 2.24	5 b	7 c	19 d	0.00 c
Rout (oryzalin + oxyfluorfen)	3G	1.12 + 2.24	6 b	6 c	13 d	1.41 c

[z]Means in a column followed by the same letter are not different (P = 0.05) according to Duncan's multiple range test.

species 10 weeks after treatment compared to the untreated control (Table 3). However, the number of prostrate spurge plants per pot in the Rout treatments were not different from other herbicide treatments after 10 weeks in all three landscape species. After 8 weeks, all herbicide treatments reduced the number of prostrate spurge plants per pot in the 'Stewartsonian' azaleas. After 10 weeks, only the Rout treatment reduced the number of weeds per pot in azalea compared to the untreated control. All herbicide treatments reduced dry weight of prostrate spurge in 'Stewartsonian' azalea compared to the control (Table 4). The Ronstar plus Surflan treatment caused the greatest reduction in dry weight of prostrate spurge and was different from the other herbicide treatments. Rout, OH-2, and the combinations of Ronstar and Surflan and Pennant reduced the number of weeds per pot in 'Helleri' holly at 10 weeks after treatment. In 'Helleri' holly and Blue Pfitzer juniper there was no reduction in dry weight of prostrate spurge (data not shown) due to herbicide treatment (Table 4). When averaged across all three landscape species, all herbicide treatments reduced the dry weight of prostate spurge compared to the control. This was due to the greater dry weight accumulation of prostrate spurge plants growing in the 'Stewartsonian' azaleas compared to the other two species (Table 4). The increased dry weight of prostrate spurge in the 'Stewartsonian' azaleas may have been due to the use of a different container media formulation or a different nutritional status of the plants caused by different potting and fertilization dates. For the Blue Pfitzer juniper, the Ronstar plus Surflan and the Rout treatments reduced the number of prostrate spurge plants per pot after 10 weeks.

Plant growth. Root grade of 'Stewartsonian' azalea and shoot dry weight of prostrate spurge were influenced by herbicide treatments (Table 4). OH-2 and the Ronstar plus Surflan treatments reduced the percentage of root ball covered by white roots compared to the untreated control. Nurserymen have reported that OH-2 caused phytotoxicity in azaleas (3). Derr (2) showed that applications of OH-2 injured 'Hershey's red' azalea. Surflan decreased root and shoot growth of 'Southern Charm' azalea (6). In our experiment, only a few live 'Stewartsonian' azalea roots were found in the lower half of the containers treated with Ronstar plus Surflan. High rates of Surflan restricted root growth of two azalea cultivars (5). Only root grade of 'Helleri' holly was affected by herbicide treatment (Table 4). Rout and OH-2 reduced the root grade of 'Helleri' holly compared

Table 3. Number of prostrate spurge plants per pot for a 10 weeks period (July 10 to September 18, 1990) in three landscape species.

Treatment	Formulation	Rate (kg/ha)	'Stewartsonian' azalea Weeks after treatment 4	6	8	10	'Helleri' holly Weeks after treatment 4	6	8	10	Blue Pfitzer juniper Weeks after treatment 4	6	8	10
			No. prostrate spurge plants/pot											
Untreated control	—	—	17.4 a	19.3 a	19.3 a	25.4 a	9.8 a	11.5 a	13.9 a	37.3 a	8.8 a	12.1 a	13.6 a	35.7 a
Ronstar	2G	4.48	6.3 bc	8.1 bc	9.9 bc	14.8 ab	2.9 b	5.4 bc	6.8 b	26.5 ab	0.8 bc	3.5 bc	6.4 bc	26.8 ab
Rout (oryzalin + oxyfluorfen)	3G	1.12 + 2.24	2.8 c	3.3 cd	4.3 cd	7.0 b	0.9 b	3.2 bc	4.1 b	7.6 b	0.3 c	1.1 c	0.9 d	3.1 b
Ornamental herbicide 2 (pendimethalin + oxyfluorfen)	3G	1.12 + 2.24	4.0 c	4.2 cd	6.3 cd	16.0 ab	0.8 b	2.1 c	4.3 b	6.4 b	2.3 bc	4.1 bc	5.3 bcd	8.2 ab
Ronstar + Surflan	2G + 40 AS	2.24 + 2.24	0.8 c	1.7 d	2.3 d	14.4 ab	0.9 b	5.2 bc	6.4 b	8.4 b	0.1 c	1.8 c	2.8 cd	7.1 b
Ronstar + Pennant	2G + 5G	2.24 + 4.48	10.6 b	11.3 b	12.8 b	19.7 ab	3.3 b	6.3 b	8.1 b	13.9 b	3.2 b	6.8 b	8.6 b	24.5 ab

[z]Means in a column followed by the same letter are not different (P = 0.05) according to the Waller-Duncan k-ratio t-test.

Table 4. Effect of herbicide treatments on plant growth (growth index, root grade and shoot dry weight) of two landscape species and dry weight of prostrate spurge shoots (1990).

Treatment	For-mulation	Rate (kg/ha)	'Stewartsonian' azalea				'Helleri' holly			
			Growth[a] index	Root[y] grade	Shoot dry weight	Spurge dry weight	Growth index	Root grade	Shoot dry weight	Spurge dry weight
Untreated control	—	—	1443	3.2 a[w]	9.0	48.3 a	925	2.8 ab	6.2	6.0
Ronstar	2G	4.48	1326	2.6 ab	9.4	27.9 bc	981	3.0 a	6.3	5.1
Rout (oryzalin + oxyfluorfen)	3G	1.12 + 2.24	1257	2.5 ab	9.1	22.3 bc	716	1.9 b	4.9	4.2
Ornamental herbicide 2 (pendimethalin + oxyfluorfen)	3G	1.12 + 2.24	1622	2.3 b	10.9	18.2 c	1046	1.8 b	5.5	2.9
Ronstar + Surflan	2G + 40 AS	2.24 + 2.24	854	1.3 c	7.7	2.3 d	1037	2.1 ab	6.6	2.3
Ronstar + Pennant	2G + 5G	2.24 + 4.48	1652	3.0 ab	9.4	32.5 b	707	2.2 ab	5.4	4.1
PR>F[x]			NS	**	NS	**	NS	*	NS	NS

[z]Growth index (height × width × width/3).

[y]Root grade: 1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80%, 5 = 81–100% of rootball surface covered with white roots.

[x]**,* indicates significant treatment effect at the 0.01 and 0.05 level, respectively.

[w]Means in a column followed by the same letter are not different (P=0.05) according to the Waller-Duncan k-ratio t-test.

to Ronstar alone but not the untreated control. Herbicide treatments had no effect on the growth index, root grade, or shoot dry weight of Blue Pfitzer juniper (data not shown). When root grade was averaged across all three species, all herbicide combinations decreased root grade compared to the untreated control and Ronstar alone. The Ronstar plus Surflan treatment decreased root grade compared to other herbicide combinations when averaged across species. None of the herbicides tested in 1990 caused visible phytotoxic responses to shoot growth on the three landscape species tested (data not shown).

While the combination of Ronstar plus Surflan decreased dry weight of prostrate spurge in azalea (Table 4), it did not decrease the number of prostrate spurge plants per pot compared to the control after 10 weeks (Table 3). Data from 1989 (Tables 1 and 2) and 1990 (Table 3) indicate that the combination of Ronstar plus Surflan did not completely prevent germination of prostrate spurge seedlings; however, there was very little fresh (Table 2) and dry weight (Table 4) accumulation due to the stunting of seedlings caused by the Surflan treatment. The combination of Ronstar and Surflan provided good control of prostrate spurge in containers (2).

Previous research indicated that one or more prostrate spurge plants per container-grown plant reduced shoot dry weight in two azalea cultivars when measured at 90 days after treatment (1). In our 1990 study, populations of prostrate spurge as great as 35 plants per container (Table 3) had no effect on the final shoot dry weight of three landscape species 70 days (10 weeks) after treatment. A longer treatment period may be required to determine the competitive effects of prostrate spurge.

Herbicide combinations containing dinitroanaline herbicides (oryzalin, prodiamine, and pendimethalin) provided good control of prostrate spurge. However, adequate control of prostrate spurge with certain combinations of herbicides in our study had no effect on foliar growth indices of the landscape species used. Some of the herbicide treatments containing oryzalin and pendimethalin reduced the root grade of 'Stewartsonian' azalea and 'Helleri' holly. If herbicides are to be applied every 10 weeks as an operational practice, the potential benefits of weed control versus potential root damage during the growing season needs to be considered. Further testing of herbicide combinations containing dinitroanaline materials for control of prostrate spurge should be conducted on other landscape species in order to determine the potential phytotoxicity of these herbicides.

(*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).

Literature Cited

1. Berchielli-Robertson, D.L., C.H. Gilliam and D.C. Fare. 1990. Competitive effects of weeds on the growth of container-grown plants. HortScience 25:77–79.

2. Derr, J.F. 1990. Oxadiazon combinations for improved container weed control. Proc. Southern Nurseryman's Assoc. Res. Conf. 258–261.

3. Gilliam, C.H., W.J. Foster, J.D. Adrain and R.L. Shumack. 1990. A survey of weed control costs and strategies in container production nurseries. J. Environ. Hort. 8:133–135.

4. Norcini, J.G. and G.W. Knox. 1990. Spotted spurge control in container-grown ornamentals. Proc. Southern Nurseryman's Assoc. Res. Conf. 35:262–264.

5. Singh, M., N.C. Glaze and S.C. Phatak. 1981. Herbicidal response of container-grown *Rhododendron* species. HortScience 16:213–215.

6. Stamps, R.H. and C.A. Neal. 1990. Evaluation of dinitroanaline herbicides for weed control in container landscape plant production. J. Environ. Hort. 8:52–57.

7. Whitwell, T. and K. Kalmowitz. 1989. Control of prostrate spurge (*Euphorbia humistrata*) and large crabgrass (*Digitaria sanguinalas*) in container grown *Ilex crenata* 'Compacta' with herbicide combinations. J. Environ. Hort. 7:35–37.