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Postemergence Prostrate Spurge (*Chamaesyce prostrata*) Control in Container-Grown Liriope[1]

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Abstract

Four experiments were conducted to evaluate herbicides for postemergence prostrate spurge (*Chamaesyce prostrata* (syn. *Euphorbia prostrata*)) control and tolerance of container-grown liriope (*Liriope muscari*). In Experiment 1, Manage, Image, Trimec Southern, and Roundup were applied at three rates each to single bib liners of 'Big Blue' liriope in 10.2 cm (4 in) pots. Pots were infested with prostrate spurge that were 1 to 2 cm (0.4 to 0.8 in) wide with no flower or seed structures. Only Roundup at 0.45 kg ai/ha (0.4 lb ai/A) provided effective postemergence spurge control (96%) and caused no short-term or long-term injury to 'Big Blue'. In Experiment 2, Finale and Roundup were applied at three rates each to established 'Big Blue' in 3.8 liter (1 gal) containers. By 21 DAT, Finale at rates of 0.28 kg ai/ha (0.25 lb ai/A) or greater caused slight though significant injury to 'Big Blue' while Roundup caused no injury. No injury was observed on any plant at 60 DAT and the following spring, growth was similar among all treatments indicating no long-term effects. In Experiment 3, Finale and Roundup applications were made to recently divided liners of 'Variegata' liriope infested with mature spurge 17.0 to 20.1 cm (6.7 to 7.9 in) wide, which were flowering and seeding. Finale at 1.12 kg ai/ha (1.0 lb ai/A) and Roundup at 1.8 kg ai/ha (1.6 lb ai/A) provided effective spurge control (100 and 92.8%, respectively) and caused no short-term or long-term injury to 'Variegata'. Lower rates were not effective in controlling mature spurge. In Experiment 4, Finale and Roundup were applied to recently divided liners of 'Big Blue' infested with mature spurge 23 to 31 cm (9.1 to 12.2 in) wide, which were flowering and seeding. At 21 DAT, Finale at 1.12 kg ai/ha (1 lb ai/A) and Roundup at 1.8 kg ai/ha (1.6 lb ai/A) provided 100% control, while lower rates of both herbicides provided poor control (14 to 85%). Both herbicides caused slight initial injury to 'Big Blue', however, injury was outgrown by 60 DAT and by the following spring all plants were similar in size and number of new bibs produced compared to non-treated controls.

Index words: herbicide, nursery production, weed control.

Herbicides used in this study: Manage (halosulfuron-methyl) methyl 5-{[(4,6-dimethoxy-2-pyrimidinyl) amino]-carbonylaminosulfonyl}-3-chloro-1-methyl-1*H*-pyrazol-4-carboxylate; Image (imazaquin) ammonium salt of 2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1*H*-imidazol-2-yl]-3-quinolinecarboxylic acid; Trimec Southern (MCPP + 2,4-D + dicamba) [2-(4-chloro-2-methyl phenoxy) propionic acid] + [(2,4-dichlorophenoxy) acetic acid] + [3,6-dichloro-O-anisic acid]; Finale (glufosinate-ammonium) 2-4-amino-(hydroxymethlyphosphinyl)-monoammonium salt; Roundup Pro (glyphosate) N-(phoshphonomethyl) glycine, in the form of its isopropylamine salt.

Species used in this study: 'Big Blue' and 'Variegata' liriope (*Liriope muscari* L.H. Bailey).

Significance to the Nursery Industry

Growers are often reluctant to apply preemergence herbicides immediately after potting up divisions of liriope (*Liriope muscari*) due to potential root inhibition. However, not using a preemergence herbicide often results in heavy weed infestations, including prostrate spurge (*Chamaesyce prostrata* (Ait.) Small (syn. *Euphorbia prostrata*)). Our research demonstrated that a single application of either Finale (glufosinate) at 1.12 kg ai/ha (1 lb ai/A) or Roundup (glyphosate) at 1.8 kg ai/ha (1.6 lb ai/A) provided excellent postemergence control of mature spurge. Finale caused slight initial injury, however plants grew past the injury in the normal production cycle. Roundup did not cause any injury, though some slight sporadic injury was observed when smaller plants were treated. Neither herbicide reduced liriope growth or bib numbers the spring following application. These data indicate that Finale and Roundup can be used as a cleanup treatment for postemergence spurge control in container-grown liriope when growers have delayed their preemergence herbicide applications until plants are rooted, or when failures in the preemergence weed management program occur.

Growers should use caution in applying Roundup or Finale to nursery crops and should conduct trials prior to treating their entire stock. The authors believe the most effective weed control is provided by using sound sanitary and cultural practices and a proven preemergence herbicide program to prevent weed populations from becoming established in container stock. Nonetheless, the results of this research provide growers with another option when they have delayed preemergence herbicide applications until liriope are rooted or when failures in their preemergence weed management program occur.

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Introduction

Prostrate spurge (*Chamaesyce prostrata* (Ait.) Small (syn. *Euphorbia prostrata*)) is a serious container nursery weed problem in the southeastern United States (10). Spurge seed typically germinate within 5 days of sowing (14) and plants grow to maturity in approximately four weeks (9). Effective preemergence herbicides for controlling prostrate spurge in container crops include Rout (oxyfluorfen + oryzalin), a combination of Ronstar (oxadiazon) and Surflan (oryzalin), or a combination of Ronstar and Barricade (prodiamine) (18). However, a survey of container nurseries in Alabama reported prostrate spurge as being the weed most often uncontrolled by preemergence herbicides (10). Liriope (*Liriope muscari*) has become popular in urban landscapes where it is used for groundcover, edging, and massing, thus becoming a major crop in nursery production. Nurseries in Alabama have reported difficulty in controlling prostrate spurge in liriope production. Liriope is typically propagated by division, after which many growers are reluctant to apply preemergence herbicides in fear that they will cause root inhibition (11) (the mode of action for dinitroanilines, commonly used in herbicides labeled for nursery crops). Because spurge can germinate within 5 days, failure to apply preemergence herbicides immediately after potting often results in widespread spurge infestations. This leads to hand-weeding, a costly remedy for weed infestations. A one-time postemergence weed control application to avoid hand weeding spurge from container-grown liriope would be a useful tool for growers.

Several herbicides have potential for postemergence spurge control in container-grown liriope. Manage (halosulfuron) and Image (imazaquin) are postemergence herbicides labeled for broadleaf weed and nutsedge control in established turfgrass. Neither caused short-term (30 days) injury nor growth reduction in liriope (12, 13). Trimec Southern (2,4-D + dicamba + mecoprop) also has potential as a postemergence herbicide because of its selectivity against broadleaf weeds in grasses and other monocots. Finale (glufosinate) has potential for use in liriope production because it is effective on a broad range of weeds as a contact herbicide and is not translocated far beyond sprayed foliage. Finale could be particularly useful in crops that are pruned back in the normal production cycle where pruning would remove slight localized injury. Roundup (glyphosate) is the most commonly used herbicide by nursery and greenhouse growers (16). Several properties of Roundup make it an attractive herbicide including: it is a broad-spectrum, nonselective herbicide with postemergence activity on virtually all annual and perennial weeds; its systemic activity provides complete control of the entire plant; it is not absorbed by woody non-green stems and it is nonvolatile so it can be applied around woody plants as long as foliage is not contacted; some plants in the dormant state are resistant to foliar applications; and it is virtually non-toxic to mammals, birds, fish, and insects (8). Many studies were conducted in the 1970s and early 1980s to determine if Roundup could be safely applied to landscape crops. Several landscape crops reported to be tolerant of over-the-top applications of Roundup at rates up to 2.2 kg ai/ha (2 lb ai/A) included: *Berberis* x *mentorensis*, *Buxus sempevirens*, *Ilex cornuta* 'Burfordii', *I. cornuta* 'Rotunda', *I. vomitoria*, *Juniperus chinensis*, *J. conferta*, *J. horizontalis*, *Ligustrum* x *vicary*, *Magnolia* x *soulangiana*, *Nandina domestica*, *Ophiopogon sp.*, *Osmanthus sp.*, *Pittosporum tobira*, *Podocarpus sp.*, *Santolina virens*, and *S. chamaecyparissus* (2, 6, 7, 17, 19, 20, 21, 22). Other species that have exhibited variable tolerance include: *Camellia japonica*, *Euonymous japonica*, *Forsythia* x *intermedia*, *Gardenia augusta* 'Radicans', *Ligustrum japonicum* 'Recurvifolium', *Photinia* x *fraseri*, and *Taxus cuspidata* (1, 5, 6, 18, 19, 20, 21, 22). Factors such as time of year in which Roundup application is made, plant size or stage of growth, and environmental conditions may cause differences in tolerance with the same species from one test to another (1, 15).

The objectives of this study were to evaluate herbicides for postemergence prostrate spurge control and tolerance of container-grown liriope to those herbicides.

Materials and Methods

Four experiments were conducted to evaluate prostrate spurge control with postemergence applied herbicides. All treatments were applied with a CO_2 backpack sprayer and an 8004 flat fan nozzle tip. Applications were calibrated to deliver 187 liters/ha (20 gal/A) in Experiment 1, and 374 liters/ha (40 gal/A) in Experiments 2–4.

Experiment 1. The first test was conducted in Mobile, AL. On September 16, 1997, containers [3.8 liter (#1)] were filled with a pinebark:peat moss substrate (3:1 by vol) amended per m^3 (yd^3) with 8.3 kg (14 lb) of 17N–3.1P–10K (Osmocote 17–7–12, Scotts Co., Marysville, OH), 3.54 kg (6 lb) of dolomitic limestone, 0.9 kg (1.5 lb) of Micromax micronutrients (Scotts Co.), and 1.2 kg (2 lb) of gypsum. In each container a single 'Big Blue' liriope bib was planted. Two days later containers were over-seeded with prostrate spurge seed collected from plants growing at the Auburn University experiment station (Auburn, AL). Plants were grown under 47% shade with overhead irrigation. Containers were treated with the following herbicides on October 1, when the spurge were 1–2 cm (0.4–0.8 in) wide: Manage at 0.0084, 0.017, or 0.034 kg ai/ha (0.0075, 0.015, or 0.03 lb ai/A) (Monsanto Co., St. Louis, MO); Image at 0.07, 0.14, or 0.28 kg ai/ha (0.0625, 0.125, or 0.25 lb ai/A) (American Cyanamid Co., Princeton, NJ); Trimec Southern at 0.64, 1.28, or 2.56 kg ai/ha (0.57, 1.14, or 2.28 lb ai/A) (PBI/Gordon Corp., Kansas City, MO); and Roundup at 0.11, 0.22, or 0.45 kg ai/ha (0.1, 0.2, or 0.4 lb ai/A) [concentrations of 0.125, 0.25, or 0.5% applied at 187 liters/ha (20 gal/A)] (Monsanto Co., St. Louis, MO). All treatments consisted of 10 single plant replicates in a randomized complete block design. Data collected were percent spurge control (from 0 to 100 where 0 = no weed injury and 100 = complete weed control) 9 and 20 days after treatment (DAT), spurge shoot fresh weight (SFW) 30 DAT, liriope injury 9 and 20 DAT, and a bib count of liriope the following spring (May 1998).

Experiment 2. This and all subsequent studies were conducted in Auburn, AL. The second study was conducted to evaluate phytotoxicity of over-the-top applications of Roundup and Finale on established liriope. Spurge control was not evaluated. Finale was added based on grower comments that liriope are normally cut back several months prior to marketing to stimulate bib development. Because Finale has little translocation beyond sprayed foliage it has potential in situations where foliage with localized injury will be pruned back in the normal production cycle. 'Big Blue' were treated in 3.8 liter (#1) containers with foliage 30 to 35 cm (11.8 to 13.8 in) long, and only a few plants flowering. Plants were treated June 1, 2000 with Finale at 0.14, 0.28, 0.56, or 1.12 kg ai/ha (0.125, 0.25, 0.5, or 1.0 lb ai/A), and Roundup at 0.45, 0.9, 1.35, or 1.8 kg ai/ha (0.4, 0.8, 1.2, or 1.6 lb ai/A) [concentrations of 0.25, 0.5, 0.75%, and 1.0% solutions applied in 374 liters/ha (40 gal/A)]. A non-treated control was also included. At 21 DAT, half the liriope in each treatment were pruned back to 2.5 cm (1 in) above the container medium. Each treatment consisted of eight single plant replicates in a completely randomized design. Data collected included foliar injury ratings 7, 14, 21, and 60 DAT, shoot fresh weight (SFW) and shoot dry weight (SDW) 331 DAT (shoots harvested the following spring), and root ratings 331 DAT on a scale of 1 to 10 where 1 = 10% coverage of the container/substrate surface and 10 = 100% coverage.

Experiment 3. Finale and Roundup were evaluated for postemergence spurge control and injury on 'Variegata' liriope. Recently divided and actively growing 'Variegata' in 10 cm (4 in) wide pots with naturally occurring spurge populations were obtained from a commercial nursery. At the time of treatment, 'Variegata' were 17.0 to 20.1 cm (6.7 to 7.9 in) tall (foliage fully extended) and prostrate spurge (naturally occurring) were 25.4 to 35.1 cm (10 to 13.8 in) long (branches fully extended) with all spurge flowering and seeding. Plants were treated June 28, 2000, with Finale at 0.28, 0.56, or 1.12 kg ai/ha (0.25, 0.5, or 1.0 lb ai/A), and Roundup at 0.45, 0.9, or 1.8 kg ai/ha (0.4, 0.8, or 1.6 lb ai/A) [0.25, 0.5, and 1.0% solutions applied in 374 liter/ha (40 gal/A)]. A non-treated control was also included. All treatments consisted of 16 single plant replicates in a completely randomized design. On September 6, 2000, plants were shifted up into 3 liter (trade gallon) containers and filled with a substrate consisting of 7:1 pinebark:sand (by vol) amended per yd^3 (m^3) with 8.9 kg (15 lb) of 17N–3.1P–10K, 3.9 kg (5 lb) of dolomitic limestone, and 0.9 kg (1.5 lb) of Micromax micronutrients. Data collected included percent spurge control 7 and 21 DAT, SFW and SDW 21 DAT, an injury rating from 1 to 5 (1 = no injury and 5 = plant death) of 'Variegata' 7, 14, 21, 28, and 50 DAT, bib number counts 300 DAT (the following spring after first flush of growth, April 24, 2001), 'Variegata' SFW 300 DAT, and 'Variegata' root dry weight (RDW) 300 DAT.

Experiment 4. Small, recently divided, actively growing, single bib 'Big Blue' liriope were treated with Finale and Roundup to determine 'Big Blue' tolerance when applications are made soon after division. 'Big Blue', with foliage 9 to 13 cm long (3.5 to 5.1 in), were in 10 cm (4 in) pots filled with a substrate similar to that used in Experiment 3. Each container had one to three prostrate spurge (naturally occurring) 23 to 31 cm (9.1 to 12.2 in) wide. Containers were treated August 24, 2000, with Finale and Roundup at rates the same as those used in Experiment 3. A non-treated control was also included. Each treatment consisted of 8 single plant replicates arranged in a completely randomized design. Data collected included percent spurge control 7, 14, and 21 DAT, spurge SFW and SDW 21 DAT, and bib numbers, root ratings, SFW, and SDW of 'Big Blue' 247 DAT (plants harvested the following spring, April 28, 2001).

Data were analyzed with: regression analysis to determine the nature of response for measured parameters with respect to herbicide rate, contrast analyses for making specific comparisons, and Dunnett's test for simultaneously comparing treatments to non-treated controls.

Results and Discussion

Experiment 1. Manage and Image provided little or no spurge control (Table 1) and were deleted from subsequent experiments. At 9 DAT, the high rate of Trimec Southern appeared to control spurge, however, re-growth began to occur from injured tissue by 20 DAT. Therefore, Trimec Southern was also dropped from subsequent experiments. Control from Roundup was initially poor; however, by 20 DAT the 0.45 kg ai/ha (0.4 lb ai/A) rate provided 96% control of the small spurge evaluated in this test. At 30 DAT, spurge SFW from middle and high Roundup rates of 0.22 and 0.45 kg ai/ha (0.2 and 0.4 lb ai/A) were 0.0 g compared

Table 1. Effect of herbicides on spurge control and 'Big Blue' injury, Experiment 1.

Herbicide	Rate (kg ai/ha)	Spurge control (%) 9 DAT[z]	Spurge control (%) 20 DAT	Spurge fresh weight (g)	'Big Blue' bib number[y]
Manage	0.0084	0	20	6.5	11.4
Manage	0.0170	0	0	6.8	11.0
Manage	0.0340	0	0	9.8	9.7
		NS[x]	NS	NS	NS
Image	0.07	0	10	9.0	11.5
Image	0.14	0	10	6.1	10.3
Image	0.28	0	0	6.5	10.6
		NS	NS	NS	NS
Trimec Southern	0.64	0	20	4.5	10.3
Trimec Southern	1.28	0	10	3.1	10.6
Trimec Southern	2.56	85	63	1.4	7.7
		L***Q***	L***Q*	NS	NS
Roundup	0.11	0	25	3.9	9.3
Roundup	0.22	15	83	0.0	11.9
Roundup	0.45	45	96	0.0	11.6
		L***	Q***	NS	NS
Control		0	0	8.6	11.6

[z]Days after treatment; treatments applied September 16, 1997.

[y]Data taken after the following spring growth flush (1998).

[x]NS, L, or Q represent no significant, linear, or quadratic responses within a herbicide.

*, **, and *** represents significance at α = 0.05, 0.01, and 0.001.

Table 2. **Established 'Big Blue' tolerance to Finale and Roundup, Experiment 2.**

Herbicide	Rate (kg ai/ha)	Injury[z] 7 DAT[y]	Injury[z] 21 DAT	Shoot dry weight (g)	Root rating
Finale	0.14	1.0	1.0	62.4	8.9
Finale	0.28	1.8	1.8[†]	71.9	8.8
Finale	0.56	1.1	2.1[†]	64.0	8.0
Finale	1.12	2.5[†]	4.9[†]	68.6	8.5
		L**[x]	L***	NS	NS
Roundup	0.45	2.0	1.3	50.8	7.9
Roundup	0.90	1.1	1.1	64.3	8.5
Roundup	1.35	1.6	1.1	55.2	8.9
Roundup	1.80	1.3	1.1	66.6	8.6
		NS	NS	NS	NS
Control		1.0	1.0	64.6	8.0
Contrast					
Roundup vs control		NS	NS	NS	NS
Finale vs control		NS	***	NS	NS
Roundup vs Finale		NS	***	NS	NS
Pruning effect		—	—	NS	NS

[z]Injury on a scale of 1 to 10 where 1 = no injury and 10 = plant death.

[y]Days after treatment; treatments applied June 1, 2000.

[†]Indicates the adjacent mean was significantly higher than non-treated controls (Dunnett's one-tail t-test where $\alpha = 0.05$).

[x]NS, L, or Q represent no significant, linear, or quadratic responses within a herbicide.

*, **, and *** represents significance at α = 0.05, 0.01, and 0.001.

to 8.6 g (0.3 oz) for non-treated controls. Only the high rate of Trimec Southern caused injury to 'Big Blue' (data not shown), which was characterized by necrosis of leaf blade tips. Roundup caused no visual injury to 'Big Blue' at 9 or 20 DAT. These data concur with those of Neal and Skroch (15) who evaluated over-the-top applications of glyphosate to green liriope (*Liriope spicata*) at six different times throughout the growing season (a separate group was treated at each application date). They reported little visual injury when applications were made at rates [0.8 and 1.5 kg ai/ha (0.7 and 1.3 lb ai/A)] and time of year (September) similar to that in our study. Their study reported the greatest injury with spring and early summer applications. The following spring, liriope in our experiment from all treatments had similar bib numbers compared to non-treated controls, indicating no long-term effects from herbicide treatments.

Experiment 2. At 7 DAT, only plants treated with Finale at 1.12 kg ai/ha (1 lb ai/A) resulted in injury to 'Big Blue' (Table 2). By 21 DAT, plants treated with Finale at rates greater or equal to 0.28 kg ai/ha (0.25 lb ai/A) were injured, with injury increasing linearly with increasing Finale rate. Injury from Finale was characterized as moderate chlorosis and bleaching of leaf blade tips. Injury from Roundup was slight and variable, though not significantly greater than non-treated controls. These data concur with those of Neal and Skroch (15), who reported only slight injury to *L. spicata* when using similar rates and application time (June) to that used in this study. After 21 DAT, half the liriope in each treatment were pruned to simulate a grower practice used to induce bib development. By 60 DAT these plants had regrown to the point that all plants were similar in appearance regardless of herbicide or pruning treatment (data not shown). These data indicate that even if Finale causes slight initial foliar injury, plants grow out of that injury and are similar in size and appearance to non-treated plants within a few weeks (60 days). After the following spring's growth flush, 'Big Blue' SFW, SDW, and root ratings were similar for all treatments, indicating no long-term effects from Finale or Roundup applications.

Experiment 3. At 7 DAT, Finale rates of 0.56 and 1.12 kg ai/ha (0.5 and 1.0 lb ai/A) provided excellent postemergence control of mature spurge (94 and 98%, respectively) while all rates of Roundup provided poor control (15 to 56%) (Table 3). By 21 DAT, Finale [1.12 kg ai/ah (1.0 lb ai/a)] and Roundup [1.8 kg ai/ha (1.6 lb ai/A)] provided 100% and 93% control respectively; however, spurge had begun to recover from the low and middle rates of both herbicides. Spurge SDW data followed a trend similar to spurge control data at 21 DAT. Unlike the first experiment where Roundup at 0.45 kg ai/ha (0.4 lb ai/A) provided excellent control, the same rate in the third experiment provided poor control. Spurge in this experiment were larger at the time of treatment, physiologically older than those in Experiment 1, and therefore may have been more difficult to control. Other studies have shown larger weeds are more difficult to control than smaller ones (4). No injury due to herbicide treatment was observed on 'Variegata'. These data are surprising in that Finale or Roundup caused no foliar injury. Previous research reported foliar applied Roundup caused slight to severe crown necrosis on 'Variegata' at rates as low as 0.34 kg ai/ha (0.3 lb ai/A) (3). Plants in the referenced experiment were treated in mid September, while plants in this experiment were treated in early June. Other research has demonstrated that 'Variegata' tolerance to Roundup is dependent on time of year in which the application is made (15). Neal and Skroch reported that at rates and application date (late June) similar to those used in this study, variegated liriope initially displayed unacceptable levels of injury, but had grown out of that injury by the following year and were similar to untreated controls. In general, they reported that variegated liriope exhibited significant tolerance to summer applications of Roundup, but that results were too variable to conclude positively that they are tolerant. No treatment reduced bib numbers in 'Variegata' the following spring. These data concur with other work in which Roundup did not reduce bib numbers of 'Variegata' the spring following application (3). Finale and Roundup did not reduce SDW or RDW compared to non-treated controls. 'Variegata' treated with Finale had greater bib numbers (contrast analyses) than non-treated controls, and greater bib numbers and SDW compared to those treated with Roundup. While this is difficult to explain, it is trivial since neither herbicide reduced bib number or SDW compared to non-treated controls. Hence, over-the-top applications of Finale and Roundup at rates necessary to provide postemergence control of mature spurge cause no short- or long-term injury to 'Variegata' when applied under these conditions.

Experiment 4. Control from Finale was initially high with all rates (84 to 100%) (Table 4). By 21 DAT Finale at 1.12 kg ai/ha (1 lb ai/A) provided 100% control while spurge began to recover from the low rate [0.28 kg ai/ha (0.25 lb ai/A)]. At 14 and 21 DAT, control from Roundup increased linearly with increasing rate, with 1.8 kg ai/ha (1.6 lb ai/A) the only rate providing effective control. These results are similar to Experiment 3, which contained spurge of similar size. SDW of spurge treated with Finale were similar across all Finale rates because initial injury was severe and weeds had not fully recovered by the time plants were harvested 21 DAT. SDW of spurge treated with Roundup followed a trend similar to control 21 DAT. Injury to 'Big Blue' increased linearly with increasing Finale rate at 14 and 21 DAT; however, the only rate causing greater injury than non-treated controls was 1.12 kg ai/ha (1 lb ai/A). Injury was light and characterized by chlorosis and yellowing of leaf blade tips on emerging foliage. By 21 DAT, injury from Roundup increased with increasing rate, however, no rate individually caused injury greater than non-treated controls (according to Dunnett's test, $\alpha = 0.05$). Injury from Roundup was sporadic in that it was limited to a single chlorotic emerging leaf blade. This was observed on four of the 24 replications treated with Roundup (across all rates), with all other plants showing no sign of injury. All plants had similar bib numbers, SDW, and RDW when harvested after the following spring growth flush. These data indicate slight initial injury to 'Big Blue' when treated with rates high enough to control prostrate spurge, however, plants outgrow this injury within the normal production cycle and injury does not otherwise interfere with plant growth and development from a production standpoint. Other research reported acceptable levels of injury when *L. spicata* are treated with Roundup at similar rates and time of year (15).

In summary, Finale at 1.12 kg ai/ha (1.0 lb ai/A) and Roundup at 1.8 kg ai/ha (1.6 lb ai/A) provide excellent postemergence control of mature spurge. Finale rates that provide effective spurge control caused slight short term injury, however, injury was temporary and had no effect on 'Big Blue' and 'Variegata' growth and development from a nursery production stand point (i.e., plant size and bib number). This indicates Finale may have potential for other crops that are pruned or cut back during the normal production cycle. Roundup rates that provided effective control of mature spurge caused no significant short- or long-term injury to 'Big Blue' and 'Variegata'. While 'Variegata' were not injured in the one study we conducted, others have reported

Table 3. Effect of Finale and Roundup on spurge control, Experiment 3.

Herbicide	Rate (kg ai/ha)	Spurge: Control (%)[z] 7 DAT[y]	Spurge: Control (%)[z] 21 DAT	Spurge: Shoot dry weight (g)	'Variegata': Bib number	'Variegata': Shoot dry weight (g)	'Variegata': Root dry weight (g)
Finale	0.28	73	47	0.7	3.8	9.2	6.4
Finale	0.56	94	87	0.1	4.6	11.7	7.4
Finale	1.12	98	100	0.0	4.0	10.6	6.1
		L***Q*[x]	L***Q***	L***Q***	NS	NS	NS
Roundup	0.45	15	11	1.7	3.4	7.3	5.0
Roundup	0.90	21	16	1.2	3.9	9.0	6.2
Roundup	1.80	56	93	0.1	3.1	7.9	5.6
		L***Q*	L***Q***	L***	NS	NS	NS
Control		2	5	1.3	3.3	8.7	6.8
Contrast							
Roundup vs control		***	***	*	NS	NS	NS
Finale vs control		***	***	***	*	NS	NS
Roundup vs Finale		***	***	***	**	**	NS

[z]Rated on a scale of 1 to 100 where 0 to 100 where 0 = no weed control and 100 = complete weed control.

[y]Days after treatment; treatments applied June 28, 2000.

[x]L or Q represent linear or quadratic responses within a herbicide.

*, **, and *** represents significance at α = 0.05, 0.01, and 0.001.

Table 4. Spurge control and injury to recently divided 'Big Blue', Experiment 4.

		Spurge			'Big Blue'				
		Control[z]		Shoot dry weight (g)	Injury[y]		Bib number	Shoot dry weight (g)	Root dry weight (g)
Herbicide	Rate (kg ai/ha)	14 DAT[x]	21 DAT		14 DAT	21 DAT			
Finale	0.28	89	79	0.3	1.3	1.0	4.1	6.2	3.5
	0.56	84	85	0.2	1.1	1.5	6.0	8.8	5.4
	1.12	100	100	0.1	1.9[†]	2.0[†]	5.9	8.6	4.3
		NS[w]	L**	NS	L***Q*	L***	NS	NS	NS
Roundup	0.45	16	14	1.7	1.0	1.0	3.9	8.2	5.1
	0.90	31	49	1.2	1.1	1.1	5.3	7.3	5.2
	1.80	97	100	0.1	1.1	1.5	5.4	7.5	4.1
		L***	L***	L***	NS	L*	NS	NS	NS
Control	0	0	0	1.3	1.0	1.0	4.3	6.9	4.2
Contrast									
Roundup vs control		***	***	*	NS	NS	NS	NS	NS
Finale vs control		***	***	***	**	*	NS	NS	NS
Roundup vs Finale		***	***	***	**	*	NS	NS	NS

[z]Rated on a scale of 1 to 100 where 0 to 100 where 0 = no weed control and 100 = complete.

[y]Injury on a scale of 1 to 10 where 1 = no injury and 10 = plant death.

[x]Days after treatment; treatments applied August 24, 2000.

[w]L or Q represent linear or quadratic responses within a herbicide.

[†]Injury ratings significantly higher than non-treated controls (Dunnett's test, $\alpha = 0.05$)

*, **, and *** represents significance at $\alpha = 0.05$, 0.01, and 0.001.

injury from Roundup applications depending on time of year application is made (15), therefore, recommendations from our data regarding safety of Roundup on 'Variegata' should be limited to mid-summer applications. Sporadic injury initially observed on 'Big Blue' was temporary and resulted in no long-term effects.

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