Determining Safety of Preemergence Herbicide Use During Propagation of Three Woody Ornamental Species

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ABSTRACT

Four different herbicides were evaluated for use during propagation of *Loropetalum chinense* 'Sizzling Pink' (loropetalum), *Viburnum odoratissimum* (viburnum), and *Rosa* 'Radrazz' (rose) in various combinations. Loropetalum cuttings were treated with Marengo G (indaziflam), Rout (oxyfluorfen + oryzalin), or Tower (dimethenamid-p), viburnum cuttings were treated with either Gallery SC (isoxaben), Rout, or Tower, and rose cuttings were treated with either Marengo G or Gallery SC. All herbicide treatments were applied at 0.5, 1, or 2× their label rate. For rose and loropetalum, herbicide treatments were either applied 14 days before sticking (DBS), on the day of sticking (0 DAS), or at 30 or 60 DAS. Viburnum cuttings were treated at 14 DBS, and at 0, 30, 60, and 90 DAS. Data collected included phytotoxicity ratings at 1, 2, and 4 weeks after treatment and shoot and root fresh weights at study conclusion. Herbicide rate had little impact on trial results. Loropetalum cuttings performed best when treated with Marengo G at either 30 or 60 DAS in which there were no significant reductions in shoot or root FW, although there was a numerical reduction in shoot and root weight. For rose, cuttings performed best when treated with the lowest two rates of Gallery SC or Marengo at 30 and 60 DAS. For viburnum, cuttings grew similarly to non-treated controls when Gallery SC was applied at 14 DBS, 0 DAS, and 90 DAS. Viburnum cuttings were also similar to non-treated controls when Rout was applied at 14 DBS or 90 DBS. Viburnum cuttings were most impacted by applications of Tower which reduced shoot and root FW at most timings.

INTRODUCTION

In restricted root environment such as a nursery container, weeds have been shown to reduce growth of ornamental species by over 60% (Fretz, 1972; Berchielli-Robertson et al., 1990). In propagation, weed control can be one of the most expensive production problems during due to lack of herbicide options. Weeds compete with cuttings for water, light, nutrients and also significantly reduce the marketability of liners. Once weeds have begun to germinate in propagation flats the only method of removal is typically hand weeding which is extremely expensive from a labor standpoint and can also disrupt or delay the rooting process as the cuttings are often disturbed (Johnson and Mead, 1987).

Although there is now a preemergence herbicide (indaziflam) labeled for use inside greenhouses, there are still no herbicides labeled for use in flats during propagation. Due to the comparatively small market and high dollar per acre value associated with propagation, chemical companies have been hesitant to label herbicides for use in small liners. There is great concern among growers concerning the safety of most preemergence herbicides and their effects during the rooting process (Davies and Duray, 1992). However, previous research has shown there is some potential with certain products during various stages of propagation. Oxadiazon (Ronstar) caused no reduction in growth or root quality when applied during propagation of Korean boxwood (*Buxus microphylla* var. *koreana*) although cuttings of Korean boxwood, abelia (*Abelia* × *grandiflora*) and compacta holly (*Ilex crenata* 'Compacta') did have reduced root growth following treatment with oryzalin (Surflan) (Thetford and Gilliam, 1991). Other research has shown oxadiazon, oxyfluorfen + oxadiazon (Regal O-O) and flumioxazin (Broadstar) caused no reduction in root quality of Girard Rose azalea (*Rhododendron* × 'Girard Rose' or two species of Japanese hollies (*Ilex crenata* var Hetzii and var. Compacta) (Cook and Neal, 2001). Cochran et

al. (2008) also showed that isoxaben (Gallery) did not cause a significant root reduction during propagation of loropetalum (*Loropetalum chinense* 'Ruby').

Most of the previous research on preemergence herbicide use during propagation was conducted over 20 years ago. In that time, several new active ingredients have been introduced into the nursery market including indaziflam (Marengo) and dimethenamid-p (Tower). While it may be unlikely that a preemergence herbicide would be labeled for use in non-rooting cuttings, there could be a possibly that label language could change to allow growers to make preemergence herbicide applications to liners at different stages of propagation at their own risk if safety is determined. The objective of this trial was to evaluate various rates of selected preemergence herbicides for use during different stages of propagation of three common ornamental species.

MATERIALS AND METHODS

This trial was conducted at the Mid-Florida Research and Education Center in Apopka, FL in 2015. On July 28, semi-hardwood cuttings of *Loropetalum chinense* 'Sizzling Pink' (loropetalum) and *Viburnum odoratissimum* (viburnum) were collected on-site at the Mid-Florida Research and Education Center, dipped in 1 part Dip'N Grow (IBA): 5 parts water and stuck in 2 in. (5.1 cm) nursery liner pots filled with Fafard® 52 mix (pinebark, peat, perlite, vermiculite, dolomitic limestone, wetting agent) that had been amended with Osmocote® Plus 15-9-12 at a rate of 4 lbs. (1.8 kg) per cubic yard. All cuttings were stuck at a depth of 1.25 in. (3.2 cm). At this time, a separate group of propagation flats were filled with the same substrate but were not

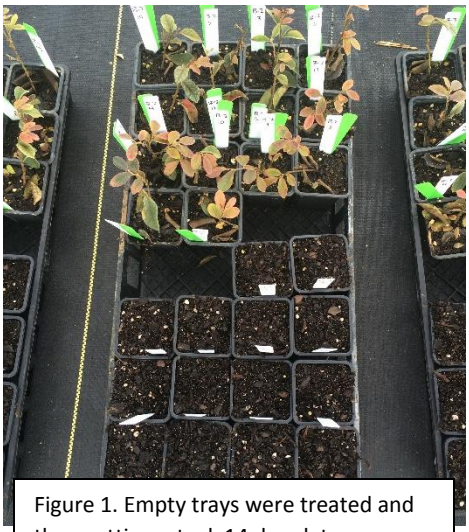

Figure 1. Empty trays were treated and then cuttings stuck 14 days later.

planted with cuttings (Figure 1). Cuttings were placed in a greenhouse and received overhead mist irrigation for 5 sec. every 10 minutes from 7:30 AM to 5:00 PM each day. On July 28, approximately 4 hours after cuttings were stuck, cuttings were taken out of the mist, placed under a 40% shade structure outside and allowed to dry. When foliage was dry, a group of loropetalum cuttings were treated with Marengo G (indaziflam), Rout (oxyfluorfen + oryzalin) or Tower while a group of viburnum cuttings were treated with Gallery SC (isoxaben), Rout, or Tower (dimethenamid-p) [cuttings were treated on the same day they were stuck, or 0 days after sticking (0 DAS). Flats containing substrate but no cuttings were also treated at this time. All treatments were applied at 0.5, 1, and 2× their recommended label rate (see Table 1 for exact rates). Spray applied treatments (Gallery and Tower) were applied with a CO_2 backpack sprayer calibrated to deliver 50 gallons per acre (468 L/ha). Granular treatments (Rout and Marengo G) were applied with a handshaker. All treatments were applied to dry foliage and were irrigated by hand immediately after treatment to wash foliage and then moved back inside the greenhouse. On August 15, a separate group of loropetalum and viburnum cuttings were collected as described above and stuck into treated propagation flats [flats that were previously treated on July 28 or 14 days before sticking (14 DBS)]. Subsequent treatments were applied at 30 and 60 days after sticking (DAS) for loropetalum and at 30, 60 and 90 DAS for viburnum. On September 21, cuttings of *Rosa* 'Radrazz' (rose) were collected from stock plants and stuck in the same substrate and treated with either Gallery SC or Marengo G as described above. Empty flats were also treated at this time and a separate group of rose cuttings were stuck into treated flats on October 5. Separate groups of rose cuttings were subsequently treated at 30 and 60 DAS (Table 1). A non-treated control was included for each species at each treatment date. Dates on which cuttings were stuck and treatments were applied for each species is listed in Table 1.

Extra cuttings were stuck for each species to monitor rooting progress throughout the trial. For plants treated 14 DBS or 0 DAS, obviously no roots were present. For cuttings treated 30 DAS, each cutting had developed approximately 3 to 5 small roots but no roots were visible when removing the liner rootball from the propagation container and were considered to be "lightly rooted". For plants treated at 60 DAS, 10 to 25% of the liner rootball was covered with visible roots and were considered to be "fairly rooted". For plants treated at 90 DAS, greater than 25% of the liner rootball was covered with visible roots and this stage was considered to be "fully rooted". This trial was designed as a completely randomized block design with 14 single cutting replications per treatment at each growth stage. Data collected included visual injury ratings on a 0 to 10 scale (0 = no injury, 10 = dead plant). For cuttings that were stuck into flats treated two weeks before sticking (WBS), phytotoxocity ratings were taken at 1, 2, and 4 weeks after sticking. Phytotoxicity ratings were recorded at 1, 2, and 4 weeks after herbicide treatment on all other groups. At approximately 160 days after sticking (January 9, 2016), shoot and root fresh weights were taken on viburnum and loropetalum cuttings. Rose root and shoot fresh weights were recorded approximately 120 days after sticking (January 15, 2016). Data were subjected to ANOVA and means were separated using Fisher's protected LSD (p= 0.05). Each species was analyzed separately.

RESULTS

In all three species, phytotoxicity ratings were closely correlated with shoot and root fresh weights (Tables 2 – 6). In most cases, any phytotoxicity that was noticed was likely the result of poor rooting (wilting) or stunted shoot growth and was not characteristic of other types

of herbicide damage (speckled foliage, “burnt” leaf tips, foliage chlorosis or necrosis, epinasty, etc.). Therefore, only shoot and root fresh weight data will be discussed.

Loropetalum.

All herbicide treatments negatively impacted loropetalum shoot and root FW when applied 14 days before sticking (Table 2). The only treatments in which cuttings rooted and survived throughout the trial were those stuck into flats treated with Marengo G (100 or 400 lbs./A). When herbicide treatments were applied immediately after sticking cuttings (0 DAS), the only treatments in which loropetalum cuttings had significantly lower shoot or root FW were Marengo G (400 lbs./A) (80% reduction in shoot growth and 64% reduction in root growth) and all three Tower treatments (all over 65% reduction in shoot and root growth) (Table 3). At 30 DAS, the only loropetalum with shoot FW similar to non-treated controls were those treated with the two rates of Marengo G or the lowest rate of Tower. Root growth was decreased by the two highest rates of Rout (62 and 75% reduction) and the two highest rates of Tower (65% reduction) (Table 4). At 60 DAS, only the highest rate of Tower reduced shoot FW (64%) but Rout (100 lbs./A and all three rates of Tower reduced root FW (Table 5).

Viburnum.

Although several treatments resulted in numerically lower shoot and root FW at 14 DBS, none had statistically lower shoot or root FW than non-treated controls (Table 2). At 0 DBS, the only treatment which significantly reduced shoot FW was Tower at 21 fl. oz./A while all three rates of Tower reduced root FW (43 to 81% reduction) (Table 3). At 30 DAS, all treatments resulted in significantly lower shoot and root FW (Table 4). When treatments were applied at 60 DAS, only

the two lowest rates of Tower significantly reduced shoot FW. In contrast, all treatments with the exception of Gallery (31 fl. oz./A) and Rout (50 lbs./A) significantly reduced root FW (Table 5). By 90 DAS, none of the herbicide treatments had much impact on viburnum cuttings (Table 6). At this time, the only treatment which significantly impact shoot or root FW was the highest rate of Tower which caused a 45% decrease in shoot growth and a 35% decrease in root growth.

Rose.

None of the rose cuttings rooted or survived when planted into flats treated with any herbicide at 14 DBS (Table 2). When treatments were applied at 0 DAS, Gallery SC (31 fl. oz./A) was the only treatment that had similar shoot FW to non-treated plants. While shoot FW were reduced in most treatments, all three Gallery treatments and the lowest rate of Marengo G had no impact on root growth (Table 3). When plants were treated at 30 DAS, the two lowest rates of Gallery and the lowest rate of Marengo G had no significant impact on shoot FW (Table 4). Root FW was not affected by the lowest rate of Gallery or the lowest rate of Marengo G. Results were similar at 60 DAS in that the two lowest rates of Gallery and the two lowest rates of Marengo G did not significantly impact shoot or root FW compared with non-treated controls (Table 5).

DISCUSSION

Application timing had more of an impact on test results than herbicide rate which had very little impact. Results varied among all three species with loropetalum and rose generally being the most sensitive to herbicide treatment and timing. In both cases, cuttings from these two species typically had better shoot and root growth when treated at 60 DAS which was after these cuttings had developed some root growth. Very few of the loropetalum or rose cuttings survived

after treatment at 14 DBS and had the lowest growth in at this timing similar to previous research on 'Hino Crimson' azalea (*Rhododendron obtusum* 'Hino Crimson') which were found to be very sensitive to herbicide applications prior to sticking (Gilliam et al., 1993). Viburnum cuttings were much more tolerant of herbicide treatment. There was no different in any treatment at 14 DBS and only one treatment (Tower) caused reduced root FW at 0 DAS. The greatest reduction in shoot and root FW occurred at 30 DAS. It is unclear why roots and shoots were impacted at 30 DAS but not as significantly at other application timings. Shoot growth was largely unaffected at 60 DAS and only one treatment impacted shoot or root growth by 90 DAS indicating that as liners become more mature, the chances of damage from herbicide application could possibly decline. However, it should be pointed out that after 90 DAS the liners would likely have already been heavily infested with weeds had they been grown in a commercial nursery setting with high weed pressure. Results were also surprising in that Rout did not have as much of a negative impact on root growth as was expected. Rout contains oryzalin, a dinitroanaline herbicide which is a root inhibitor. Oryzalin has been investigated in previous propagation trials and in most cases has reduced root growth (Gilliam et al., 1993; Thetford and Gilliam, 1991). While Rout did reduce root growth of all three species at various application timings, in many cases it was similar to other herbicide treatments.

It is also important to note that all applications were made outside of the greenhouse and then cuttings were placed back inside after being irrigated. In this trial, only a small number of flats were treated with herbicide during each evaluation. Had a larger number of plants been treated or a smaller greenhouse used, more herbicide would be contained inside the greenhouse which would have significantly increased the risk of phytotoxicity from volatilization. Additionally, making herbicide applications inside a greenhouse would have also significantly

increased non-target losses of herbicides which would inevitably occur, and would further increase the risk for volatility issues. In most cases, treated plants must remain outside of any enclosed structure for at least 2 to 3 weeks (or longer) following a herbicide application to reduce chances of injury from volatilization.

RECCOMENDATIONS

Based upon results from this trial, it appears there could be potential for use of preemergence herbicides during different stages of propagation; however, results were variable at each application timing and variable within each species. There were no herbicide-species combinations that did not reduce shoot or root growth of cuttings during at least one application timing. The only herbicide which did not result in numerically (or statistically) lower shoot or root fresh weights when applied at any of the three rates was Gallery SC applied to viburnum 14 DBS. A significant amount of further testing would be needed before any wide spread recommendations could be made and growers should continue to focus on proper sanitation and prevention practices during propagation to reduce weed pressure. Additional work would also be needed to determine liner performance after transplanting into larger nursery containers. If grower's wished to test various herbicides for use during propagation, a small group of plants should be treated under local environmental conditions and monitored for any injury or growth differences prior to making a widespread application. Herbicide applications should also be made outside of any fully enclosed structure.

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Table 1. Propagation and treatment outline.					
	Cutting Stage[z]				
	Before Sticking	Immediately After Sticking	Lightly Rooted	Fairly Rooted	Fully Rooted
	2 WBS	0 DAS	30 DAS	60 DAS	90 DAS
	Sizzling Pink' Loropetalum				
Cuttings stuck:	8/15/2015	7/28/2015	7/28/2015	7/28/2015	---
Treatment dates:	7/28/2015	7/28/2015	9/21/2015	9/21/2015	---
Herbicides evaluated:	1. Marengo G at 100, 200 and 400 lbs. per acre. 2. Rout at 50, 100 and 200 lbs. per acre. 3. Tower at 10.5, 21, and 42 fl. oz. per acre.				
	Sweet Viburnum				
Cuttings Stuck:	8/15/2015	7/28/2015	7/28/2015	7/28/2015	7/28/2015
Treatment Dates:	7/28/2015	7/28/2015	9/21/2015	9/21/2015	10/23/2015
Herbicides evaluated:	1. Gallery SC at 15.5, 31, and 62 fl. oz. per acre. 2. Rout at 50, 100 and 200 lbs. per acre. 3. Tower at 10.5, 21, and 42 fl. oz. per acre.				
	Knockout Rose				
Cuttings stuck:	10/5/2015	9/21/2015	9/21/2015	9/21/2015	---
Treatments dates:	9/21/2015	9/21/2015	10/23/2015	11/20/2015	---
Herbicides evaluated:	1. Gallery SC at 15.5, 31, and 62 fl. oz. per acre. 2. Marengo G at 100, 200 and 400 lbs. per acre.				

[z]Before sticking = empty flats treated prior to sticking cuttings; Immediately after sticking = cuttings were stuck and then treated on the same day (no roots); Lightly rooted = 3 to 5 developed roots but none visible in the liner rootball; Fairly rooted = 10 to 25% of roots visible in the liner rootball; Fully rooted = greater than 25% of roots visible in the liner rootball; WBS = weeks before sticking; DAS = days after sticking.

Table 2. Effects of applying preemergence herbicides 14 days before sticking (14DBS) cuttings of three common woody ornamentals.

Treatment		Phytotoxicity Ratings (0 - 10)[z]			Fresh Wts (g)[y]			
Herbicide	**Rate[x]**	**1WAS[w]**	**2WAS**	**4WAS**	**Shoot FW**	**% +/-**	**Root FW**	**% +/-**
Sizzling Pink' Loropetalum								
Marengo G	100 lbs./A	0.0 a[v]	3.20 a	8.1 ab	0.14 b	-89	0.10 b	-91
Marengo G	200 lbs./A	0.0 a	2.00 abc	10.0 a	0.00 b	-100	0.00 b	-100
Marengo G	400 lbs./A	0.0 a	2.83 ab	10.0 a	0.20 b	-84	0.25 b	-78
Rout	50 lbs./A	0.0 a	1.33 bcd	10.0 a	0.00 b	-100	0.00 b	-100
Rout	100 lbs./A	0.0 a	1.83 abc	10.0 a	0.00 b	-100	0.00 b	-100
Rout	200 lbs./A	0.0 a	3.17 a	10.0 a	0.00 b	-100	0.00 b	-100
Tower	10.5 fl.oz./A	0.0 a	0.83 cd	10.0 a	0.00 b	-100	0.00 b	-100
Tower	21 fl.oz./A	0.0 a	1.50 bcd	10.0 a	0.00 b	-100	0.00 b	-100
Tower	42 fl.oz./A	0.0 a	2.83 ab	10.0 a	0.00 b	-100	0.00 b	-100
Control	NA	0.0 a	0.00 d	0.0 c	1.30 a	-	1.16 a	-
Sweet Viburnum								
Gallery SC	15.5 fl.oz./A	0.0 a	0.0 a	0.00 c	4.42 ab	7	9.27 a	42
Gallery SC	31 fl.oz./A	0.0 a	0.0 a	1.00 abc	4.77 ab	16	8.77 ab	35
Gallery SC	62 fl.oz./A	0.0 a	0.0 a	0.00 c	4.17 abc	1	7.74 abc	19
Rout	50 lbs./A	0.0 a	0.0 a	0.17 bc	5.29 a	28	7.14 abc	10
Rout	100 lbs./A	0.0 a	0.0 a	1.33 abc	4.45 ab	8	6.96 bcd	7
Rout	200 lbs./A	0.0 a	0.0 a	1.50 ab	3.63 abc	-18	4.58 de	-30
Tower	10.5 fl.oz./A	0.0 a	0.0 a	1.00 abc	2.50 c	-39	3.94 e	-39
Tower	21 fl.oz./A	0.0 a	0.0 a	0.83 abc	3.17 bc	-23	3.60 e	-45
Tower	42 fl.oz./A	0.0 a	0.0 a	2.00 a	2.32 c	-43	4.58 de	-30
Control	NA	0.0 a	0.0 a	0.00 c	4.12 abc	-	6.51 bcde	-
Knockout Rose								
Gallery SC	15.5 fl.oz./A	0.0 a	3.00 d	10.0 a	0.00 b	-100	0.00 b	-100
Gallery SC	31 fl.oz./A	0.0 a	3.83 cd	10.0 a	0.00 b	-100	0.00 b	-100
Gallery SC	62 fl.oz./A	0.0 a	4.33 bc	10.0 a	0.00 b	-100	0.00 b	-100
Marengo G	100 lbs./A	0.0 a	4.67 abc	10.0 a	0.00 b	-100	0.00 b	-100
Marengo G	200 lbs./A	0.0 a	5.17 ab	10.0 a	0.00 b	-100	0.00 b	-100
Marengo G	400 lbs./A	0.0 a	5.50 a	10.0 a	0.00 b	-100	0.00 b	-100
Control	NA	0.0 a	0.00 e	0.0 b	1.23 a	-	2.15 a	-

[z]Phytotoxicity ratings taken on a scale of 0 to 10, 0 = no injury, 10 = dead plant.

[y] % +/- = percent increase or decrease (-) in shoot or root fresh weights in comparison with non-treated control. Red font shows treatments which caused a significant decrease in shoot or root fresh weight compared with non-treated.

[x] lbs./A = pounds of product applied per acre; fl. oz./A = fluid ounces of produce applied per acre.

[w]WAS = weeks after sticking. All flats were treated two weeks prior to sticking cuttings.

[v]Means within a column followed by the same letter are not significantly different based on Fisher's Protected LSD test (p = 0.05).

Table 3. Effects of applying preemergence herbicides immediately after sticking (0DAS) cuttings of three common woody ornamentals.

Treatment		Phytotoxicity Ratings (0 - 10)[z]			Fresh Wts (g)[y]			
Herbicide	**Rate[x]**	**1WAT[w]**	**2WAT**	**4WAT**	**Shoot FW**	**% +/-**	**Root FW**	**% +/-**
Sizzling Pink' Loropetalum								
Marengo G	100 lbs./A	0.0 a[v]	1.0 dc	5.0 b	0.40 bc	-38	0.41 ab	-41
Marengo G	200 lbs./A	0.0 a	0.8 cd	1.7 c	0.40 bc	-38	0.51 ab	-27
Marengo G	400 lbs./A	0.0 a	2.2 ab	7.3 ab	0.13 c	-80	0.25 bc	-64
Rout	50 lbs./A	0.0 a	0.0 d	0.0 c	0.65 ab	2	0.71 a	1
Rout	100 lbs./A	0.0 a	0.0 d	0.0 c	0.84 a	31	0.65 a	-7
Rout	200 lbs./A	0.0 a	0.3 d	0.0 c	0.96 a	50	0.60 ab	-14
Tower	10.5 fl.oz./A	0.0 a	1.8 bc	8.3 a	0.20 c	-69	0.24 bc	-66
Tower	21 fl.oz./A	0.0 a	3.0 a	10.0 a	0.00 c	-100	0.0 c	-100
Tower	42 fl.oz./A	0.0 a	2.5 ab	10.0 a	0.00 c	-100	0.0 c	-100
Control	NA	0.0 a	0.0 d	0.0 c	0.64 ab	-	0.70 a	-
Sweet Viburnum								
Gallery SC	15.5 fl.oz./A	0.0 a	0.0 a	0.17 bc	5.54 bcd	-11	12.16 a	3
Gallery SC	31 fl.oz./A	0.0 a	0.0 a	0.00 c	8.47 a	36	10.01 ab	-16
Gallery SC	62 fl.oz./A	0.0 a	0.0 a	0.00 c	6.76 abc	9	8.88 bc	-25
Rout	50 lbs./A	0.0 a	0.0 a	0.00 c	5.66 bcd	-9	13.00 a	10
Rout	100 lbs./A	0.0 a	0.0 a	0.00 c	7.10 ab	14	12.44 a	5
Rout	200 lbs./A	0.0 a	0.0 a	0.67 abc	7.69 ab	23	10.40 ab	-12
Tower	10.5 fl.oz./A	0.0 a	0.0 a	0.17 bc	3.81 de	-48	6.69 cd	-43
Tower	21 fl.oz./A	0.0 a	0.0 a	1.00 ab	2.91 e	-53	4.46 de	-62
Tower	42 fl.oz./A	0.0 a	0.0 a	1.17 a	4.41 cde	-29	2.62 e	-81
Control	NA	0.0 a	0.0 a	0.00 c	6.23 abcd	-	11.84 ab	-
Knockout Rose								
Gallery SC	15.5 fl.oz./A	0.0 a	1.17 b	1.00 b	0.66 bc	-49	1.86 ab	-23
Gallery SC	31 fl.oz./A	0.0 a	0.66 b	1.17 b	0.97 ab	-25	1.65 ab	-32
Gallery SC	62 fl.oz./A	0.0 a	3.00 a	8.33 a	0.34 bc	-74	0.84 ab	-65
Marengo G	100 lbs./A	0.0 a	1.17 b	1.67 b	0.61 bc	-53	1.50 ab	-38
Marengo G	200 lbs./A	0.0 a	3.33 a	6.67 a	0.28 c	-79	0.66 b	-73
Marengo G	400 lbs./A	0.0 a	4.50 a	8.33 a	0.14 c	-89	0.36 b	-85
Control	NA	0.0 a	0.00 b	0.00 b	1.30 a	-	2.43 a	-

[z]Phytotoxicity ratings taken on a scale of 0 to 10, 0 = no injury, 10 = dead plant.

[y] % +/- = percent increase or decrease (-) in shoot or root fresh weights in comparison with non-treated control. Red font shows treatments which caused a significant decrease in shoot or root fresh weight compared with non-treated.

[x] lbs./A = pounds of product applied per acre; fl. oz./A = fluid ounces of produce applied per acre.

[w]WAT = weeks after treatment. Treatments were applied immediately after cuttings were stuck.

[v]Means within a column followed by the same letter are not significantly different based on Fisher's Protected LSD test (p = 0.05).

Table 4. Effects of applying preemergence herbicides 30 days after sticking (30DAS) cuttings of three common woody ornamentals.

Treatment		Phytotoxicity Ratings (0 - 10)[z]			Fresh Wts (g)[y]			
Herbicide	**Rate[x]**	**1WAT[w]**	**2WAT**	**4WAT**	**Shoot FW**	**% +/-**	**Root FW**	**% +/-**
Sizzling Pink' Loropetalum								
Marengo G	100 lbs./A	0.0 a[v]	0.50 a	0.0 a	1.31 a	7	0.86 a	-15
Marengo G	200 lbs./A	0.0 a	0.00 a	0.0 a	1.14 ab	-7	0.81 ab	-20
Marengo G	400 lbs./A	0.0 a	0.50 a	0.0 a	0.72 bc	-42	0.57 abc	-44
Rout	50 lbs./A	0.0 a	0.00 a	0.0 a	0.72 bc	-42	0.65 abc	-36
Rout	100 lbs./A	0.0 a	0.00 a	0.0 a	0.60 c	-51	0.38 bc	-62
Rout	200 lbs./A	0.0 a	0.00 a	0.0 a	0.61 c	-50	0.25 c	-75
Tower	10.5 fl.oz./A	0.0 a	0.00 a	0.0 a	0.93 abc	-24	0.75 ab	-26
Tower	21 fl.oz./A	0.0 a	0.00 a	0.0 a	0.56 c	-55	0.35 bc	-65
Tower	42 fl.oz./A	0.0 a	0.00 a	0.0 a	0.76 bc	-38	0.35 bc	-65
Control	NA	0.0 a	0.00 a	0.0 a	1.23 a	-	1.01 a	-
Sweet Viburnum								
Gallery SC	15.5 fl.oz./A	0.0 a	0.0 a	0.83 ab	2.54 d	-76	4.36 cd	-62
Gallery SC	31 fl.oz./A	0.0 a	0.0 a	0.33 ab	3.74 cd	-64	6.95 bc	-40
Gallery SC	62 fl.oz./A	0.0 a	0.0 a	0.67 ab	3.88 cd	-63	7.44 bc	-35
Rout	50 lbs./A	0.0 a	0.0 a	0.33 ab	3.88 cd	-63	7.43 b	-35
Rout	100 lbs./A	0.0 a	0.0 a	0.17 ab	3.31 cd	-68	5.30 bcd	-54
Rout	200 lbs./A	0.0 a	0.0 a	0.00 b	5.25 bc	-50	7.42 b	-36
Tower	10.5 fl.oz./A	0.0 a	0.0 a	0.67 ab	4.60 bc	-56	6.47 bcd	-44
Tower	21 fl.oz./A	0.0 a	0.0 a	0.00 b	6.20 b	-41	6.93 bc	-40
Tower	42 fl.oz./A	0.0 a	0.0 a	1.17 a	3.44 cd	-67	3.96 d	-66
Control	NA	0.0 a	0.0 a	0.00 b	10.46 a	-	11.53 a	-
Knockout Rose								
Gallery SC	15.5 fl.oz./A	0.0 a	0.33 a	0.00 a	1.81 ab	-8	2.28 ab	-28
Gallery SC	31 fl.oz./A	0.0 a	0.50 a	0.67 a	1.72 abc	-12	2.07 b	-34
Gallery SC	62 fl.oz./A	0.0 a	0.00 a	0.00 a	1.14 c	-42	1.50 b	-52
Marengo G	100 lbs./A	0.0 a	0.67 a	0.83 a	1.52 abc	-22	2.31 ab	-27
Marengo G	200 lbs./A	0.0 a	0.00 a	0.00 a	1.09 c	-44	2.21 b	-30
Marengo G	400 lbs./A	0.0 a	0.00 a	0.00 a	1.29 bc	-34	2.18 b	-31
Control	NA	0.0 a	0.00 a	0.00 a	1.96 a	-	3.15 a	-

[z]Phytotoxicity ratings taken on a scale of 0 to 10, 0 = no injury, 10 = dead plant.

[y] % +/- = percent increase or decrease (-) in shoot or root fresh weights in comparison with non-treated control. Red font shows treatments which caused a significant decrease in shoot or root fresh weight compared with non-treated.

[x] lbs./A = pounds of product applied per acre; fl. oz./A = fluid ounces of produce applied per acre.

[w]WAT = weeks after treatment. Treatments were applied immediately after cuttings were stuck.

[v]Means within a column followed by the same letter are not significantly different based on Fisher's Protected LSD test (p = 0.05).

Table 5. Effects of applying preemergence herbicides 60 days after sticking (60DAS) cuttings of three common woody ornamentals.

Treatment		Phytotoxicity Ratings (0 - 10)[z]			Fresh Wts (g)[y]			
Herbicide	**Rate[x]**	**1WAT[w]**	**2WAT**	**4WAT**	**Shoot FW**	**% +/-**	**Root FW**	**% +/-**
Sizzling Pink' Loropetalum								
Marengo G	100 lbs./A	0.0 a[v]	1.70 bc	0.00 c	0.68 ab	-15	0.84 ab	-16
Marengo G	200 lbs./A	0.0 a	0.50 abc	0.50 bc	0.79 ab	-1	0.68 abc	-32
Marengo G	400 lbs./A	0.0 a	0.33 bc	1.17 abc	0.64 ab	-20	0.65 abc	-35
Rout	50 lbs./A	0.0 a	0.17 bc	0.00 c	0.64 ab	-20	0.79 ab	-32
Rout	100 lbs./A	0.0 a	0.50 abc	0.00 c	0.64 ab	-20	0.45 bc	-55
Rout	200 lbs./A	0.0 a	0.33 bc	1.67 abc	1.07 a	34	0.64 abc	-36
Tower	10.5 fl.oz./A	0.0 a	1.17 ab	1.67 abc	0.68 ab	-15	0.45 bc	-55
Tower	21 fl.oz./A	0.0 a	0.50 abc	3.33 ab	0.72 ab	-10	0.49 bc	-51
Tower	42 fl.oz./A	0.0 a	1.50 a	4.17 a	0.29 c	-64	0.24 c	-76
Control	NA	0.0 a	0.00 c	0.00 c	0.80 ab	-	1.00 a	-
Sweet Viburnum								
Gallery SC	15.5 fl.oz./A	0.0 a	0.0 a	0.00 a	6.53 ab	-25	8.03 b	-39
Gallery SC	31 fl.oz./A	0.0 a	0.0 a	0.00 a	7.42 ab	-15	10.99 ab	-16
Gallery SC	62 fl.oz./A	0.0 a	0.0 a	0.00 a	6.89 ab	-21	8.83 b	-33
Rout	50 lbs./A	0.0 a	0.0 a	0.67 a	7.08 ab	-19	10.16 ab	-22
Rout	100 lbs./A	0.0 a	0.0 a	0.00 a	7.42 ab	-15	8.92 b	-32
Rout	200 lbs./A	0.0 a	0.0 a	0.00 a	6.88 ab	-22	7.85 b	-40
Tower	10.5 fl.oz./A	0.0 a	0.0 a	0.67 a	4.93 b	-44	8.31 b	-37
Tower	21 fl.oz./A	0.0 a	0.0 a	0.00 a	5.44 b	-38	9.11 b	-30
Tower	42 fl.oz./A	0.0 a	0.0 a	0.00 a	6.32 ab	-28	7.38 b	-44
Control	NA	0.0 a	0.0 a	0.00 a	8.76 a	-	13.09 a	-
Knockout Rose								
Gallery SC	15.5 fl.oz./A	0.0 a	0.33 b	0.50 a	1.61 ab	-12	2.53 ab	-28
Gallery SC	31 fl.oz./A	0.0 a	0.50 ab	0.00 a	1.77 a	-3	2.53 ab	-28
Gallery SC	62 fl.oz./A	0.0 a	1.33 a	0.67 a	1.05 b	-42	1.66 b	-53
Marengo G	100 lbs./A	0.0 a	0.00 b	0.00 a	1.30 ab	-29	2.52 ab	-29
Marengo G	200 lbs./A	0.0 a	0.17 b	0.33 a	1.54 ab	-15	2.42 ab	-31
Marengo G	400 lbs./A	0.0 a	0.33 b	0.00 a	1.05 b	-42	2.22 b	-37
Control	NA	0.0 a	0.00 b	0.00 a	1.82 a	-	3.53 a	-

[z]Phytotoxicity ratings taken on a scale of 0 to 10, 0 = no injury, 10 = dead plant.

[y] % +/- = percent increase or decrease (-) in shoot or root fresh weights in comparison with non-treated control.
Red font shows treatments which caused a significant decrease in shoot or root fresh weight compared with non-treated.

[x] lbs./A = pounds of product applied per acre; fl. oz./A = fluid ounces of produce applied per acre.

[w]WAT = weeks after treatment. Treatments were applied immediately after cuttings were stuck.

[v]Means within a column followed by the same letter are not significantly different based on Fisher's Protected LSD test (p = 0.05).

Table 6. Effects of applying preemergence herbicides 90 days after sticking (90DAS) Sweet Viburnum cuttings.

Treatment		Phytotoxicity Ratings (0 - 10)[z]			Fresh Wts (g)[y]			
Herbicide	**Rate[x]**	**1WAT[w]**	**2WAT**	**4WAT**	**Shoot FW**	**% +/-**	**Root FW**	**% +/-**
Gallery SC	15.5 fl.oz./A	0.0 a[v]	0.0 a	0.00 b	7.88 a	10	9.10 ab	-4
Gallery SC	31 fl.oz./A	0.0 a	0.0 a	0.50 b	4.56 bc	-36	7.79 ab	-18
Gallery SC	62 fl.oz./A	0.0 a	0.0 a	0.00 b	5.38 abc	-25	8.80 ab	-7
Rout	50 lbs./A	0.0 a	0.0 a	0.00 b	6.90 ab	-4	9.52 a	0
Rout	100 lbs./A	0.0 a	0.0 a	0.00 b	5.39 abc	-24	7.91 ab	-17
Rout	200 lbs./A	0.0 a	0.0 a	2.00 a	6.23 abc	-13	8.10 ab	-15
Tower	10.5 fl.oz./A	0.0 a	0.0 a	0.00 b	6.32 abc	-12	9.85 a	4
Tower	21 fl.oz./A	0.0 a	0.0 a	0.00 b	4.91 bc	-31	8.59 ab	-10
Tower	42 fl.oz./A	0.0 a	0.0 a	0.50 b	3.92 c	-45	6.17 b	-35
Control	NA	0.0 a	0.0 a	0.00 b	7.16 ab	-	9.50 a	-

[z]Phytotoxicity ratings taken on a scale of 0 to 10, 0 = no injury, 10 = dead plant.

Red font shows treatments which caused a significant decrease in shoot or root fresh weight compared with non-treated.

[v]Means within a column followed by the same letter are not significantly different based on Fisher's Protected LSD test (p = 0.05).