

Phytotoxicity of selected herbicides to containerized nursery stock: a review of herbicide trials in 2008

Principle investigators: Hannah Mathers and Luke Case

Significance to the industry: Weed control continues to be a major expense for nursery growers, and many species still have few, if any options for chemical weed control. The IR-4 program helps to alleviate problems faced by nursery growers by adding new uses to existing pesticides or new pesticides to the nursery/landscape or any 'minor use' cropping industries. It is imperative that growers use this program because it is based largely on growers' needs. Anyone can go to the website www.ir4.rutgers.edu and list the needs of the operation. The objectives of the 2007 IR-4 herbicide tests were to find more postemergence herbicides (all weeds) and preemergence and postemergence herbicides for nutsedge control. Many of the chemical companies also see a need for more herbicide labels in the nursery industry, and therefore, support their own research trials done in conjunction with universities. This year at The Ohio State University, trials were performed for Monsanto Co. (St. Louis, MO), and BASF Corp. (Research Triangle Park, NC).

Materials and Methods:

IR-4. Eight species were selected to determine phytotoxicity of preemergence herbicides: red maple (*Acer rubrum* 'Sun Valley'), butterfly bush (*Buddleia davidii* 'Nanho Blue'), Japanese holly (*Ilex crenata* 'Convexa'), Norway spruce (*Picea abies*), red oak (*Quercus rubra*), lilac (*Syringa xtribrida* 'Lark Song'), yew (*Taxus media* 'Runyan'), and Japanese tree lilac (*Syringa reticulata* 'Ivory Silk'). The trial was set up at The Ohio State University, Columbus, Ohio, and herbicides applied on 29 May, 2008. Herbicides and rates tested included Freehand (dimethenamid-p + pendimethalin) (BASF Corp.) at 2.65 (1X), 5.3 (2X), and 10.6 (4X) lbs ai/ac, Tower (dimethenamid-p) (BASF Corp.) at 0.97 (1X), 1.94 (2X), and 3.88 (4X) lbs ai/ac, V-10142 (imazosulfuron) (Valent U.S.A Corp., Walnut Creek, CA) at 0.75 (1X), 1.5 (2X), and 3.0 (4X) lbs ai/ac, and mesotrione – G (mesotrione) (Syngenta Corp., Wilmington, DE) at 2.1 (1X), 4.2 (2X), and 6.3 (3X) lbs ai/ac. Tower is an emulsifiable concentrate which was sprayed on with a CO₂ backpack sprayer with 8002 evs nozzles in a spray volume of 25 gallons per acre. All other herbicides were in the granular form and spread by shaker jars. Herbicides were reapplied on 10 July 2008. The protocol specified that BroadStar (flumioxazin) (Valent U.S.A. Corp.) not be applied at the first application timing, but at the second, so it was also applied on 10 July 2008 at 0.375 (1X), 0.75 (2X), and 1.5 (4X) lbs ai/ac. Immediately after each application, ½ acre-inch irrigation was applied. Phytotoxicity evaluations were performed at 1 WA1T (week after first treatment), 2 WAT, 4 WAT, 1 WA2T (week after second treatment), 2 WA2T, and 4 WA2T. Visual ratings were performed on a scale of 0-10 with 0 being no phytotoxicity, 10 being dead, and ≤3 commercially acceptable.

Monsanto trial. Ten species were selected to determine phytotoxicity of Certainty (sulfosulfuron) (Monsanto Corp.) and SedgeHammer (halosulfuron) (Gowan Co., Yuma, AZ). Species selected included arborvitae (*Thuja occidentalis* 'Smaragd'), viburnum (*Viburnum plicatum tomentosum* 'Mariesii'), hydrangea (*Hydrangea macrophylla*

'Forever Pink'), Japanese holly (*Ilex crenata* 'Convexa'), daylily (*Hemerocallis* 'Fathers Best White'), dogwood (*Cornus sericea* 'Cardinal'), serviceberry (*Amelanchier canadensis* 'Rainbow Pillar'), boxwood (*Buxus* 'Antarctica'), Norway spruce (*Picea abies*), and rhododendron (*Rhododendron* 'PJM'). Certainty was applied at rates of 0.06 (1X) and 0.12 (2X) lbs ai/ac, and SedgeHammer was applied at a rate of 0.06 lbs ai/ac. Certainty and SedgeHammer were applied on June 25, 2008 via CO₂ backpack sprayer with 8002 evs nozzles in a spray volume of 25 gallons per acre. A nonionic surfactant was included with both herbicides at a rate of 0.25% volume of total spray volume. One treatment was a second application of the 1X Certainty, which was applied on July 25, 2008. Phytotoxicity visual ratings were performed at 2 WAT, 4 WAT, 6 WAT, 8 WAT, and 12 WAT. Visual ratings were based on a scale of 0-10 with 0 being no phytotoxicity, 10 being dead, and ≤ 3 commercially acceptable. Percent growth reduction (% GR) was also taken at 6 WAT, 8 WAT, and 12 WAT based on the untreated controls.

BASF trial. A trial was performed for BASF in which Tower and Freehand were applied at the 1X rate described above, and also at a 3X rate (7.95 and 2.91 lbs ai/ac for Freehand and Tower, respectively) in the methods also described above. Species selected to receive Freehand applications included arborvitae (*Thuja occidentalis* 'Smaragd'), honeylocust (*Gleditsia triacanthos*), portulaca (*Portulaca* 'Hot-shot Rose'), pentas (*Pentas* 'Kaleidoscope Pink'), red oak (*Quercus rubra*), lilac (*Syringa xtribrida* 'Lark Song'), and red maple (*Acer rubrum* 'Sun Valley'). Species selected to receive Tower applications included dogwood (*Cornus sericea* 'Cardinal'), daylily (*Hemerocallis* 'Fathers Best White'), maiden grass (*Miscanthus sinensis* 'Silver Feather'), viburnum (*Viburnum plicatum tomentosum* 'Mariesii'), Norway spruce (*Picea abies*), red oak (*Quercus rubra*), lilac (*Syringa xtribrida* 'Lark Song'), and red maple (*Acer rubrum* 'Sun Valley'). Treatments were applied on 11 June 2008 and 4 August 2008. Phytotoxicity visual ratings were performed on 1 WAT, 2 WAT, 4 WAT, 6 WAT, 1 WA2T, 2 WA2T, and 4 WA2T on a scale of 0-10 with 0 being no phytotoxicity, 10 being dead, and ≤ 3 commercially acceptable.

Results and Discussion:

IR-4. Red maple showed very low phytotoxicity from all rates of Freehand and mesotrione – G (Table 1). Tower injured red maple with increasing rates with the 4X rate providing higher than commercially acceptable ratings. The first application was much more injurious than the second application. The butterfly bush showed injury from both the V-10142 (especially at the 2X and 4X rates) and the mesotrione – G (at all rates) (Table 1). The 1X rate of V-10142 gave a varying response from the butterfly bush (i.e. some showed no injury while others showed less than acceptable injury), which indicates that very low rates of V-10142 can only be used on the butterfly bush. Butterfly bush was not injured by the BroadStar at any of the rates tested (Table 2). The Japanese holly exhibited no injury from the V-10142; however, the mesotrione – G was very injurious to the Japanese holly at all rates (Table 1). Japanese holly was not injured from any rate of BroadStar (Table 2). The Norway spruce showed little, if any, injury from the Tower applications (Table 1). Red oak varied in response to the herbicides in which it received. Freehand and V-10142 were not injurious at any of the rates on the oak. However, Tower did injure red oak, especially at the higher rates. Red oak did not exhibit normal injury symptoms from the mesotrione – G (bleaching of leaves), but more of plants were

stunted from the mesotrione – G than any other treatment, and therefore, had high visual ratings (Table 1). Red oak was only slightly injured by the 4X rate of BroadStar (Table 2). The lilac exhibited no phytotoxicity from the Freehand applications. The 1X and 2X rates of Tower did not injure the lilac, but the 4X rate of Tower did injure the lilac, especially after the second application. Mesotrione is injurious to the lilac at all rates (Table 1). Yew was injured beyond commercially acceptable levels from the 4X applications of both V-10142 and mesotrione – G, although injury was observed at all rates for both herbicides (Table 1). BroadStar was not injurious to the yew (Table 2). Japanese tree lilac was also not injured by BroadStar (Table 2).

Monsanto. Certainty was not injurious to the rhododendron (Table 3). Certainty was injurious to all the other species tested; however, the species exhibited varying degrees of injury, and rate and number of applications was also important for the amount of injury (Table 3). Dogwood and hydrangea showed the most injury from the Certainty than any other species. Hydrangea and dogwood were injured from the 1X, 2X, and two applications of the 1X rate. However, hydrangea did start to grow normally at the very end of the trial from the single application of the 1X rate (Table 3). Japanese holly, viburnum, serviceberry, and boxwood exhibited about the same amount and types of injury symptoms from the Certainty. Both rates injure those species initially, but slowly grow out of the injury (although none fully caught up with the untreated) and did not exhibit the type of injury symptoms by the end of the trial, especially at the 1X rates. However, if the second application is made (which corresponds to 6 WAT), the injury symptoms reappear (Table 3) and more injury is noticeable (Table 3). The arborvitae showed very little injury from the Certainty applications. Daylily initially showed much injury from the Certainty, but by the end of the trial, very little injury was noticeable, especially with the 1X rate (either one or two applications). The Norway spruce was significantly injured by the two applications of the Certainty, although there was some growth reduction from all rates (Table 3).

SedgeHammer did not injure hydrangea or rhododendron whatsoever (Table 3). All other species showed some injury to SedgeHammer, but like Certainty, to varying degrees. Norway spruce, Japanese holly, viburnum, and arborvitae were not injured by SedgeHammer to beyond commercially acceptable levels, but there was still some growth reduction (Table 3). SedgeHammer did injure to beyond commercially acceptable levels the daylily, dogwood, serviceberry, and boxwood. Daylily, serviceberry, and boxwood grew out of the injury symptoms, but were still smaller than the untreated controls (Table 3). It should be mentioned again here that SedgeHammer was only applied at a 1X rate and only one application was made.

BASF. Freehand was only injurious to the pentas and portulaca, but the portulaca was only affected by the 3X rate, especially after the first application (Table 4). The pentas was significantly affected by both rates to commercially unacceptable levels. There was some stunting on the red oak by the Freehand, but the injury was not above commercially acceptable.

The 1X rate of Tower significantly injured the red oak and red maple, but only at the first and last evaluation and was not above commercially acceptable levels (Table 5). The 3X rate of Tower significantly injured the red oak, red maple, dogwood, viburnum, and lilac; however, only the lilac had phytotoxicity visual ratings that were above commercially acceptable, after two applications.

Based on the container trials in 2008 at The Ohio State University, Freehand can be applied to arborvitae, honeylocust, red oak, lilac, and red maple with almost no problems, and 1X rates can be applied to portulaca. Tower can be applied to daylily, maiden grass, and Norway spruce at any of the rates tested, and 1X rates can be applied to dogwood, lilac, viburnum, and red maple. V-10142, if it gets a label, is not injurious to Japanese holly or red oak at any rate. Mesotrione – G, if labeled is not injurious to red maple at any rate, and more work should be done to determine injury levels to red oak. BroadStar is not injurious to butterfly bush, red oak, Japanese holly, yew, or Japanese tree lilac, at least when application is delayed until July. Certainty herbicide is only completely safe on Rhododendron; however, arborvitae is only slightly injured. SedgeHammer is safe on hydrangea and rhododendron, and also slightly injurious to arborvitae and Japanese holly.

Table 1. Phytotoxicity of Freehand, Tower, mesotrione-G, and V-10142 on selected containerized ornamentals.

<i>Acer rubrum</i> 'Sun Valley'		Phytotoxicity Ratings ^z					
Treatment	Rate	1 WA1T ^y	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	2.65 lb ai/ac	0.17 ^x	0.4	0.5	0.7	0.8	1.3
Freehand 2X	5.3 lb ai/ac	0.1	0.4	0.4	0.7	1.0	1.9
Freehand 4X	10.6 lb ai/ac	0.8*	0.2	0.2	0.3	0.6	2.0
Tower 1X	0.97 lb ai/ac	1.6*	0.8*	0.3	0.3	0.7	1.2
Tower 2X	1.94 lb ai/ac	2.4*	1.3*	0.7	1.2	1.3	3.0
Tower 4X	3.88 lb ai/ac	3.7*	2.2*	0.7	1.9	1.5	2.4
Mesotrione-G 1X	2.1 lb ai/ac	0.3	0.2	0.1	0.4	0.8	1.6
Mesotrione-G 2X	4.2 lb ai/ac	0.3	0.2	0.2	0.4	0.7	1.5
Mesotrione-G 3X	6.3 lb ai/ac	0.1	0.3	0.6	0.6	0.3	1.0
Untreated	--	0.0	0.0	0.7	1.1	1.2	1.2

<i>Buddleia davidii</i> 'Nanho Blue'		Phytotoxicity Ratings					
Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
V-10142 1X	0.75 lb ai/ac	0.5	1.2	2.3	1.8	1.4	2.1
V-10142 2X	1.5 lb ai/ac	2.4*	2.8*	3.8*	2.9	2.5	2.4*
V-10142 4X	3.0 lb ai/ac	3.4*	3.7*	5.2*	4.8*	5.2*	5.5*
Mesotrione-G 1X	2.1 lb ai/ac	2.7*	5.0*	7.3*	7.8*	8.0*	8.8*
Mesotrione-G 2X	4.2 lb ai/ac	2.8*	5.0*	7.8*	9.1*	9.2*	9.6*
Mesotrione-G 3X	6.3 lb ai/ac	2.8*	5.8*	8.8*	9.6*	9.7*	10*
Untreated	--	0.0	0.0	0.0	0.0	0.0	0.0

<i>Ilex crenata</i> 'Convexa'		Phytotoxicity Ratings					
Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
V-10142 1X	0.75 lb ai/ac	0.0	0.0	0.0	0.0	0.0	0.0
V-10142 2X	1.5 lb ai/ac	0.0	0.0	0.0	0.0	0.2	0.0
V-10142 4X	3.0 lb ai/ac	0.0	0.0	0.0	0.0	0.2	0.0
Mesotrione-G 1X	2.1 lb ai/ac	0.0	1.6*	3.1*	3.0*	3.1*	3.5*
Mesotrione-G 2X	4.2 lb ai/ac	0.0	2.9*	4.5*	4.5*	4.4*	5.1*
Mesotrione-G 3X	6.3 lb ai/ac	0.1	4.1*	5.6*	5.1*	5.8*	5.8*
Untreated	--	0.0	0.0	0.0	0.0	0.0	0.0

<i>Picea abies</i>		Phytotoxicity Ratings					
Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.97 lb ai/ac	0.3	0	0.1	0.0	0.0	0.3
Tower 2X	1.94 lb ai/ac	1.2*	0.8*	0.8*	0.3	0.2	0.8
Tower 4X	3.88 lb ai/ac	0.8*	0.2	0.7	0.4	0.4	1.2
Untreated	--	0	0	0.1	0.3	0.3	0.5

z = Phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 dead, and ≤3 commercially acceptable.

y = WA1T: weeks after first treatment, WA2T: weeks after second treatment

x = Ratings marked with * within the same column are significantly different from the control, based on Dunnett's t-test (α = 0.05)

Table 1, cont. Phytotoxicity of Freehand, Tower, mesotrione-G, and V-10142 on selected containerized ornamentals.

<i>Quercus rubra</i>		Phytotoxicity Ratings					
Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	2.65 lb ai/ac	0.4	0.8	0.9	1.5	1.9*	2.7*
Freehand 2X	5.3 lb ai/ac	0.9	0.6	0.5	0.5	0.7	0.9
Freehand 4X	10.6 lb ai/ac	0.7	0.6	0.1	0.5	0.9	1.9
Tower 1X	0.97 lb ai/ac	2.0*	2.3	0.8	1.3	1.7	2.4*
Tower 2X	1.94 lb ai/ac	2.4*	2.0	1.0*	2.1*	2.3*	2.0
Tower 4X	3.88 lb ai/ac	4.7*	3.8*	2.3*	3.2*	4.2*	3.5*
V-10142 1X	0.75 lb ai/ac	0.5	0.6	0.2	0.1	0.5	1.2
V-10142 2X	1.5 lb ai/ac	1.2	0.5	0.2	0.4	0.6	1.8
V-10142 4X	3.0 lb ai/ac	0.2	0.0	0.2	0.7	0.8	2.7*
Mesotrione-G 1X	2.1 lb ai/ac	0.0	2.9	0.3	1.1	1.2	2.5*
Mesotrione-G 2X	4.2 lb ai/ac	0.9	1.0	0.3	1.4	2.6*	4.1*
Mesotrione-G 3X	6.3 lb ai/ac	0.4	0.5	0.5	2.2*	2.5*	3.2*
Untreated	--	0.0	0.0	0.0	0.0	0.0	0.0

<i>Syringa xtribrida</i> 'Lark Song'		Phytotoxicity Ratings					
Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	2.65 lb ai/ac	0.5	0.4	0.2	0.2	0.1	0.4
Freehand 2X	5.3 lb ai/ac	0.2	0.4	0.0	0.1	0	0.2
Freehand 4X	10.6 lb ai/ac	0.2	0.4	0.3	1.2	0.5	1.5*
Tower 1X	0.97 lb ai/ac	0.8	0.7	0.6	0.8	0.5	0.8
Tower 2X	1.94 lb ai/ac	1.2	0.7	0.8	0.7	0.3	0.8
Tower 4X	3.88 lb ai/ac	0.6	0.7	1.7*	3.2*	3.0*	2.9*
Mesotrione-G 1X	2.1 lb ai/ac	0.5	1.6*	3.4*	4.1*	5.2*	5.8*
Mesotrione-G 2X	4.2 lb ai/ac	1.4*	3.5*	6.2*	7.7*	8.0*	8.7*
Mesotrione-G 3X	6.3 lb ai/ac	1.2*	3.5*	6.8*	8.7*	9.0*	9.8*
Untreated	--	0.0	0.0	0.0	0.0	0.0	0.0

<i>Taxus media</i> 'Runyan'		Phytotoxicity Ratings					
Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
V-10142 1X	0.75 lb ai/ac	0.9	0.8	1.7	0.6	0.7	2.6*
V-10142 2X	1.5 lb ai/ac	1.2	1.5*	2.2*	1.2	1.7*	2.8*
V-10142 4X	3.0 lb ai/ac	2.0*	1.1*	3.0*	2.7*	2.1*	3.0*
Mesotrione-G 1X	2.1 lb ai/ac	0.9	0.3	0.3	0.4	0.2	0.4
Mesotrione-G 2X	4.2 lb ai/ac	0.2	0.2	1.9*	1.2	1.6*	3.1*
Mesotrione-G 3X	6.3 lb ai/ac	1.7*	1.4*	2.5*	1.8*	2.2*	3.2*
Untreated	--	0.0	0.0	0.2	0.2	0.2	0.2

z = Phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 dead, and ≤3 commercially acceptable.

y = WA1T: weeks after first treatment, WA2T: weeks after second treatment

x = Ratings marked with * within the same column are significantly different from the control, based on Dunnett's t-test ($\alpha = 0.05$)

Table 2. Phytotoxicity of BroadStar on selected containerized ornamentals.

<i>Buddleia davidii</i> 'Nanho Blue'		Phytotoxicity visual ratings ^z		
Treatment	Rate	1 WAT ^y	2 WAT	4 WAT
BroadStar 1X	0.375 lb ai/ac	0 ^x	0.0	0.0
BroadStar 2X	0.75 lb ai/ac	0.0	0.0	0.0
BroadStar 4X	1.5 lb ai/ac	0.0	0.5	0.6
Untreated	--	0.0	0.0	0.0

<i>Quercus rubra</i>		1 WAT	2 WAT	4 WAT
Treatment	Rate			
BroadStar 1X	0.375 lb ai/ac	0.5	0.6	1.0
BroadStar 2X	0.75 lb ai/ac	0.9	1.2	1.0
BroadStar 4X	1.5 lb ai/ac	0.3	1.2	2.2*
Untreated	--	0.2	0.9	0.0

<i>Taxus media</i> 'Runyan'		1 WAT	2 WAT	4 WAT
Treatment	Rate			
BroadStar 1X	0.375 lb ai/ac	0.0	0.0	0.1
BroadStar 2X	0.75 lb ai/ac	0.2	0.0	0.0
BroadStar 4X	1.5 lb ai/ac	0.0	0.0	0.2
Untreated	--	0.0	0.0	0.0

<i>Syringa reticulata</i> 'Ivory Silk'		1 WAT	2 WAT	4 WAT
Treatment	Rate			
BroadStar 1X	0.375 lb ai/ac	0.2	0.8	0.3
BroadStar 2X	0.75 lb ai/ac	0.2	0.6	0
BroadStar 4X	1.5 lb ai/ac	0.3	0.8	0.4
Untreated	--	0	0	0

<i>Ilex crenata</i> 'Convexa'		1 WAT	2 WAT	4 WAT
Treatment	Rate			
BroadStar 1X	0.375 lb ai/ac	0.0	0.0	0.0
BroadStar 2X	0.75 lb ai/ac	0.0	0.0	0.0
BroadStar 4X	1.5 lb ai/ac	0.0	0.0	0.0
Untreated	--	0.0	0.0	0.0

z = Phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 dead, and ≤3 commercially acceptable.

y = WA1T: weeks after first treatment, WA2T: weeks after second treatment

x = Ratings marked with * within the same column are significantly different from the control, based on Dunnett's t-test ($\alpha = 0.05$)

Table 3. Phytotoxicity of selected ornamentals from Certainty and Sedgehammer.

Thuja occidentalis 'Smaragd'

Treatment	2 WAT ^z	4 WAT	6 WAT		8 WAT		12 WAT	
	VR ^y	VR	VR	GR ^x	VR	GR	VR	GR
Certainty	2.0 ^w	1.0	0.8	10	1.0	0.0	0.6	7.0
Certainty (2 apps.) ^v	1.6 [*]	0.8	1.6	8.0	1.8	4.0	0.6	2.0
Certainty 2X rate	2.0 [*]	1.0	0.8	10	0.8	8.0	0.4	3.0
Sedgehammer	2.0 [*]	2.4 [*]	0.8	0.0	1.4	0	1.0	7.0
Untreated	0.0	0.0	0.0	10	0.0	6.0	0.0	0.0

Viburnum plicatum tomentosum 'Mariesii'

Treatment	2 WA1T	4 WAT	6 WAT		8 WAT		12 WAT	
	VR	VR	VR	GR	VR	GR	VR	GR
Certainty	2.2 [*]	1.4 [*]	0.8	8.0	1.2	*13.0 [*]	1.8 [*]	19.0 [*]
Certainty (2 apps.)	2.2 [*]	1.8 [*]	3.2 [*]	2.0	2.8 [*]	7.0	1.6	13.0 [*]
Certainty 2X	2.8 [*]	2.6 [*]	2.2 [*]	24.0 [*]	2.4 [*]	21.0 [*]	2.0 [*]	29.0 [*]
Sedgehammer	2.8 [*]	2.4 [*]	0.6	3.0	1.8	10.0	1.6	18.0 [*]
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Hydrangea macrophylla 'Forever Pink'

Treatment	2 WA1T	4 WAT	6 WAT		8 WAT		12 WAT	
	VR	VR	VR	GR	VR	GR	VR	GR
Certainty	2.8 [*]	4.0 [*]	3.0 [*]	29.0 [*]	2.8 [*]	18.0 [*]	2.8 [*]	13.0 [*]
Certainty (2 apps.)	3.8 [*]	3.6 [*]	4.6 [*]	32.0 [*]	4.6 [*]	23.0 [*]	3.8 [*]	19.0 [*]
Certainty 2X	4.0 [*]	4.0 [*]	4.2 [*]	24.0 [*]	4.6 [*]	17.0 [*]	4.0 [*]	15.0 [*]
Sedgehammer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Ilex crenata 'Convexa'

Treatment	2 WA1T	4 WAT	6 WAT		8 WAT		12 WAT	
	VR	VR	VR	GR	VR	GR	VR	GR
Certainty	1.2 [*]	3.4 [*]	2.2 [*]	13.0 [*]	2.5 [*]	18.8 [*]	1.8 [*]	7.0
Certainty (2 apps.)	1.0 [*]	3.0 [*]	4.6 [*]	37.0 [*]	4.8 [*]	35.0 [*]	3.2 [*]	14.0 [*]
Certainty 2X	1.8 [*]	3.6 [*]	4.2 [*]	33.0 [*]	3.5 [*]	33.8 [*]	2.0 [*]	14.0 [*]
Sedgehammer	0.8 [*]	1.4 [*]	0.2	8.0	1.8 [*]	16.2 [*]	0.2	3.0
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

z = WAT: weeks after treatment

y = VR: phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 dead, and ≤3 commercially acceptable

x = GR: % growth reduction

w = Treatment ratings and growth reductions followed by * are significantly different from the control based on Dunnett's t-test (α = 0.05)

v = Certainty was reapplied for this treatment at 4 weeks after the initial treatment

Table 3, cont. Phytotoxicity of selected ornamentals from Certainty and Sedgehammer.

Hemerocallis 'Fathers Best White'

Treatment	2 WA1T	4 WAT	6 WAT		8 WAT		12 WAT	
	VR	VR	VR	GR	VR	GR	VR	GR
Certainty	0.2	2.2*	4.2*	34.0*	4.0*	28.8*	1.2	12.0*
Certainty (2 apps.)	0.4	1.6	6.8*	62.0*	7.5*	68.8*	1.2	8.0*
Certainty 2X	0.8	3.4*	6.8*	68.0*	6.2*	62.5*	2.2*	16.0*
Sedgehammer	1.0	3.4*	4.6*	42.0*	3.0*	22.5*	0.6	1.0
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cornus sericea 'Cardinal'

Treatment	2 WAT ^z	4 WAT	6 WAT		8 WAT		12 WAT	
	VR ^y	VR	VR	GR ^x	VR	GR	VR	GR
Certainty	2.6 ^w	4.0*	4.0*	24.0*	4.6*	23.0*	3.2*	16.0*
Certainty (2 apps.) ^v	2.8*	4.2*	5.2*	36.0*	5.6*	40.0*	5.4*	34.0*
Certainty 2X	2.8*	4.4*	5.0*	28.0*	5.4*	32.0*	4.0*	23.0*
Sedgehammer	3.6*	5.6*	5.8*	42.0*	6.6*	42.0*	5.6*	37.0*
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Amelanchier canadensis 'Rainbow Pillar'

Treatment	2 WA1T	4 WAT	6 WAT		8 WAT		12 WAT	
	VR	VR	VR	GR	VR	GR	VR	GR
Certainty	1.8*	3.0*	2.0*	19.0*	2.8**	16.0	1.6	7.0
Certainty (2 apps.)	1.2*	1.8*	4.2*	16.0	4.0*	11.0	2.8*	7.0
Certainty 2X	2.6*	3.4*	2.6*	28.0*	3.2*	25.0*	2.6*	15.0*
Sedgehammer	3.0*	4.0*	3.6*	35.0*	4.2*	34.0*	2.0*	12.0
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Buxus 'Antarctica'

Treatment	2 WA1T	4 WAT	6 WAT		8 WAT		12 WAT	
	VR	VR	VR	GR	VR	GR	VR	GR
Certainty	1.8*	1.6*	1.2	14.0	1.4	13.0	1.2	11.0
Certainty (2 apps.)	1.6*	1.0	1.2	9.0	1.8	8.0	1.0	8.0
Certainty 2X	2.6*	3.4*	2.6*	20.0*	3.0*	15.0*	2.8*	14.0*
Sedgehammer	3.4*	4.4*	2.6*	20.0*	2.2	17.0*	2.4*	18.0*
Untreated	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0

Picea abies

Treatment	2 WA1T	4 WAT	6 WAT		8 WAT		12 WAT	
	VR	VR	VR	GR	VR	GR	VR	GR
Certainty	0.2	0.4	1.2	12.0	2.0*	14.0	2.0	15.0
Certainty (2 apps.)	0.4	2.4*	3.2*	46.0*	4.6*	52.0*	4.4*	52.0*
Certainty 2X	0.0	1.0	1.6	10.0	2.6*	6.0	1.8	8.0
Sedgehammer	0.2	0.6	1.0	14.0	2.2*	19.0*	1.2	13.0
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

z = WAT: weeks after treatment

y = VR: phytotoxicity visual ratings

x = GR: % growth reduction

w = Treatment ratings and growth reductions followed by * are significantly different from the control based on Dunnett's t-test ($\alpha = 0.05$)

v = Certainty was reapplied for this treatment at 4 weeks after the initial treatment

Table 4. Phytotoxicity visual ratings of selected containerized ornamentals to Freehand.

Thuja occidentalis 'Smaragd'

Treatment	1 WAT ^z	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	0.5 ^{y,x}	0.5	1.2	0.2	1.2	0.5	0.5
Freehand 3X	0.5	0.2	1.2	1.0	1.0	1.2	0.5
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Gleditsia triacanthos

Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	1.0*	0.8*	0.8	0.5	0.0	0.0	0.0
Freehand 3X	1.5*	1.0*	0.8	1.8	0.8	0.8	1.2
Untreated	0.0	0.0	0.0	0.0	0.0	1.0	1.8

Portulaca 'Hot-shot Rose'

Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	0.0	1.2*	0.8	0.2	0.8	1.2*	1.0
Freehand 3X	0.8	3.0*	2.8*	1.5*	2.0*	2.5*	1.8*
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Pentas 'Kaleidoscope Pink'

Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	0.0	0.0	2.2*	3.5*	3.8*	4.0*	3.8*
Freehand 3X	0.2	0.0	3.2*	4.2*	4.2*	5.5*	5.2*
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Quercus rubra

Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	0.4	0.8	0.9	1.3	1.5	1.9	2.7*
Freehand 3X	1.5	0.8	1.0	0.7	1.3	1.4	2.6*
Untreated	0.0	0.0	0.0	0.2	0.0	0.0	0.0

Syringa xtribrida 'Lark Song'

Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	0.5	0.4	0.2	0.8	0.2	0.0	0.4
Freehand 3X	0.4	0.0	0.2	0.5	0.8	0.8	1.4
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Acer rubrum 'Sun valley'

Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Freehand 1X	0.2	0.4	0.5	0.8	0.7	0.8	1.2
Freehand 3X	0.6	0.4	0.5	0.8	1.2	0.8	0.4
Untreated	0.0	0.0	0.7	1.0	1.1	1.2	1.2

z = WAT: weeks after first treatment, WA2T: weeks after second treatment

y = visual ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 dead and ≤ 3 commercially acceptable

x = Visual ratings marked with * are significantly different from the control based on Dunnett's t-test ($\alpha = 0.05$)

Table 5. Phytotoxicity of selected containerized ornamentals to Tower.

<i>Cornus sericea</i> 'Cardinal'							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.5	0.5	0.5	0.0	0.0	0.8	0.2
Tower 3X	1.8*	2.8*	2.0*	0.5	1.0	1.8*	1.2*
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

<i>Hemerocallis</i> 'Fathers Best White'							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.5	0.5	2.5	2.2	3.5	3.5	4.0
Tower 3X	1.0	1.0	1.0	0.8	1.5	1.2	0.5
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

<i>Miscanthus sinensis</i> 'Silver Feather'							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tower 3X	1.0	0.5	0.5	0.0	0.0	0.0	0.0
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

<i>Viburnum plicatum tomentosum</i> 'Mariesii'							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.0	0.0	0.2	0.5	0.5	1.2	0.2
Tower 3X	0.8	0.0	0.0	0.5	1.5	2.8*	2.8*
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

<i>Picea abies</i>							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.3	0.0	0.1	0.2	0.0	0.0	0.3
Tower 3X	0.6	0.6	0.6	0.1	0.6	0.8	0.6
Untreated	0.0	0.0	0.1	0.1	0.3	0.3	0.5

<i>Quercus rubra</i>							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	2.0*	2.3	1.1	1.5	1.3	1.7	2.4*
Tower 3X	2.5*	1.3	0.5	1.7	2.1	2.0	2.4*
Untreated	0.0	0.0	0.0	0.2	0.0	0.0	0.0

<i>Syringa xtribrida</i> 'Lark Song'							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.8	0.7	0.6	0.5	0.8	0.5	0.8
Tower 3X	1.5*	1.0*	1.7*	1.6*	4.7*	4.3*	4.2*
Untreated	0.0	0.0	0.0	0.0	0.0	0.0	0.0

<i>Acer rubrum</i> 'Sun valley'							
Treatment	1 WAT	2 WAT	4 WAT	6 WAT	1 WA2T	2 WA2T	4 WA2T
Tower 1X	1.6*	0.8*	0.3	0.4	0.3	0.7	1.2
Tower 3X	1.9*	0.6	0.1	0.4	2.9*	2.6	1.5
Untreated	0.0	0.0	0.7	1.0	1.1	1.2	1.2

z = WAT: weeks after first treatment, WA2T: weeks after second treatment

y = visual ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 dead and ≤ 3 commercially acceptable

x = Visual ratings marked with * are significantly different from the control based on Dunnett's t-test ($\alpha = 0.05$)