Yearly Research Summary Report
2011 Ornamental Research

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Weed Control and phytotoxicity to selected landscape ornamentals from applications of FreeHand and Snapshot

Dr. Hannah Mathers and Luke Case

Introduction. Weed control in landscapes is predominantly achieved by preemergence herbicides followed by directed applications of glyphosate or handweeding. However, few herbicides exist for landscapes that have good control of both grass and broadleaf weeds but are not phytotoxic to desirable plants. Snapshot (isoxaben + trifluralin, Dow AgroSciences, Indianapolis, IN) is a combination herbicide that does provide good weed control while safe to a wide range of ornamental species and is used extensively by the landscape industry because of these characteristics. However, some weeds are not controlled by Snapshot and alternatives are needed. FreeHand (dimethanid-p + pendimethalin) is a herbicide released by BASF that also has good weed control and is safe to a wide range of species, but since it is fairly new (release was in 2008), crop tolerance is not as fully understood as Snapshot. The objectives of this study were to determine phytotoxicity and efficacy of FreeHand over a variety of annual bedding plants in comparison to Snapshot and untreated control.

Materials and Methods. Five species of landscape ornamentals, which included salvia (*Salvia farnicea*), geranium (*Pelargonium xhortorum* 'Pinto Salmon'), snapdragon (*Antirrhinum majus* 'Madame butterfly'), impatiens (*Impatiens balsamina* Tom Thumb Mixed'), and ageratum (*Ageratum houstonianum* 'Hawaii Royal') were planted into 6' x 4' plots of previously tilled soil on 22 June, 2011. Two subsamples of each species were planted together into each plot; however, species were randomly assigned places in each plot. Immediately after planting, approximately 1.5" hardwood mulch was applied to the plots. 100 lb/ac of urea (46-0-0) was also applied to each plot on 22 June, 2011. Treatments were then applied, which consisted of FreeHand at 100, 200, and 400 lbs/ac and Snapshot at 200 lbs/ac, which were compared also to untreated (mulch only with no weed control) and handweeded (mulch + handweed) treatments. Handweeding occurred once per week from 1 WAT to 8 WAT, with no handweeding between 8 WAT and 12 WAT. Trial was set up in a completely randomized design with four replications/treatment. Irrigation was not applied due to an impending rain, which brought 0.42" rain starting approximately 14 hours after treatment application. Phytotoxicity visual ratings were taken at 2, 4, 8 and 12 WAT (weeks after treatment) on a scale of 0-10 with 0 being no phytotoxicity and 10 death, with ≤3 commercially acceptable. Phytotoxicity was evaluated based on the best subsample of each species of the handweeded plots.

Results and discussion.

Weed control. Control of perennial species was not included in the visual ratings. Canada thistle (*Cirsium arvense*) was especially prevalent in the plots, which made weed control ratings a little tougher. Other prevalent weed species included green foxtail (*Setaria viridis*), redroot pigweed (*Amaranthus retroflexus*), large crabgrass (*Digitaria sanguinalis*), common purslane (*Portulaca oleracea*), prostrate spurge (*Chamaesyce prostrata*), and common lambsquarters (*Chenopodium album*). All herbicide treatments provided commercially acceptable weed control at 2 and 4 WAT (Table 1). However, by 8 WAT, FreeHand at 100 lbs/ac and Snapshot did not provide commercially acceptable control (Figure 1 and 2) while FreeHand at 200 and 400 lbs/ac did provide acceptable control. At 12 WAT, FreeHand at 200 and 400 lbs/ac continued to provided

commercially acceptable control; however, the 400 lbs/ac rate gave significantly higher visual ratings than the 200 lbs/ac rate (Figure 3 and 4). As previously mentioned, no handweeding occurred from 8 WAT to 12 WAT, which is why the visual ratings from the handweeded plots went down to 7.5.

Phytotoxicity. The inclusion of a handweed treatment was based solely on providing a check for what the ornamental species should look like if no weed competition exists. The mulch only plots had a high competition with weed species (Figure 5). Impatiens and geranium were very susceptible to weed competition, which is reflective in the phytotoxicity visual ratings of the mulch only treatment (5.2 and 5.1, respectively, Table 2). Although impatiens and geranium had high visual ratings from FreeHand, they are most likely not treatment related and more research needs to be done for those species. Salvia and Ageratum showed a response from FreeHand, with visual ratings increasing as rate increased. However, only the Salvia showed above commercially acceptable ratings from the 400 lbs/ac rate of FreeHand. Snapdragon did show some response from FreeHand; however, the 200 and 400 lbs/ac rates were similar, but both still provided commercially acceptable ratings.

Data from this trial indicates that FreeHand at 200 lbs/ac is sufficient for control of many annual species in a landscape setting of up to 12 weeks when hardwood mulch is present. FreeHand at 400 lbs/ac is more than sufficient, and can add increased phytotoxicity to some species, in this trial, ageratum and salvia. FreeHand at 200 lbs/ac is comparable to the Snapshot at 200 lbs/ac, even providing more weed control at 12 WAT than the Snapshot.

Table 1. Weed control of FreeHand and Snapshot vs. untreated check and handweed.

Treatment	Rate	2 WAT[z]		4 WAT		8 WAT		12 WAT	
FreeHand	100 lbs/ac	8.8[yx]	c	7.0	c	5.8	c	4.8	d
FreeHand	200 lbs/ac	9.3	abc	8.7	a	8.7	a	7.0	b
FreeHand	400 lbs/ac	9.8	ab	9.0	a	8.2	a	8.3	a
Snapshot	200 lbs/ac	9.0	bc	8.0	b	6.8	b	6.0	c
Untreated	--	0.0	d	0.0	d	0.0	d	0.0	e
Handweed	--	10.0	a	9.0	a	9.0	a	7.5	b

Table 2. Phytotoxicity of FreeHand and Snapshot on several species of annuals vs. untreated check and handweed, averaged over 2, 4, 8, and 12 WAT.

Treatment	Rate	Salvia		Geranium		Snapdragon		Impatiens		Ageratum	
FreeHand	100 lbs/ac	1.1		3.2		1.0		4.0		0.4	
FreeHand	200 lbs/ac	1.9	**	2.1		2.9	*	5.8	**	0.8	
FreeHand	400 lbs/ac	3.1	**	3.9		2.3		2.6		2.2	**
Snapshot	200 lbs/ac	1.3		3.6		2.0		3.7		0.8	
Untreated	--	1.1		5.1	*	1.9		5.2	**	2.3	**
Handweed	--	0.5		1.5		0.3		1.7		0.0	

z = weeks after treatment

y =weed control ratings based on a 0-10 scale with 0 being no weed control, 10 perfect weed control, and ≥7 commercially acceptable.

x = weed control ratings followed by the same letter in the same column are not significantly different based on lsmeans ($\alpha = 0.05$)

w = phytotoxicity visual ratings followed by ** and * denotes significance from the handweed at α=0.05 and 0.10, respectively

Figure 1. FreeHand at 100 lbs/ac at 12 WAT.

Figure 2. Snapshot at 200 lbs/ac at 12 WAT.

Figure 3. FreeHand at 200 lbs/ac at 12 WAT.

Figure 4. FreeHand at 400 lbs/ac at 12 WAT.

Figure 5. Weed competition of mulch only (no handweed) plots at 12 WAT.

Evaluation of different formulations of indaziflam for weed control in relation to placement of mulch

Principle investigators: Dr. Hannah Mathers and Luke Case

Objectives. The objectives of this study were to compare efficacy of granule and liquid formulations of indaziflam and to investigate whether placing on top of or below mulch has any effects on weed control.

Materials and methods. Applications of indaziflam were applied immediately before (liq. or gr. under) or after mulch was put down (liq. or gr. under) on top of previously tilled soil. Double processed hardwood mulch was laid down in 6'x3' plots at approximately 1.5 inch (3.81 cm) deep. Formulations of indaziflam consisted of a 0.03% granule formulation applied at 150 lbs/ac (0.045 lb ai/ac) and a 7.4% SC liquid formulation applied at 9 oz/ac (0.43 lb ai/ac). Applications were applied on 28 June, 2011. The liquid formulation was applied with a CO_2 backpack sprayer with a volume of 25 gal/ac. Immediately after herbicides were applied, plots were irrigated via overhead irrigation. Evaluations consisted of visual ratings at 1, 3, 7, and 11 weeks after treatment (WAT). Visual ratings were based on the untreated plots without mulch on a 0-10 scale with 0 being no weed control and 10 perfect weed control and $\geq$7 commercially acceptable.

Results and discussion. Based on this study, type of formulation was not as important as the placement of the herbicide in relation to the mulch (Table 1). The liquid and granule formulations were not significantly different at any evaluation in terms of placement, e.g. liq. over is not significantly different from gr. over at any evaluation (Figures 1 and 2). This study indicates there is a slight advantage of applying indaziflam before application of hardwood mulch. The indaziflam may be binding temporarily to the hardwood mulch, which is common with many preemergence herbicides based on other studies conducted by The Ohio State University (Mathers, 2001; Case and Mathers, 2003). There are two points that justify this theory. The consistency of the herbicide-over-mulch provides one justification for this theory. For example, the liq. under went down from 9.75 at 1 WAT to 7.0 at 11 WAT, but the liq. over only went from 7.25 at 1 WAT to 6.0 at 11 WAT (Table 1). The other point to consider is that the untreated mulch (Figure 3) provided similar levels of control to the herbicide-over treatments at 1 and 3 WAT (Table 1). However, at 7 WAT, the untreated mulch provided visual ratings much lower than the herbicide-over treatments. 11 weeks is impressive for acceptable control for the herbicide-under treatments and is probably acceptable for the industry; however, it would be interesting to see what would happen with the herbicide-over treatments if the study would have been carried out further.

Table 1. Weed control of liquid and granule formulations of indaziflam applied under or over hardwood mulch vs. untreated with mulch and untreated without mulch.

Treatment	1 WAT[z]	3 WAT	7 WAT	11 WAT
Gr. Under	9.75[y x] a	9.75 a	8.3 a	7.3 a
Liq. Under	9.75 a	8.5 a	8.3 a	7.0 a
Gr. Over	7 b	6.75 b	5.8 b	5.5 b
Liq. Over	7.25 ab	6.75 b	6.3 b	6.0 ab
Unt. No mulch	2 c	0 c	0.0 d	0.0 d
Unt. Mulch	6 b	6.75 b	2.5 c	2.8 c

z = weeks after treatment

y = visual ratings based on a 0-10 scale with 0 being no weed control, 10 perfect weed control and ≥7 commercially acceptable.

x = Treatment ratings followed by the same letter in the same column are not significantly different, based on lsmeans ($\alpha = 0.05$).

Figure 1. Application of the indaziflam granular formulation under hardwood mulch.

Figure 2. Application of the indaziflam liquid formulation under hardwood mulch.

Figure 3. Hardwood mulch alone with no herbicide.

Phytotoxicity and efficacy of several products to control liverwort in three propagation environments in Michigan

Principle investigators: Dr. Hannah Mathers, Luke Case, and Lynne Sage

Significance to the industry. Weed control continues to be a large component of ornamental production systems, and with the reduced economy, nursery and greenhouse managers are looking for more ways to cut costs. Reducing hand weeding would be one way to cut costs in the production process, and weed control via herbicides and other alternatives to hand weeding are welcomed by the growers. In propagation, liverwort (*Marchantia polymorpha*), is a large problem faced by many Michigan growers due to the high amounts of water and nutrients applied, and the propagation houses have favorable environments for liverwort growth. Reducing liverwort during propagation would be a huge cost saving for many Michigan growers. The objectives of this study are to compare products to control liverwort and the effects of these treatments on crop growth.

Materials and methods. Three cooperating nurseries located near Grand Haven, MI were selected as sites for the liverwort control treatments, which included Berryhill Family of Nurseries (BFN, formerly Zelenka Nursery), Spring Meadow Nursery, Inc., and Northland Farms Nursery, LLC. Species selected for phytotoxicity ratings at BFN included Dappled willow (*Salix integra* 'Hakuro Nishiki'), Black lace elderberry (*Sambucus nigra* 'Blacklace'), Annabelle hydrangea (*Hydrangea arborescens* 'Annabelle'), Forever Pink hydrangea (*Hydrangea macrophylla* 'Forever Pink'), and My Monet weigela (*Weigela florida* 'My Monet'). Specie selected for phytotoxicity at Spring Meadow included Ghost weigela (*Weigela florida* 'Ghost'). Species selected for phytotoxicity at Northland Farms included Big Daddy hosta (*Hosta* 'Big Daddy'), Sagae hosta (*Hosta* 'Sagae'), Crimson pygmy barberry (*Berberis thunbergii* 'Crimson pygmy') and Ostrich fern (*Matteuccia struthiopteris*). Treatments that were applied on March 3, 2011 consisted of Tower (dimethenamid-p) at 32 oz/ac, Racer at 10% v/v, SureGuard (flumioxazin) at 4 oz/ac, GreenMatch at 20% v/v, Bryophyter at 2% v/v, WeedPharm at 10% v/v and baking soda. Baking soda was applied at 50 ml/ft^2 at Zelenka Nursery, 25 ml/ft^2 at Spring Meadow, and was put on as a dusting at Northland Farms. An additional treatment of a "granular" baking soda was put on at Spring Meadow Nursery. The granular form has larger pellets than the more common form of the soda used for baking purposes. Terracyte Pro G at 10 lbs/1000 ft^2 was applied on March 18, 2011 at BFN and Spring Meadow, and GreenMatch at 20% v/v was applied on March 31, 2011 at BFN and Spring Meadow. Racer was reapplied on March 31, 2011 at Northland Farms and BFN. On April 15, 2011, Bryophyter, Tower, and WeedPharm were reapplied at BFN, Tower and Terracyte were reapplied at Spring Meadow, and Bryophyter and Tower were reapplied at Northland Farms at the rates described above. All liquid treatments were applied with a CO_2 backpack sprayer with a spray volume of 45 gal/ac using 8003 vs nozzles with a spacing of 12 inches. IR-4 protocol requires at least 90 gal/ac, so two passes were made with the sprayer. Evaluations of phytotoxicity and efficacy were taken at 1, 2, 4, 5, 6, 7, 8, and 9 WAIT (weeks after initial treatment). Phytotoxicity was evaluated on a scale of 0-10 with 0 being no phytotoxicity and 10 death and $\leq$3 commercially acceptable.

Efficacy was evaluated on a scale of 0-10 with 0 being no control and 10 perfect control with ≥7 commercially acceptable.

Results and discussion.

Efficacy. All treatments provided some level of control of liverwort in comparison to the untreated pots at each location; however, there is some variance between locations with the products (Tables 1-3). There were some environmental differences. At BFN, daytime temperatures were generally around 60 °F (heated greenhouse), high relative humidity; Spring Meadow daytime temperatures were generally around 65-70 °F (heated greenhouse), moderate relative humidity; and Northland Farms daytime temperatures were generally around 50-55 °F (supplemental heated hoop house), high relative humidity. Spring Meadow sells most of their product as propagated material, which is the reason for the higher temperatures. At Spring Meadow, generally excellent control was obtained with all treatments throughout the experiment. Spring Meadow had the highest infestation with liverwort, but by around 5 WAIT the liverwort were starting to die off in part due to competition of water and nutrients from the crop, and by the end of the experiment, the untreated controls even had a visual rating of 4.2 (Table 2). For the treatments that were used at BFN and Northland Farms, similar results were obtained (Tables 1 and 3). The differences between the products are the quickness of control and the length of control. GreenMatch, Racer, Bryophyter, baking soda and WeedPharm are very fast acting ("contact" type herbicides), each producing very good results within 1 WAIT (Tables 1-3). Terracyte is in the middle of how quickly control is obtained, followed by SureGuard and Tower, respectively. The quickness of the herbicide is somewhat inversely related to the amount of residual the product provides. Tower is the slowest acting herbicide, and control increased gradually until the end of the experiment at each location, but it did not provide acceptable ratings at any of the evaluations with two applications at BFN and Northland Farms (Tables 1 and 2). SureGuard was applied only once, and by week 4 provided commercially acceptable ratings at each location and SureGuard continued to provide commercially acceptable ratings throughout the experiment (Tables1-3). Similar results were obtained at BFN and Northland Farms for Bryophyter and Racer. Racer was reapplied at 4 WAIT and Bryophyter was reapplied at 6 WAIT at both BFN and Northland Farms (Tables 1 and 3). As an observation, liverwort came back very quickly from applications of Racer, maybe even more abundant than what was originally in the pot before the initial application (Figure 1). Reasons for this are not known, but it could be suspected from the increase in nitrogen from the ammonium in the Racer. GreenMatch was never reapplied; however, visual ratings at BFN indicate that a reapplication is necessary after 3 WAIT (Table 1). Based on the visual ratings at BFN, WeedPharm may have the longest residual of the "contact" herbicides; reapplication was not needed until 6 WAIT (Table 1). Baking soda works excellent for control of liverwort (Tables 1-3). The baking soda treatment arose from growers in Michigan. Treatment rate was unknown, which is why there are different rates at each location. Only a "dusting" is needed for control, with this rate providing at least 4 weeks of control (Table 3).

Phytotoxicity. All treatments were phytotoxic to at least one of the species tested (Tables 1-3). Although SureGuard is slow to act on liverwort, it acts as a "contact" herbicide on susceptible plants, with visual symptoms showing up within a day or two. Normal use rates over ornamentals are 8-12 oz/ac, but because of the activitity on liverwort, the use rate was reduced to 4 oz/ac to possibly reduce phytotoxicity to the crop. However, even at 4 oz/ac, SureGuard still injured most species that had broken dormancy (Tables 1-3). This is a key concept with SureGuard, and there are several examples to represent this. 'Annabelle' hydrangea was just breaking dormancy at BFN; some buds had broken, some had not when the SureGuard was applied. Those that had broken dormancy were severely injured or even died, while those that had not broken dormancy were not injured at all (Table 1, Fig. 2). The higher visual ratings in comparison to the control are because there are more dead plants in the SureGuard treated flats. The concept of dormancy can also be seen with 'My Monet' weigela at BFN (Fig. 3) (normally SureGuard is injurious to weigela, see Table 2), and hosta and barberry at Northland Farms (Table 3). There are no phytotoxicity visual ratings at Northland Farms until 8 WAIT because this is when all plants finally broke dormancy. At Northland Farms, ostrich fern visual ratings indicate that there was some injury from a dormant application of SureGuard (Table 3); however, what the ratings *do not* indicate is that one replication was injured and two replications were not injured (data not shown). Tower injured all ten species that were tested (Tables 1-3). One of the major issues with Tower is the injury it causes when applied at budbreak or to species that have just leafed out, and this is certainly the case with many of the species tested. Bryophyter, GreenMatch, Racer, and WeedPharm all caused burning to leaf tissue after application (Tables 1-3). This burning can be light to severe, with injury related to the species, size, and maturity of the crop. If the crop was not killed after application, injury from these herbicides was temporary, with visual ratings decreasing over time for many of the treatments (Tables1-3). With Bryophyter, GreenMatch, Racer, and WeedPharm, if the crop was susceptible to injury, then all replications showed injury; however, with Terracyte, this was not the case (Fig. 4). Some replications exhibited injury, while some did not, and visual ratings indicate that Terracyte was injurious to four of the six species tested (Tables 1 and 2). In this study, Terracyte was applied as a granule, so injury was probably from the granule not getting washed from the leaves in a timely fashion. This could lead to future recommendations for Terracyte when used for liverwort control with crops present. Baking soda at 50 or 25 ml/ft^2 is much too high rate, causing death of five of the six species tested (Tables 1-2). However, the "dusting" at Northland Farms caused much less injury, with significant injury only to the ostrich fern (Table 3).

Conclusions. From these trials, all treatments provided control of liverwort; however, the issue is phytotoxicity with all treatments. More research needs to be conducted with SureGuard in relation to dormant applications. One advantage of using SureGuard is that it controls weeds preemergence also, and many of these herbicides do not control weeds. This was evident with Bryophyter and Racer at Northland Farms; weeds were starting to germinate by the end of the trial, and more weeds were present in the pots that were treated with Bryophyter and Racer than pots treated with SureGuard (data not shown). The "contact" herbicides (Bryophyter, Racer, WeedPharm and GreenMatch) also have application for use in dormant situations; however,

reapplication is necessary, and in many cases, is not advised. WeedPharm has the best residual of the “contact” herbicides, and more research is warranted for WeedPharm. WeedPharm also provided the least injury from the “contact” herbicides to Dappled willow, ‘Blacklace’ elderberry, ‘Annabelle’ hydrangea, ‘My monet’ weigela, and‘Forever pink’ hydrangea (Table 1). Coverage is also *essential* for the “contact” herbicides. Whenever there was a crop canopy, liverwort control generally decreased. More research is warranted for baking soda so an actual rate can be used (as opposed to just “dusting”), and phytotoxicity to more species is needed.

Table 1. Efficacy and phytotoxicity to several ornamental species at 8 evaluation dates for several liverwort control products at BFN nursery near Grand Haven, MI.

Efficacy visual ratings[z]

Treatment	Rate	1 WAIT	2 WAIT	4 WAIT	5 WAIT	6 WAIT	7 WAIT	8 WAIT	9 WAIT
Green Match	20% v/v	--	--	--	8.8 b	8.2 bc	5.8 d	6.3 e	5.2 e
Racer	10% v/v	7.9 b	7.0 b	✓4.8[y] e	7.0 d	5.8 d	1.9 f	3.5 g	2.9 b
Sureguard	4 oz/ac + Surfactant	4.4 c	6.5 b	8.7 b	8.9 b	8.6 b	6.6 c	8.4 d	7.8 bc
Tower	32 oz/ac	1.9 d	4.4 c	5.3 e	3.2 e	✓4.4 e	3.0 e	5.6 f	6.6 d
Terracyte Pro G	10 lbs/1000 ft^2	--	--	6.9 d	7.8 c	7.7 c	9.2 ab	9.4 ab	9.3 a
BryoPhyter	2% v/v	9.6 a	9.8 a	7.6 c	6.7 d	✓6.3 d	8.7 b	8.6 cd	7.6 c
Weed Pharm	10% v/v	9.9 a	9.9 a	8.8 b	8.3 b	✓7.9 bc	9.3 ab	9.2 bc	8.4 b
Baking Soda powder	50 ml/ft^2	10.0 a	10.0 a	10.0 a	10.0 a	10.0 a	9.9 a	10.0 a	10.0 a
Untreated	--	2.1 d	0.9 d	1.0 f	1.4 f	2.2 f	0.6 g	2.3 h	1.9 g

Phytotoxicity visual ratings[x]

Dappled willow (*Salix integra* 'Hakuro Nishiki')

Treatment	Rate																
Green Match	20% v/v	--		--		--		6.7	**	7.2		6.9	**	5.2	**	3.2	
Racer	10% v/v	6.6	**	4.8	**	✓4.1	**	7.3	**	6.0		7.5	**	5.0	**	5.0	**
Sureguard	4 oz/ac + Surfactant	9.1	**	9.2	**	8.7	**	8.6	**	9.2	**	9.2	**	8.2	**	7.7	**
Tower	32 oz/ac	1.4	**	0.8		0.8		0.5	**	✓5.8		7.2	**	4.6		4.1	*
Terracyte Pro G	10 lbs/1000 ft^2	--		--		0.4		0.0	**	5.4		4.3		0.0	**		
BryoPhyter	2% v/v	8.0	**	5.9	**	4.8	**	4.7		✓5.6		8.6	**	7.2	**	7.1	**
Weed Pharm	10% v/v	5.4	**	4.1	**	4.8	**	4.1		✓5.9		7.8	**	5.3	**	4.6	**
Baking Soda powder	50 ml/ft^2	8.9	**	10.0	**	10.0	**	10.0	**	10.0	**	10.0	**	10.0	**	10.0	**
Untreated	--	0.0		0.0		0.0		4.4		5.3		4.7		2.9		1.5	

Black lace elderberry (*Sambucus nigra* 'Blacklace')

Treatment	Rate																
Green Match	20% v/v	--		--		--		9.0	**	9.0	**	9.0	**	7.3	**	7.3	**
Racer	10% v/v	9.3		7.0	**	✓6.7	**	9.8	**	9.3	**	9.5	**	8.8	**	9.0	**
Sureguard	4 oz/ac + Surfactant	6.2	**	6.3	**	7.3	**	6.6	**	5.3		5.6	**	5.5		5.3	
Tower	32 oz/ac	4.0	**	4.1		3.7		3.7		✓3.6		3.9		4.5		4.2	
Terracyte Pro G	10 lbs/1000 ft^2	--		--		4.1		4.5		4.5		4.7	**	5.3		4.9	
BryoPhyter	2% v/v	7.6		6.4	**	6.5	**	6.0	*	✓5.4		9.3	**	9.1	**	8.7	**
Weed Pharm	10% v/v	3.3	**	3.7		2.9		3.1		✓2.2		6.0	**	3.8		4.0	
Baking Soda powder	50 ml/ft^2	6.9	**	7.3	**	8.8	**	8.9	**	9.3	**	9.6	**	9.3	**	9.5	**
Untreated	--	0.0	**	2.4		2.7		2.8		2.9		1.3		2.8		2.7	

Annabelle hydrangea (*Hydrangea arborescens* 'Annabelle')

Treatment	Rate																
Green Match	20% v/v	--		--		--		10.0	**	10.0		10.0	**	9.9	**	9.9	**
Racer	10% v/v	7.4		8.3	**	✓8.9	**	9.9	**	9.8		9.9	**	9.7	**	9.8	**
Sureguard	4 oz/ac + Surfactant	8.3		7.5	**	7.2	*	6.6		6.0		5.9	**	6.0		5.9	
Tower	32 oz/ac	4.5		2.7		2.8		3.0		✓2.3		7.3	**	6.4	*	6.6	*
Terracyte Pro G	10 lbs/1000 ft^2	--		--		7.1	*	7.3	**	7.3		7.8	**	7.4	**	7.3	**
BryoPhyter	2% v/v	8.8		8.3	**	8.5	**	8.4	**	✓8.4		9.7	**	9.5	**	9.3	**
Weed Pharm	10% v/v	4.4		3.3		3.8		3.3		✓2.7		6.3	**	4.7		4.5	
Baking Soda powder	50 ml/ft^2	8.8		9.8	**	10.0	**	10.0	**	10.0		10.0	**	10.0	**	10.0	**
Untreated	--	6.7		3.5		3.7		3.7		3.5		2.5		3.3		3.3	

z = visual ratings based on a 0-10 scale with 0 being no control, 10 perfect control and ≥7 commercially acceptable. Ratings followed by the same letter in the same evaluation date are not significantly different based on lsmeans (α = 0.05)

y = ✓ indicates that treatment was reapplied on specified date

x = phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 death and ≤3 commercially acceptable. Ratings followed by * and ** are significantly different from the untreated control based on dunnett's t-test (α = 0.10 and 0.05, respectively).

Table 1, continued.

Monet weigela (*Weigela florida* 'My Monet') Treatment	Rate	1 WAIT		2 WAIT		4 WAIT		5 WAIT		6 WAIT		7 WAIT		8 WAIT		9 WAIT	
Green Match	20% v/v	--		--		--		8.5	**	8.8	**	9.2	**	8.1	**	8.2	**
Racer	10% v/v	6.6	**	4.3		✓3.8		7.7	**	6.5	**	8.4	**	6.0	**	5.3	
Sureguard	4 oz/ac + Surfactant	4.7	**	1.7		1.5		1.0		1.0		1.3		1.0		0.9	
Tower	32 oz/ac	7.2	**	7.3	**	6.7	*	6.3	*	✓6.2	*	7.8	**	7.3		7.2	**
Terracyte Pro G	10 lbs/1000 ft^2	--		--		0.9		0.6		1.1		2.2	*	3.8		4.2	
BryoPhyter	2% v/v	6.8	**	5.4	*	5.3		4.6		✓4.4		8.8	**	7.7	**	7.3	**
Weed Pharm	10% v/v	3.0	**	1.7		1.5		1.3		✓1.6		6.4		5.5		5.1	
Baking Soda powder	50 ml/ft^2	9.0	**	9.6	**	9.9	**	9.8	**	9.9	**	10.0	**	10.0	**	10.0	**
Untreated	--	0.0		2.1		3.4		3.1		3.0		4.7		2.9		2.8	
Forever Pink hydrangea *(Hydrangea macrophylla* 'Forever Pink') Treatment	Rate																
Green Match	20% v/v	--		--		--		6.5	**	7.5	**	9.2	**	7.8	**	7.3	**
Racer	10% v/v	5.4	**	4.7	**	✓2.3		8.8	**	7.9	**	8.6	**	5.5	**	4.0	
Sureguard	4 oz/ac + Surfactant	9.8	**	9.9	**	9.9	**	9.9	**	9.9	**	9.9	**	9.8	**	9.8	**
Tower	32 oz/ac	0.5		3.1	**	2.8		1.2		✓0.8		8.5	**	7.0	**	8.1	**
Terracyte Pro G	10 lbs/1000 ft^2	--		--		5.6	**	4.1		4.2		7.1	**	4.8	*	4.4	
BryoPhyter	2% v/v	5.8	**	7.2	**	6.6	**	6.3	**	✓5.8	**	9.0	**	8.8	**	8.2	**
Weed Pharm	10% v/v	4.7	**	4.1	**	5.1	**	3.3		✓2.4		6.6	**	4.2		3.4	
Baking Soda powder	50 ml/ft^2	9.8	**	10.0	**	10.0	**	10.0	**	10.0	**	10.0	**	10.0	**	10.0	**
Untreated	--	0.8		1.3		1.5		2.8		2.9		2.6		3.0		3.0	

z = visual ratings based on a 0-10 scale with 0 being no control, 10 perfect control and ≥7 commercially acceptable. Ratings followed by the same letter in the same evaluation date are not significantly different based on lsmeans (α = 0.05)

y = ✓ indicates that treatment was reapplied on specified date

x = phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 death and ≤3 commercially acceptable. Ratings followed by * and ** are significantly different from the untreated control based on dunnett's t-test (α = 0.10 and 0.05, respectively).

Table 2. Efficacy and phytotoxicity to several ornamental species at 8 evaluation dates for several liverwort control products at Spring Meadow nursery near Grand Haven, MI.

Efficacy visual ratings[z]

Treatment	Rate	1 WAIT	2 WAIT	4 WAIT	5 WAIT	6 WAIT	7 WAIT	8 WAIT	9 WAIT
Baking Soda powder	50 ml/ft^2	9.6 ab	9.9 a	9.9 a	10.0 a	10.0 a	9.3 a	10.0 a	9.5 a
Racer	10% v/v	7.2 d	7.3 c	7.2 c	7.9 c	9.6 a	8.8 ab	7.8 b	7.3 b
Sureguard	4 oz/ac + Surfactant	6.8 d	7.4 c	10.0 a	10.0 a	10.0 a	7.6 b	10.0 a	10.0 a
Tower	32 oz/ac	0.1 e	2.0 d	3.1 e	2.6	✓7.5[y] b	5.6 c	9.6 a	9.2 a
Terracyte Pro G	10 lbs/1000 ft^2	--	--	5.3 d	6.6 d	✓8.0 b	8.9 ab	9.8 a	8.8 a
BryoPhyter	2% v/v	8.3 c	8.2 b	9.1 b	9.0 b	9.5 a	8.4 ab	8.7 a	8.8 a
Weed Pharm	10% v/v	10.0 a	9.8 a	10.0 a	10.0 a	10.0 a	9.2 ab	9.9 a	9.8 a
Green Match	20% v/v	--	--	--	5.1 e	7.1 b	5.3 c	7.4 b	8.3 a
Baking Soda granular	25 ml/ft^2	9.0 b	10.0 a	10.0 a	10.0 a	10.0 a	9.0 ab	9.3 a	8.8 a
Untreated		0.0 e	0.0 e	0.0 f	0.1 f	3.0 c	1.9 d	2.6 c	4.2 c

Phytotoxicity visual ratings[x]

Ghost weigela (*Weigela florida* 'Ghost')

Treatment	Rate																
Baking Soda powder	50 ml/ft^2	0.5		0.4		0.6		1.0		0.4		1.0		0.2		0.5	
Racer	10% v/v	2.7	**	3.1	**	1.1		1.9		1.7		4.3	**	0.7		0.8	
Sureguard	4 oz/ac + Surfactant	7.9	**	7.1	**	5.7	**	5.6	**	2.5	*	4.7	**	2.8	**	2.5	**
Tower	32 oz/ac	0.0		0.5		0.9		1.3		✓2.3		5.5	**	3.4	**	5.2	**
Terracyte Pro G	10 lbs/1000 ft^2	--		--		0.5		2.1	**	✓1.3		5.1	**	2.7	**	2.8	**
BryoPhyter	2% v/v	3.3	**	4.5	**	2.2	**	2.2	**	0.4		2.0		0.5		0.8	
Weed Pharm	10% v/v	1.2		2.1	**	1.3		2.3	**	1.8		4.5	**	0.2		0.8	
Green Match	20% v/v	--		--		--		5.5	**	4.9	**	6.7	**	3.3	**	2.1	
Baking Soda granular	25 ml/ft^2	0.9		1.3		1.7	*	1.5		1.9		4.7	**	1.2		0.8	
Untreated		0.6		0.6		0.4		0.6		0.9		1.0		0.6		0.7	

z = visual ratings based on a 0-10 scale with 0 being no control, 10 perfect control and ≥7 commercially acceptable. Ratings followed by the same letter in the same evaluation date are not significantly different based on lsmeans (α = 0.05)

y = ✓ indicates that treatment was reapplied on specified date

x = phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 death and ≤3 commercially acceptable. Ratings followed by * and ** are significantly different from the untreated control based on dunnett's t-test (α = 0.10 and 0.05, respectively).

Table 3. Efficacy and phytotoxicity to several ornamental species at 8 evaluation dates for several liverwort control products at Northland Farms nursery near Grand Haven, MI.

Efficacy visual ratings[z]

Treatment	Rate	1 WAIT	2 WAIT	4 WAIT	5 WAIT	6 WAIT	7 WAIT	8 WAIT	9 WAIT
Racer	10% v/v	6.0 c	4.0 b	✓5.0[y] c	7.4 bc	7.4 b	5.7 b	5.9 b	5.3 c
Sureguard	4 oz/ac + Surfactant	4.5 c	5.7 b	8.0 b	8.4 ab	9.4 a	7.9 a	9.3 a	9.1 a
Tower	32 oz/ac	1.9 d	2.9	3.9 c	2.0 d	✓4.9 c	4.5 b	6.2 b	6.4 bc
BryoPhyter	2% v/v	8.0 b	8.3 a	7.7 b	6.8 c	✓5.5 c	8.3 a	8.7 a	7.7 b
Baking soda dusted		9.7 a	10.0 a	9.9 a	✓9.2 a	--	9.5 a	10.0 a	10.0 a
Untreated		0.0 e	4.8 b	3.8 c	3.4 d	5.1 c	4.1 b	3.3 c	7.0 bc

Phytotoxicity visual ratings[x]

Big Daddy hosta (*Hosta* 'Big Daddy')

Treatment	Rate										
Racer	10% v/v	--	--	--	--	--	--	1.3		1.0	
SureGuard	4 oz/ac + Surfactant	--	--	--	--	--	--	0.0		0.0	
Tower	32 oz/ac	--	--	--	--	--	--	3.7	**	2.7	**
Bryophyter	2% v/v	--	--	--	--	--	--	0.0		0.0	
Baking soda dusted		--	--	--	--	--	--	1.3		0.7	
Untreated		--	--	--	--	--	--	0.0		0.0	

Sagae hosta (*Hosta* 'Sagae')

Treatment	Rate										
Racer	10% v/v	--	--	--	--	--	--	0.0		0.7	
SureGuard	4 oz/ac + Surfactant	--	--	--	--	--	--	0.0		0.0	
Tower	32 oz/ac	--	--	--	--	--	--	3.7	**	2.3	**
Bryophyter	2% v/v	--	--	--	--	--	--	0.0		0.0	
Baking soda dusted		--	--	--	--	--	--	0.0		0.1	
Untreated		--	--	--	--	--	--	0.0		0.0	

Ostrich fern (*Matteuccia struthiopteris*)

Treatment	Rate										
Racer	10% v/v	--	--	--	--	--	--	1.0		0.7	
SureGuard	4 oz/ac + Surfactant	--	--	--	--	--	--	5.3	**	3.3	
Tower	32 oz/ac	--	--	--	--	--	--	5.7	**	3.0	
Bryophyter	2% v/v	--	--	--	--	--	--	2.7		1.0	
Baking soda dusted		--	--	--	--	--	--	6.0	**	4.3	**
Untreated		--	--	--	--	--	--	0.0		0.0	

Crimson pygmy barberry (*Berberis thunbergii* 'Crimson pygmy')

Treatment	Rate										
Racer	10% v/v	--	--	--	--	--	--	1.2		1.0	
SureGuard	4 oz/ac + Surfactant	--	--	--	--	--	--	1.8		1.7	
Tower	32 oz/ac	--	--	--	--	--	--	4.9		5.8	*
Bryophyter	2% v/v	--	--	--	--	--	--	4.9		4.3	
Baking soda dusted		--	--	--	--	--	--	5.3		5.2	
Untreated		--	--	--	--	--	--	2.5		2.5	

z = visual ratings based on a 0-10 scale with 0 being no control, 10 perfect control and ≥7 commercially acceptable. Ratings followed by the same letter in the same evaluation date are not significantly different based on lsmeans (α = 0.05)

y = ✓ indicates that treatment was reapplied on specified date

x = phytotoxicity ratings based on a 0-10 scale with 0 being no phytotoxicity, 10 death and ≤3 commercially acceptable. Ratings followed by * and ** are significantly different from the untreated control based on dunnett's t-test (α = 0.10 and 0.05, respectively).

Figure 1. Racer over top of hydrangea 'Forever red' at 2 weeks after 2nd application. Notice abundance of liverwort.

Figure 2. SureGuard over top of hydrangea 'Annabelle' at 9 weeks after treatment. Injury only occurred to plants that had broken dormancy. At this point, liverwort had started to come back.

Figure 3. SureGuard over 'My monet' weigela at BFN at 9 WAT.

Figure 4. Terracyte Pro G over hydrangea 'Forever red' at 5 WAT. Notice spotting and leaf necrosis on edges of leaves.

Phytotoxicity of several weed control products to containerized and field grown plants at three Michigan nurseries

Principle investigators: Dr. Hannah Mathers and Luke Case

Significance to the industry. Weed control continues to be a large component of ornamental production systems, and with the reduced economy, nursery and greenhouse managers are looking for more ways to cut costs. Herbicides greatly reduce costs per acre in comparison to handweeding; several studies have revealed handweeding can cost more than $5000/ac, and sometimes upwards of $10,000/ac, depending on the level of weed infestation. Increasing the number of "tools" for weed control is beneficial for growers, as not all weed control programs are created equal. These "tools" can include preemergence herbicides, postemergence herbicides, handweeding, mulching, and various other cultural activities that may reduce weed infestations. The purpose of the IR-4 program is to increase the number of labeled pesticides for minor use crops, of which ornamentals fall into. In coordination with the IR-4 program and the Specialty Crop Block grant from the Michigan Department of Agriculture and Rural Development, several studies were carried out to determine phytotoxicity of several species of ornamental plants from different herbicides. These herbicides could then potentially be used by the nurseries in their weed control program.

Materials and methods. Three cooperating nurseries located near Grand Haven, MI were selected as sites for the phytotoxicity trials, which included Berryhill Family of Nurseries (BFN, formerly Zelenka Nursery), Spring Meadow Nursery, Inc., and Northland Farms Nursery, LLC. At BFN and Northland Farms, containerized and field trials were carried out, while at Spring Meadow, only containerized trials were performed. For the containerized portion at BFN, species selected included peony (*Paeonia* 'Sarah Bernhardt'), hydrangea (*Hydrangea* 'Forever ever'), common lilac (*Syringa* 'Common Purple'), yew (*Taxus xmedia* 'Hicksii'), daylily, (*Hemerocallis* 'Stella d'Oro'), and butterfly bush (*Buddleia davidii* 'Nanho Purple'). The species selected for the field trial at BFN included forsythia (*Forsythia* 'Lynwood Gold'), common lilac (*Syringa* 'Common Purple'), flowering almond (*Prunus glandulosa*), and potentilla (*Potentilla fruticosa* 'Mckays White'). For the containerized portion at Northland Farms, species selected included yew (*Taxus xmedia* 'Hicksii'), butterfly bush (*Buddleia davidii* 'Royal Red'), purple coneflower (*Echinacea purpurea* 'Magnus'), fountain grass (*Pennisetum alopecuroides* 'Hamlin'), variegated dogwood (*Cornus sericea* 'Variegated'), and daylily (*Hemerocallis* 'Happy Returns'). Two varieties of yew were included in the field trial at Northland Farms (*Taxus xmedia* 'Runyon' and *Taxus* 'Hicksii'). Species selected at Spring Meadow included spirea (*Spirea* 'Double Play'), weigela (*Weigela* 'Ghost'), lilac (*Syringa* 'Boomerang Purple'), rose (*Rosa* 'Home Run'), hydrangea (*Hydrangea macrophylla* 'City Vienna'), and hibiscus (*Hibiscus* 'Chiffon China'). Herbicides selected for the containerized portion included BroadStar (flumioxazin, Valent U.S.A) at 0.375, 0.75, and 1.5 lb ai/ac on peony, spirea, and weigela; indaziflam (Bayer Corp.) at 0.11, 0.22, and 0.44 lb ai/ac on 'Forever ever' hydrangea, 'Hicksii'

yew, lilac (both 'Boomerang Purple' and 'Common Purple'), and rose; certainty (sulfosulfuron, Monsanto Corp.) at 0.06, 0.12, and 0.24 lb ai/ac on variegated dogwood; Tower (dimethanimid-p, BASF Corp.) at 0.97, 1.94, and 3.88 lb ai/ac on daylily (both 'Stella d'Oro' and 'Happy Returns'); Gallery (isoxaben, Dow AgroSciences) at 0.66, 1.22, and 2.44 lb ai/ac on butterfly bush (both 'Nanho Purple' and 'Royal Red'); FreeHand (dimethenamid-p + pendimethalin, BASF Corp.) at 2.65, 5.3, and 10.6 lb ai/ac on purple coneflower, fountain grass, weigela, spirea, and hydrangea ('City Vienna'); Snapshot (isoxaben + trifluralin, Dow AgroSciences) at 2.5, 5.0, and 10.0 lb ai/ac on hibiscus and hydrangea ('City Vienna'); and Biathalon (oxyfluorfen + prodiamine, OHP, Inc.) at 2.75, 5.5, and 11.0 lb ai/ac on hibiscus. The containerized trials were set up on May 20, 2011 at all locations, with each location having at least 10 replications/herbicide/rate. Treatments were reapplied at 6 weeks after original treatments were applied. Pot sizes were different at each location; at BFN, one-gallon trade size pots were used, at Northland Farms, one-gallon trade size pots were used (with the exception of dogwood and butterfly bush which were in 40-cell trays), and at Spring Meadow, 4 inch pots were used. Phytotoxicity evaluations were performed at 1 WA1T (week after first treatment), 2 WA1T, 4 WA1T, 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. All liquid treatments were applied with a CO_2 backpack sprayer with a spray volume of 25 gal/ac using nozzles delivering 0.15 gal/min with a spacing of 12 inches.

Herbicides selected for the field portion at BFN included Tower at 0.97 lb ai/ac on forsythia and lilac, Tower + Pendulum (pendimethalin, BASF Corp.) at 0.97 + 2.0 lb ai/ac, respectively on forsythia, lilac, potentilla, and flowering almond; and Biathalon at 2.75 and 5.5 lb ai/ac on potentilla. Herbicides were applied at BFN on April 30, 2011; all species were still dormant at time of application. Herbicides were applied in 3' x 3' plots with 4 replications/treatment. Phytotoxicity evaluations were performed at 1, 3, 6, and 8 weeks after treatment (WAT). Visual ratings were performed on a scale of 0-10 with 0 being no phytotoxicity, 10 being dead, and ≤3 commercially acceptable. All liquid treatments were applied with a CO_2 backpack sprayer with a spray volume of 25 gal/ac using nozzles delivering 0.15 gal/min with a spacing of 12 inches. Tower was the only herbicide trialed at Northland Farms at rates of 0.97, 1.94, and 3.88 lb ai/ac on yew (*Taxus xmedia* 'Runyon' and *Taxus* 'Hicksii'). Plot size included 3 plant subsamples in each replication, with 4 replications/rate for each variety. Tower was applied on May 20, 2011 and reapplied on June 30, 2011 with a CO_2 backpack sprayer with a spray volume of 25 gal/ac using nozzles delivering 0.15 gal/min with a spacing of 12 inches. Phytotoxicity evaluations were performed at 1 WA1T (week after first treatment), 2 WA1T, 4 WA1T, 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.

Results and Discussion. Refer to Table 1 for all results discussed below for the containerized material.

Buddleia. Gallery was tested on *Buddleia* 'Nanho Blue' at BFN and 'Royal Red' at Northland Farms. There was damage from the Gallery at both locations; however, the extent of damage is related to plant size. At BFN, plants were much bigger than those at Northland Farms, and damage was much more extensive at Northland Farms. *Buddleia* treated with the 1X and 2X rates of Gallery at BFN were still marketable by the end of the trial, but the damage could still be seen. Gallery damage at Northland Farms exceeded marketability ratings for all rates. It can be concluded that Gallery should not be used as a preemergence herbicide on *Buddleia davidii*.
Cornus sericea 'Variegated'. Certainty provided extensive damage to *Cornus* in 40 cell trays at Northland Farms. Certainty has been previously tested by The Ohio State University on *Cornus* (2008 Yearly Research Summary Report), and similar results were found. *Cornus* should not be treated with Certainty.
Echinacea purpurea. *Echinacea* is one genera that has relatively few herbicides labeled; this genera is very sensitive to many herbicides. FreeHand was tested on *Echinacea purpurea* 'Magnus' at Northland Farms. The amount of damage to *Echinacea* increased with increasing rates of FreeHand. Plants treated with 1X rate had acceptable ratings at each evaluation, and plants treated with 2X rate were acceptable by the end of the trial, but there was much more evidence of stunting and growth deformations with the 2X and 4X rates (Figure 1).
Hemerocallis. Tower was applied to *Hemerocallis* 'Stella d'Oro' at BFN and 'Happy Returns' at Northland Farms. At both locations, no phytotoxicity was evident from any of the rates of Tower. This has also been seen with Tower applications to 'Stella d'Oro' at trials located at The Ohio State University and Tower damage to 'Strawberry Candy' was seen only at the 4X rate at Lincoln Nursery in 2010 (2010 Yearly Research Summary Report).
Hibiscus. Biathalon and Snapshot were applied to *Hibiscus* 'Chiffon China' at Spring Meadow. There was no significant damage to *Hibiscus* from Biathalon from any rate. Snapshot did cause some damage in the form of overall yellowing of *Hibiscus*, with damage increasing with rate. However, most of the damage was from the first application, and the yellowing became less apparent as time went on. Visual ratings decreased to commercially acceptable ratings by the end of the trial from Snapshot.
Hydrangea. Snapshot and FreeHand were applied to *Hydrangea* 'City Vienna' at Spring Meadow, and both Snapshot and FreeHand caused significant damage to *Hydrangea*. Damage from Snapshot generally increased with increasing rates, with the second application causing damage to beyond commercially acceptable ratings for the 2X and 4X rates. Damage to *Hydrangea* from FreeHand was highest after the first application with the 4X rate, but damage from the second application was fairly constant across all rates. It is clear that FreeHand can cause damage to *Hydrangea*, but damage was inconsistent from pot to pot, at least in 4" containers (Figure 3). Based on data submitted to IR-4 from other researchers, damage to FreeHand has been highly variable, even with the same cultivar, and further research is needed.
Hydrangea 'Forever Ever' was treated with indaziflam at BFN; it was very clear the 2X and 4X rates caused significant injury to *Hydrangea*. Plants had yellow growing points and yellow leaves and the indaziflam also caused weaker stems (Figure 4). At the 1X rate, damage was not

significantly different from the control, indicating indaziflam could have potential for *Hydrangea* at lower rates, although including *Hydrangea* on the label of indaziflam would be doubtful based on this research.

Paeonia. BroadStar was applied to *Paeonia* 'Sarah Bernhardt' at BFN nursery. The *Paeonia* was transplanted from field stock that was still dormant at time of application. BroadStar does cause some damage to *Paeonia*, but based on this research, it is unclear as to the extent of damage. The 1X rate caused the most damage, which in this trial was in the form of dead plants (Figure 5). It should not be assumed that the BroadStar caused the plants to die; many of the plants never did emerge, which is evident with the visual ratings on the controls. More research is needed with BroadStar on *Paeonia*, on both dormant and actively growing plants.

Pennisetum. FreeHand was applied to *Pennisetum alopecuriodes* 'Hamlin' at Northland Farms. The FreeHand caused significant growth reduction and a decrease in flowering of *Pennisetum*, with damage increasing with increasing rates (Figure 5). Not much injury was seen with one application, but after two applications, significant injury became evident. *Pennisetum* should not be treated with FreeHand, especially if plants are going to be marketed with flower heads visible, as FreeHand decreases the number of flower heads.

Rosa. At Spring Meadow Nursery, *Rosa* 'Home Run' was treated with indaziflam. No injury was evident from any rate of indaziflam, indicating the *Rosa* 'Home Run' could be added to the label of indaziflam.

Spirea. BroadStar and FreeHand were applied to *Spirea* 'Double Play' at Spring Meadow Nursery. BroadStar caused significant injury to *Spirea*, mostly after the first application, with injury being temporary. Most of the injury was in the form of leaf burning; however, trimming is a common practice at many nurseries, and no leaf burning was evident after the leaves were trimmed. There was not as much injury from BroadStar after the second application as there was after the first application. There was very little injury from FreeHand on *Spirea*, which indicates that *Spirea* 'Double Play' should be included on the FreeHand label.

Syringa. Indaziflam was applied to *Syringa* 'Boomerang Purple' at Spring Meadow and 'Common Purple' at BFN. Damage to *Syringa* was different at each location. No damage was seen from indaziflam at BFN, but significant damage at the 2X and 4X rates was seen at Spring Meadow. The variation could be from the different pot sizes; at Spring Meadow, 4" pots were used and at BFN, 1-gallon trade size pots were used. The damage at Spring Meadow was in the form of stunting, with damage increasing with increasing rates. More research is needed with indaziflam over *Syringa*.

Taxus. Indaziflam was applied over top of *Taxus* 'Hicksii' at both BFN and Northland Farms. Both locations provided similar results, no phytotoxicity was evident at any of the rates tested, indicating *Taxus* 'Hicksii' should be included on the label of indaziflam.

Weigela. BroadStar and FreeHand were applied to *Weigela* 'Ghost' at Spring Meadow. Some injury was seen with BroadStar at the 2X and 4X rates, but all plants were marketable. No injury was seen from any rate of FreeHand. *Weigela* is on the label of both BroadStar and Freehand.

For the field trials, Tower was applied over *Taxus* 'Hicksii' and 'Runyon' at Northland Farms. There was no evidence from injury from any rate of Tower on both cultivars (Table 2). A combination of Tower + Pendulum was applied at BFN over *Potentilla* 'Mckays White', *Prunus glandulosa, Forsythia* 'Lynwood Gold', and *Lilac* 'Common purple'. The herbicides were applied as a dormant application, and no phytotoxicity was evident to any of the cultivars at any evaluation date from the rates tested. The combination of Tower + Pendulum would be a good addition to a weed control program over these species as dormant applications. Additional research is needed for application over actively growing plants. Biathalon was applied at BFN over dormant *Potentilla* 'Mckays White', and no phytotoxicity was seen at any evaluation date, indicating Biathalon could be used in the field over dormant *Potentilla* (Table 2). Biathalon has been applied over actively growing *Potentilla* in other trials located at The Ohio State University (2010 Yearly Research Summary Reports) and there was no phytotoxicity from Biathalon in containers. Tower alone was also applied over *Syringa* and *Forsythia* at BFN as a dormant spray. No phytotoxicity was evident from this application to these species (Table 2).

Table 1. Phytotoxicity visual ratings to several ornamental species from various herbicides in containers at three Michigan Nurseries.

Buddleia davidii 'Nanho Blue'						BFN											
Treatment	Rate	1 WA1T[z]		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
Gallery 1X	0.66 lb ai/ac	0.3[y]		2.5	**[x]	3.1	**	4.0	**	2.4	**	2.7	**
Gallery 2X	1.33 lb ai/ac	0.0		2.3	**	2.7	**	4.0	**	1.8	**	2.3	**
Gallery 4X	2.65 lb ai/ac	0.5		4.3	**	3.4	**	5.5	**	3.6	**	3.9	**
Untreated	--	0.2		0.0		0.2		0.0		0.3		0.2	
Buddleia davidii 'Royal Red'						Northland Farms							
Treatment	Rate	2.0	**	2.5	**	4.5	**	7.0	**	5.0	**	5.0	**
Gallery 1X	0.66 lb ai/ac	1.0	**	2.0	**	4.1	**	7.0	**	5.0	**	5.0	**
Gallery 2X	1.33 lb ai/ac	3.0	**	5.3	**	6.6	**	9.0	**	7.0	**	8.0	**
Gallery 4X	2.65 lb ai/ac	0.0		0.0		0.2		0.0		0.0		0.0	
Untreated	--												
Cornus 'Variegated'						Northland farms							
Treatment	Rate												
Certainty 1X	0.06 lb ai/ac	2.9	**	7.3	**	4.6	**	7.0	**	6.0	**	6.0	**
Certainty 2X	0.12 lb ai/ac	1.8	**	6.6	**	4.3	**	6.0	**	5.0	**	5.0	**
Certainty 4X	0.24 lb ai/ac	1.9	**	8.4	**	4.4	**	9.0	**	7.0	**	8.0	**
Untreated	--	0.3		0.0		0.0		0.0		0.0		0.0	
Echinacea purpurea 'Magnus'						Northland farms							
Treatment	Rate	1 WA1T		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
FreeHand 1X	2.65 lb ai/ac	--		0.0		1.4	**	2.0	**	1.3		0.6	
FreeHand 2X	5.3 lb ai/ac	--		0.0		2.1	**	4.0	**	2.3	**	1.7	**
FreeHand 4X	10.6 lb ai/ac	--		0.0		3.6	**	6.0	**	3.8	**	3.3	**
Untreated	--	--		0.0		0.0		0.0		0.2		0.0	
Hemerocallis 'Happy Returns'						Northland farms							
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		0.3		0.0		0.2		0.2	
Tower 2X	1.94 lb ai/ac	0.7		0.0		0.5		0.0		0.2		0.1	
Tower 4X	3.88 lb ai/ac	0.4		0.0		0.4		0.0		0.3		0.2	
Untreated	--	0.2		0.0		0.4		0.0		0.3		0.2	
Hemerocallis 'Stella d'Oro'						BFN							
Treatment	Rate	1 WA1T		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
Tower 1X	0.97 lb ai/ac												
Tower 2X	1.94 lb ai/ac			NO PHYTOTOXICITY PRESENT									
Tower 4X	3.88 lb ai/ac												
Untreated	--												
Hibiscus 'Chiffon China'						Spring Meadow							
Treatment	Rate	1 WA1T		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
Snapshot 1X	2.5 lb ai/ac	0.5		2.0		3.5	**	3.0		1.0	**	0.5	
Snapshot 2X	5.0 lb ai/ac	0.4		2.0		3.7	**	4.0		1.5	**	1.2	**
Snapshot 4X	10.0 lb ai/ac	0.2		2.0		3.6	**	3.0		2.0	**	0.9	**
Biathalon 1X	2.75 lb ai/ac	0.7		2.0		0.8		0.0		0.2		0.0	
Biathalon 2X	5.5 lb ai/ac	0.4		2.0		1.2	**	0.0		0.0		0.0	
Biathalon 4X	11.0 lb ai/ac	0.3		2.0		1.4	**	2.0		0.5		0.0	
Untreated	--	0.3		2.0		0.0		1.0		0.0		0.0	

z = WA1T: weeks after first treatment; WA2T: weeks after second treatment

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

x = visual ratings followed by *,** are significantly different from the control based on Dunnett's t-test (α = 0.10 and 0.05, respectively.

Table 1, cont. Phytotoxicity visual ratings to several ornamental species from various herbicides in containers at three Michigan Nurseries.

Hydrangea 'City Vienna'						Spring Meadow							
Treatment	Rate	1 WA1T[z]		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
Snapshot 1X	2.5 lb ai/ac	0.5[y]		2.0	**[x]	2.3	**	4.0	**	0.8		1.8	
Snapshot 2X	5.0 lb ai/ac	2.2	**	2.5	**	1.3		5.0	**	2.2	**	4.1	**
Snapshot 4X	10.0 lb ai/ac	1.6	**	4.5	**	1.7		5.6	**	5.6	**	5.6	**
FreeHand 1X	2.65 lb ai/ac	0.0		1.3	*	0.4		4.0	**	0.4		2.6	**
FreeHand 2X	5.3 lb ai/ac	0.2		2.7	**	0.6		6.0	**	1.3		2.5	**
FreeHand 4X	10.6 lb ai/ac	0.4		3.4	**	0.8		4.0	**	1.5		2.4	**
Untreated	--	0.3		0.0		0.7		3.0		0.2		0.3	
Hydrangea 'Forever Ever'						BFN							
Treatment	Rate	1 WA1T		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
Indaziflam 1X	0.11 lb ai/ac	0.0		2.5		0.9		2.8		0.9		2.4	**
Indaziflam 2X	0.22 lb ai/ac	0.0		2.5		1.5	*	6.0	**	3.0	**	3.8	**
Indaziflam 4X	0.44 lb ai/ac	0.0		5.1	**	1.1		5.0	**	4.2	**	4.1	**
Untreated	--	0.0		2.8		0.1		1.1		0.3		0.0	
Paeonia 'Sarah Bernhardt'						BFN							
Treatment	Rate	1 WA1T		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
BroadStar 1X	0.375 lb ai/ac	--		1.0	**	2.4	**	8.5	**	5.3	*	5.7	*
BroadStar 2X	0.75 lb ai/ac	--		0.8	**	2.4	**	7.5	**	4.1		4.3	
BroadStar 4X	1.5 lb ai/ac	--		1.3	**	1.7		4.7		3.2		4.3	
Untreated	--	--		0.0		0.4		4.2		2.5		2.9	
Pennisetum alopecuroides 'Hamlin'						Northland Farms							
Treatment	Rate	1 WA1T		2 WA1T		4 WA1T		1 WA2T		2 WA2T		4 WA2T	
FreeHand 1X	2.65 lb ai/ac	--		0.0		0.0		0.0		0.9	**	1.5	**
FreeHand 2X	5.3 lb ai/ac	--		0.0		0.8	**	2.0	**	3.7	**	3.7	**
FreeHand 4X	10.6 lb ai/ac	--		0.0		1.5	**	5.0	**	3.9	**	4.8	**
Untreated	--	--		0.0		0.0		0.0		0.0		0.0	
Rosa 'Home Run'						Spring Meadow							
Indaziflam 1X	0.11 lb ai/ac	0.5	*	0.0		0.0		0.0		0.0		0.0	
Indaziflam 2X	0.22 lb ai/ac	0.0		0.0		0.0		0.0		0.0		0.0	
Indaziflam 4X	0.44 lb ai/ac	0.0		0.0		0.0		0.0		0.0		0.0	
Untreated	--	0.1		0.0		0.0		0.0		0.0		0.0	
Spirea 'Double Play'						Spring Meadow							
BroadStar 1X	0.375 lb ai/ac	1.1	*	0.0		0.2		1.0		0.5		0.4	
BroadStar 2X	0.75 lb ai/ac	2.3	**	0.0		1.0	*	2.0		0.8		0.2	
BroadStar 4X	1.5 lb ai/ac	2.8	**	0.0		1.0	*	2.0		1.0		1.2	**
FreeHand 1X	2.65 lb ai/ac	0.5		0.0		2.1	**	0.0		0.0		0.0	
FreeHand 2X	5.3 lb ai/ac	0.6		0.0		1.0	*	3.0		0.7		0.0	
FreeHand 4X	10.6 lb ai/ac	0.7		0.0		1.1	*	2.0		0.4		0.6	
Untreated	--	0.1		0.0		0.0		2.0		0.4		0.0	
Syringa 'Boomerang Purple'						Spring Meadow							
Indaziflam 1X	0.11 lb ai/ac	0.3		1.0	**	1.5	**	--		0.3		0.2	
Indaziflam 2X	0.22 lb ai/ac	0.1		2.3	**	3.1	**	--		0.9	*	2.8	**
Indaziflam 4X	0.44 lb ai/ac	2.0	**	3.3	**	3.8	**	--		3.1	**	4.4	**
Untreated	--	0.0		0.3		0.2		--		0.2		0.3	

z = WA1T: weeks after first treatment; WA2T: weeks after second treatment

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

x = visual ratings followed by *,** are significantly different from the control based on Dunnett's t-test

(α = 0.10 and 0.05, respectively.

Table 1, cont. Phytotoxicity visual ratings to several ornamental species from various herbicides in containers at three Michigan Nurseries.

Syringa 'Common Purple'					BFN		
Treatment	Rate	1 WA1T[z]	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Indaziflam 1X	0.11 lb ai/ac						
Indaziflam 2X	0.22 lb ai/ac			NO PHYTOTOXICITY PRESENT			
Indaziflam 4X	0.44 lb ai/ac						
Untreated	--						
Taxus 'Hicksii' container					BFN		
Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Indaziflam 1X	0.11 lb ai/ac	0.4[y]	0.0	0.4	0.0	0.0	0.2
Indaziflam 2X	0.22 lb ai/ac	0.8	0.0	0.4	0.0	0.8	0.7
Indaziflam 4X	0.44 lb ai/ac	1.2	0.0	0.4	0.0	0.8	0.5
Untreated	--	0.4	0.0	0.1	0.0	0.2	0.2
Taxus 'Hicksii' container					Northland Farms		
Treatment	Rate						
Indaziflam 1X	0.11 lb ai/ac	0.0	0.0	0.0	0.0	0.0	0.0
Indaziflam 2X	0.22 lb ai/ac	0.3	0.0	0.0	0.0	0.0	0.0
Indaziflam 4X	0.44 lb ai/ac	0.7 **[x]	0.0	0.0	0.0	0.0	0.0
Untreated	--	0.0	0.0	0.0	0.0	0.0	0.0
Weigela 'Ghost'					Spring Meadow		
BroadStar 1X	0.375 lb ai/ac	0.6	0.0	1.0	0.0	0.3	0.5
BroadStar 2X	0.75 lb ai/ac	2.0 **	0.0	1.3 **	0.0	0.9	0.3
BroadStar 4X	1.5 lb ai/ac	1.5 **	0.0	1.5 **	0.0	2.0 **	2.0 **
FreeHand 1X	2.65 lb ai/ac	0.1	0.0	0.9	0.0	0.5	0.0
FreeHand 2X	5.3 lb ai/ac	0.6	0.0	0.4	0.0	0.0	0.0
FreeHand 4X	10.6 lb ai/ac	0.1	0.0	1.1	0.0	0.6	1.0 **
Untreated	--	0.0	0.0	0.1	0.0	0.2	0.1

z = WA1T: weeks after first treatment; WA2T: weeks after second treatment

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

x = visual ratings followed by *,** are significantly different from the control based on Dunnett's t-test (α = 0.10 and 0.05, respectively.

Table 2. Phytotoxicity visual ratings of several species of field grown ornamentals to selected herbicides at two Michigan nurseries.

Taxus 'Runyon' field grown				Northland Farms			
Treatment	Rate	1 WA1T[z]	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Tower 1X	0.97 lb ai/ac	--	0.0[y]	0.5	0.0	0.0	0.0
Tower 2X	1.94 lb ai/ac	--	0.0	0.3	0.0	0.1	0.0
Tower 4X	3.88 lb ai/ac	--	0.0	0.2	0.0	0.0	0.0
Untreated	--	--	0.0	0.4	0.0	0.0	0.0
Taxus 'Hicksii' field grown				Northland Farms			
Treatment	Rate						
Tower 1X	0.97 lb ai/ac	--	0.0	0.2	0.0	0.0	0.0
Tower 2X	1.94 lb ai/ac	--	0.0	0.0	0.0	0.3	0.0
Tower 4X	3.88 lb ai/ac	--	0.0	0.4	0.0	0.2	0.0
Untreated	--	--	0.0	0.4	0.0	0.2	0.0

Forsythia 'Lynwood Gold'					
Treatment	Rate	1 WAT[x]	3 WAT	6 WAT	8 WAT
Tower	0.97 lb ai/ac	No phytotoxicity present at any date			
Tower + Pendulum	0.97 + 2.0 lb ai/ac, respectively	No phytotoxicity present at any date			
Untreated	--				
Syringa 'Common Purple'					
Tower	0.97 lb ai/ac	No phytotoxicity present at any date			
Tower + Pendulum	0.97 + 2.0 lb ai/ac, respectively	No phytotoxicity present at any date			
Untreated	--				
Potentilla 'Mckays White'					
Tower + Pendulum	0.97 + 2.0 lb ai/ac, respectively	No phytotoxicity present at any date			
Biathalon	100 lb/ac	No phytotoxicity present at any date			
Biathalon	200 lb/ac	No phytotoxicity present at any date			
Untreated	--				
Prunus glandulosa					
Tower + Pendulum	0.97 + 2.0 lb ai/ac, respectively	No phytotoxicity present at any date			
Untreated	--				

z = WA1T: weeks after first treatment; WA2T: weeks after second treatment

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

x = weeks after treatment

Figure 1. Damage to *Echinacea purpurea* ‘Magnus from FreeHand. Rates going clockwise from top left: 4X, 2X, 1X, Untreated control.

Figure 2. Damage to *Hibiscus* ‘Chiffon China from Snapshot. Notice yellowing of leaves on plant on the right in comparison to control on left.

Figure 3. Damage from FreeHand. Untreated is on left followed by 1X, 2X, and 4X rates, respectively.

Figure 4. Damage from 2X rate of Indaziflam on left in comparison to untreated control, right.

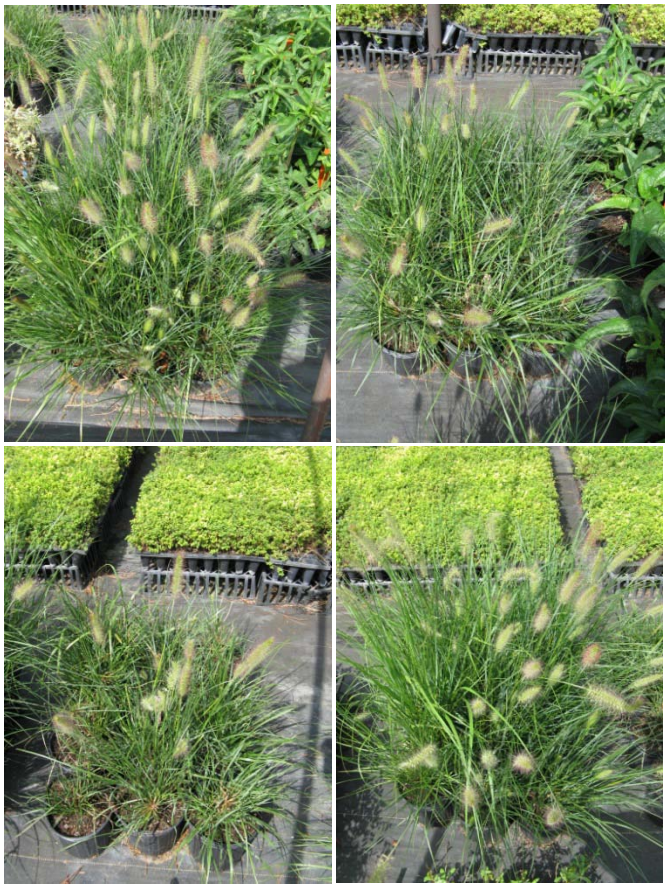

Figure 5. Damage from FreeHand to *Pennisetum alopecuroides* ‘Hamlin’. Clockwise from top left: 1X, 2X, Untreated, 4X, respectively.

Phytotoxicity of several weed control products to selected ornamentals in Ohio

Principle investigators: Dr. Hannah Mathers and Luke Case

Significance to the industry. Weed control continues to be a large component of ornamental production systems, and with the reduced economy, nursery and greenhouse managers are looking for more ways to cut costs. Herbicides greatly reduce costs per acre in comparison to handweeding; several studies have revealed handweeding can cost more than $5000/ac, and sometimes upwards of $10,000/ac, depending on the level of weed infestation. Increasing the number of "tools" for weed control is beneficial for growers, as not all weed control programs are created equal. These "tools" can include preemergence herbicides, postemergence herbicides, handweeding, mulching, and various other cultural activities that may reduce weed infestations. The purpose of the IR-4 program is to increase the number of labeled pesticides for minor use crops, of which ornamentals fall into. In coordination with the IR-4 program, several studies were carried out to determine phytotoxicity of several species of ornamental plants from different herbicides. These herbicides could then potentially be used by nurseries in their weed control programs.

Materials and Methods. Species selected for phytotoxicity trials in containers included Yellowwood (*Cladrastis kentuckea*), tulip tree (*Liriodendron tulipifera*), hawthorn (*Cratageous monogyna*), red maple (*Acer xfreemanii* 'Autumn Blaze'), ceonothus (*Ceonothus americanus*), redstem dogwood (*Cornus sericea* 'Cardinal'), witchhazel (*Fothergilla* 'Mt. Airy'), honeylocust (*Gleditsia triacanthos*), pin oak (*Quercus pinnata*), blue spruce (*Picea pungens* var. *glauca*), Japanese tree lilac (*Syringa reticulata* 'Ivory Silk'), and yew (*Taxus xmedia* 'Runyon'). On 10 May, 2011 and a reapplication on 21 June 2011, Biathalon (oxyfluorfen + prodiamine) at 2.75, 5.5 and 11.0 lb ai/ac was applied to pin oak; FreeHand (dimethenamid-p + pendimethalin) at 2.65, 5.3, and 10.6 lb ai/ac was applied to yellowwood and honeylocust; Echelon (F6875)(sulfentrazone + prodiamine) at 0.375, 0.75, and 1.5 lb ai/ac was applied to yellowwood; and indaziflam at 0.11, 0.22, and 0.44 lb ai/ac was applied to Japanese tree lilac. On 20 May, 2011 and a reapplication on 1 July, 2011, indaziflam at 0.11, 0.22, and 0.44 lb ai/ac was applied to yew; Certainty (sulfosulfuron) at 0.06, 0.12, and 0.24 lb ai/ac was applied to redstem dogwood; Tower (dimethenamid-p) at 0.97, 1.94, and 3.88 lb ai/ac was applied to pin oak and yellowwood; Gallery (isoxaben) at 0.66, 1.32, and 2.64 lb ai/ac was applied to tulip tree, witchhazel, and red maple; and BroadStar (flumioxazin) at 0.375, 0.75, and 1.5 lb ai/ac to ceonothus. Indaziflam at rates described above was applied to blue spruce on 8 June 2011 with a reapplication on 20 July, 2011 in a 7 gallon pot-in-pot system. Treatments were immediately watered in with overhead irrigation except for the pot-in-pot, which was via spot spitters™(John Deere Landscaping, Moline, IL). Liquid treatments were applied with a CO_2 backpack sprayer delivering 25 gal/ac using nozzles delivering 0.15 gal/min with a spacing of 12 inches. Phytotoxicity evaluations were performed at 1 WA1T (week after first treatment), 2 WA1T, 4

WA1T, 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. All pots were handweeded twice throughout the trial periods.

Results and discussion. Unless otherwise indicated, please refer to Table 1 for all results discussed.

Gallery. Gallery was applied to *Liriodendron tulipifera*, *Fothergilla* 'Mt. Airy', and *Acer xfreemanii* 'Autumn Blaze'. The *Acer* and *Fothergilla* were injured by all rates of Gallery with the first application being much more injurious than the second application. Although all *Acer* plants were marketable by the end of the trial, some injury was still evident and growth index indicates that plants were slightly smaller. The 4X rate was the only rate that gave phytotoxicity visual ratings above commercially acceptable; however, although not significant, growth indices indicates that all rates have some effect to *Liriodendron*, and more research is needed for this species.

BroadStar. *Ceonothus americanus* and *Cratageous monogyna* received applications of BroadStar, and both species displayed visual injury in the form of leaf spotting shortly after application, with the first application being much more injurious than the second application. Only the 4X rate on the *Ceonothus* gave commercially unacceptable injury ratings at 2 WA1T. The injury was temporary and all plants from both species were marketable by the end of the trial. Growth indices was higher with plants treated with BroadStar due to the level of weed control from the treatments in comparison to the controls which had weed infestations that were hand weeded twice throughout the trial as indicated above.

Certainty. Certainty was applied to *Cornus sericea* 'Cardinal', and was very injurious at all rates. Most of the plants that received 2X and 4X rates died by the end of the trial; this indicates that Certainty should not be applied to *Cornus*. This research confirms other research conducted by The Ohio State University with Certainty on *Cornus* (2008 Yearly Research Summary Reports).

FreeHand. *Gleditsia triacanthos*, and *Cladrastis kentuckea* received applications of FreeHand. Both species suffered some transplant shock that lasted throughout the experiment, but some conclusions can be made. On both species, plants that were treated with all rates of FreeHand did not suffer any more than the plants that were left untreated, and many of the *Cladrastis* that were untreated died (data not shown) from weed competition even though periodic hand weeding occurred. Although more data is needed, this research indicates that FreeHand is safe to *Cladrastis* and *Gleditsia*. Data from 2008 (2008 Yearly Research Summary Reports) also indicates that little to no injury occurs to *Gleditsia* from 1X and 3X rates.

Biathalon. Biathalon was applied to *Quercus pinnata*, and visual ratings indicate that some injury in the form of leaf margin yellowing can occur. This yellowing is apparent at all rates, but all plants were marketable by the end of the trial. Growth indices also indicate that some

stunting can occur, and the 2X rate provided a significant growth reduction. More research is needed with *Quercus pinnata* to confirm the results from this trial.

Indaziflam. Indaziflam was applied to *Syringa reticulata* 'Ivory Silk', *Taxus* 'Runyon', and *Picea pungens* var. *glauca*. *Syringa* suffered some transplant shock which is evident by the visual ratings of the controls. There was some yellowing of leaves that occurred on some the *Syringa*, but this was not evident in all plants, which is why there are slightly higher (but not significant) visual ratings in comparison to the controls. In other trials conducted in Michigan (data not shown), *Syringa* was stunted in 4" pots from 2X and 4X rates of Indaziflam, but in one gallon containers, no injury was evident. Size of plant material or size of container (or both) may have influence on how much injury there is from Indaziflam applications to *Syringa.* *Taxus* did show some leaf yellowing from the 4X rate of Indaziflam, and growth index also indicates some injury at the highest rate and all plants that received 1 X and 2X applications were marketable with little to no injury. There was no injury from Indaziflam on *Picea* from any rate in the 7 gallon pot-in-pot system.

Tower. *Quercus pinnata* and *Cladrastis kentuckea* received applications of Tower. Both species exhibited injury from Tower applications with all rates providing significant differences in visual ratings for *Quercus* and the 2X and 4X rates providing significant differences in visual ratings for *Cladrastis.* Tower also significantly reduced growth in comparison to the controls on *Quercus*. The injury on *Quercus* and *Cladrastis* was evident in the form on leaf burning shortly after application. Tower is known for leaf burning, especially when applied at bud break or on newly emerged leaves. Data from 2008 (2008 Yearly Research Summary Reports) on *Quercus rubra* also indicates that leaf burning occurs from Tower applications shortly after bud break.

F6875. *Cladrastic kentuckea* receieved applications of F6875, and no significant injury occurred. Although all plants suffered from transplant shock, *Cladrastis* that received 2X and 4X applications of F6875 had the greatest growth in comparison to all other treatments. More research is needed to confirm that no injury is evident on *Cladrastis* from applications of F6875.

Table 1. Phytotoxicity from selected herbicides on containerized ornamentals in Ohio.

Acer xfreemanii 'Autumn Blaze'

Treatment	Rate	1 WA1T[z]	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
Gallery 1X	0.66 lb ai/ac	2.6[yx] **	3.0 **	2.4 **	3.0 **	2.3 **	1.3	32.9
Gallery 2X	1.32 lb ai/ac	3.6 **	4.0 **	2.5 **	2.9 **	2.8 **	2.0 **	27.3 *
Gallery 4X	2.64 lb ai/ac	4.0 **	3.8 **	3.0 **	3.7 **	3.6 **	2.3 **	29.8
Untreated	--	0.3	1.2	0.4	0.3	0.0	0.2	38.8

Ceonothus americanus

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
BroadStar 1X	0.375 lb ai/ac	1.6	1.5	2.5	2.6	2.6	2.0	3.0
BroadStar 2X	0.75 lb ai/ac	1.4	0.8	1.3	2.4	2.3	0.7	6.8
BroadStar 4X	1.5 lb ai/ac	2.8 **	3.1 **	2.9	2.0	2.3	1.4	4.9
Untreated	--	1.0	0.6	1.8	2.8	1.7	1.8	1.8

Cornus sericea 'Cardinal'

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T
Certainty 1X	0.06 lb ai/ac	3.4 **	4.2 **	7.3 **	7.3 **	7.9 **	9.0 **
Certainty 2X	0.12 lb ai/ac	3.1 **	4.3 **	7.2 **	7.2 **	7.8 **	9.1 **
Certainty 4X	0.24 lb ai/ac	3.0 **	3.8 **	7.1 **	7.1 **	8.0 **	9.4 **
Untreated	--	0.6	0.3	0.8	0.8	0.0	0.0

Cratageous monogyna

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
BroadStar 1X	0.375 lb ai/ac	0.8	1.3 **	0.9	--	1.0	1.6	25.0 *
BroadStar 2X	0.75 lb ai/ac	2.3 **	2.5 **	1.4	--	1.5	1.3	24.3
BroadStar 4X	1.5 lb ai/ac	2.2 **	2.4 **	2.1 **	--	2.0	2.0	20.7
Untreated	--	0.2	0.3	0.8	--	1.7	0.7	17.7

Fothergilla 'Mt. Airy'

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
Gallery 1X	0.66 lb ai/ac	3.1 **	2.8 **	1.9	2.7	2.8	5.0	-0.2
Gallery 2X	1.32 lb ai/ac	2.6 **	2.6 **	2.3	2.6	2.9	5.3	2.8
Gallery 4X	2.64 lb ai/ac	4.2 **	4.8 **	4.2 **	3.8	4.0	4.6	3.9
Untreated	--	0.8	0.8	0.8	2.4	4.2	6.3	0.1

Gleditsia triacanthos

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
FreeHand 1X	2.65 lb ai/ac	2.3	2.8	4.3	--	3.8	3.6	6.6
FreeHand 2X	5.3 lb ai/ac	1.7	1.8	2.7	--	2.9	4.0	-0.1
FreeHand 4X	10.6 lb ai/ac	1.5	1.7	1.8	--	1.8	2.9	3.9
Untreated	--	1.5	2.0	2.6	--	5.0	6.3	4.3

z = WA1T: weeks after first treatment; WA2T: weeks after second treatment

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

x = visual ratings followed by *,** are significantly different from the control based on Dunnett's t-test (α = 0.10 and 0.05, respectively.

Table 1, cont. Phytotoxicity from selected herbicides on containerized ornamentals in Ohio.

Liriodendron tulipifera

Treatment	Rate	1 WA1T[z]	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
Gallery 1X	0.66 lb ai/ac	0.6[yx]	0.8	0.8	0.7	0.5	0.8	18.8
Gallery 2X	1.32 lb ai/ac	0.7	0.8	0.4	0.9	0.9	1.3	16.6
Gallery 4X	2.64 lb ai/ac	3.0	3.3	2.7	4.0 *	3.7 *	5.1 **	5.8 *
Untreated	--	1.8	1.4	1.2	0.8	0.8	1.3	26.5

Quercus pinnata

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
Biathalon 1X	2.75 lb ai/ac	0.0	2.7	1.9 *	--	1.8 **	1.2	15.9
Biathalon 2X	5.5 lb ai/ac	0.0	2.8	0.9	--	1.8 **	1.4	14.0 **
Biathalon 4X	11.0 lb ai/ac	0.0	2.8	2.8 **	--	2.1 **	1.5	17.0
Tower 1X	0.97 lb ai/ac	2.1	1.7	0.8	3.7 **	2.2 **	3.6 **	14.0 **
Tower 2X	1.94 lb ai/ac	2.2	2.8	2.1 **	3.8 **	3.4 **	2.6 **	14.0 **
Tower 4X	3.88 lb ai/ac	2.8 *	2.8	2.3 **	4.5 **	3.8 **	3.7 **	10.8 **
Untreated	--	1.3	2.3	0.4	0.7	0.1	0.4	21.2

Picea pungeans var. glauca

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
Indaziflam 1X	0.11 lb ai/ac	0.3	0.2	0.1	--	0.3	0.3	0.9
Indaziflam 2X	0.22 lb ai/ac	0.0	0.2	0.0	--	0.2	0.1	0.7
Indaziflam 4X	0.44 lb ai/ac	0.1	0.1	0.1	--	0.3	0.3	-1.0
Untreated	--	0.0	0.1	0.2	--	0.4	0.2	-0.2

Syringa reticulata 'Ivory Silk'

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
Indaziflam 1X	0.11 lb ai/ac	--	1.17	2.17	--	2.58	2.5	4.1
Indaziflam 2X	0.22 lb ai/ac	--	1	3.42	--	3	3.58	6.5
Indaziflam 4X	0.44 lb ai/ac	--	1.25	3.17	--	3.92	4.17	5.4
Untreated	--	--	0.67	1.75	--	1.17	1.5	2.2

Taxus xmedia 'Runyon'

Treatment	Rate	1 WA1T	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI
Indaziflam 1X	0.11 lb ai/ac	1.0	1.9	0.9	0.7	0.8	0.8	2.6
Indaziflam 2X	0.22 lb ai/ac	1.7 **	2.1	1.0	0.8	0.8	0.7	1.4
Indaziflam 4X	0.44 lb ai/ac	2.2 **	2.8 **	2.3 *	2.0 *	3.0 *	3.2	-6.1
Untreated	--	0.3	0.4	0.2	0.1	0.0	0.2	2.8

z = WA1T: weeks after first treatment; WA2T: weeks after second treatment

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

x = visual ratings followed by *,** are significantly different from the control based on Dunnett's t-test (α = 0.10 and 0.05, respectively.

Table 1, cont. Phytotoxicity from selected herbicides on containerized ornamentals in Ohio.

Cladrastis kentuckea

Treatment	Rate	1 WA1T[z]	2 WA1T	4 WA1T	1 WA2T	2 WA2T	4 WA2T	GI	
FreeHand 1X	2.65 lb ai/ac	1.4[yx]	1.7	2.3	--	3.5	5.2	7.6	**
FreeHand 2X	5.3 lb ai/ac	1.2	1.5	1.9	--	3.4	4.9	5.0	**
FreeHand 4X	10.6 lb ai/ac	1.3	2.6	3.7	--	5.5	6.7	6.6	**
F6875 1X	0.38 lb ai/ac	1.6	2.2	2.8	--	5.1	6.4	5.9	**
F6875 2X	0.75 lb ai/ac	1.6	1.9	2.7	--	3.9	5.4	9.6	**
F6875 4X	1.5 lb ai/ac	1.4	1.6	2.5	--	4.8	6.3	9.3	**
Tower 1X	0.97 lb ai/ac	1.6	1.8	2.3	3.8	3.9	4.5	1.5	**
Tower 2X	1.94 lb ai/ac	2.3 **	2.5	3.1	4.3	5.1	5.7	6.4	**
Tower 4X	3.88 lb ai/ac	2.8 **	3.4 **	4.5	6.7	6.4	6.5	1.9	**
Untreated	--	1.1	1.8	3.6	7.5	8.3	8.8	-15.7	

z = WA1T: weeks after first treatment; WA2T: weeks after second treatment

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

x = visual ratings followed by *,** are significantly different from the control based on Dunnett's t-test (α = 0.10 and 0.05, respectively.

The Price is Wrong – A Correlation Between Speaker Fees and Program Attendance

Denise M. Johnson, Dr. Hannah Mathers, and Pamela J. Bennett from The Ohio State University, Horticulture & Crop Science Department.

The Ohio State University Nursery Short Course (OSU NSC) has been providing the green industry with cutting edge educational information, research updates, and innovations for nursery, landscape, garden center, tree care and turf professionals for 82 years. The three sponsors of the OSU NSC: The Ohio State University Department of Horticulture and Crop Science, The OSU Extension Nursery, Landscape and Turf Team, and The Ohio Nursery and Landscape Association, work closely together in the planning and implementation of this program. On January 24-26, 2011, nearly 100 sessions were presented by nationally and locally recognized experts and industry leaders to more than 2000 attendees. The educational sessions are organized into tracks of five 60-minute presentations per track that focus on selected topics. The afternoon tracks are all back to basic topics so that managers will have time at the trade show while employees attend sessions.

Annual on-site attendee evaluations of each speaker have been used from 2007 through 2011. Using a Likert scale evaluation tool, data has been analyzed concerning the quality of the speaker, usefulness of the presentation, and how applicable the session information is to the participants' job.

Analyzing five years of attendance in relation to speaker fees indicates spending more on speakers will not necessarily equate to larger attendance numbers. A further analysis of participant satisfaction surveys for these same years will also be considered to clarify what warrants attendance increases in educational programs.

Greening the Highways: Out-plant survival of deciduous trees in stressful environments. Greater Toronto Area, Ontario, Canada

Dr. Hannah Mathers and Michele Bigger

Significance to the Industry.
Deforestation and degradation of existing world forests is occurring at a significant rate (4). Forests and trees offer economic, sociological and environmental benefits (3). With decreases in natural forests (4), the building of the urban forest is vital. Over 174 thousand miles (280,300 km) of roads compose the national highways systems of the United States and Canada (1, 2). It is estimated that 90% of Americans live within 5 miles (8 km) of the US national highway system (1). Right-of-way lands adjacent to roadways offer possible opportunities to build part of the urban forest. Successful highway greening installations could impact the industry both economically and environmentally.
However, these unique landscapes can be highly stressful environments detrimental for both plant growth and survival. In order to see the benefits of trees planted along the highways, the trees, which compose these landscapes, first must survive. Greening the Highways is North America's first long term out-plant research project on survival of deciduous trees along highways (5). This research had three objectives; 1.) Evaluate survival of deciduous trees in a highway environment, 2.) Explore Geohumus®, (Geohumus International, GmbH & Co. KG, Frankfurt, Germany) a media amendment added during production for increasing out-plant survival, reduced water stress, and improved height and caliper growth, and 3) Evaluate different production environments for increasing out-plant survival and deciduous tree growth.

Materials and methods. In June 2010 six sites were planted with trees along Highway 401, in the greater Toronto area, Ontario, Canada. Three sites (1, 2, & 3) are located in the city of Mississauga at the intersection of Highway 401 and Highway 427. Three additional sites (4, 5, & 6) are located at the intersection of Highway 401 and Allen Road in the city of North York (Figures 1 & 2).

Figure 1: Sites 1, 2, & 3
Image: Google Earth

Figure 2: Sites 4, 5, & 6
Image: Google Earth

All design, landscape drawings, contract documents, and construction administration was done by Ministry of Transportation Ontario (MTO). The installation's focus was to provide a landscape planting for the intersections, thus it is important to note standard statistical design generally used for scientific study was not adhered to. Site preparation included clearing and grubbing of existing organic and inorganic debris, sub-soiling (24" inches (600 mm)), placement and incorporation of soil amendment , and cultivation (8" (200 mm), not including the additional soil amendment) (Table 1).

Table 1. Description of soil amendments and mulches at each site.

Site	Location	Soil Amendment Type	Spread Depth	Soluble Salts Specified (mS/cm)	Soluble Salts Tested (mmhos/cm)	pH Specified	pH Tested	Mulch Type	Finished Product Size
1	Highway 401 & Highway 427	Mushroom Compost	6" (150 mm)	≤2	7.90-9.05	6.5-8.5	7.45-7.6	Gro-bark Northwoods Utility Pine Mulch	5/8" (15.8 mm) to 1" (25.4 mm)
2	Highway 401 & Highway 427	Mushroom Compost	6" (150 mm)	≤2	7.90-9.05	6.5-8.5	7.45-7.6	Generic Shredded Bark Mulch	3/8" (10 mm) to 3 1/2" (90 mm)
3	Highway 401 & Highway 427	Root Zone Mix	6" (150 mm)	≤2	1.36-1.72	6.0-7.0	6.4-6.86	Gro-bark Hardwood Blend	5/8" (15.8 mm) to 2" (50.8 mm)
4	Highway 401 & Allen Road	Mushroom Compost	6" (150 mm)	≤2	7.90-9.05	6.5-8.5	7.45-7.6	Nincompoop	N/A
5	Highway 401 & Allen Road	Compost	6" (150 mm)	≤3.5	N/A	5.5-8.5	N/A	Gro-bark Hardwood Blend	5/8" (15.8 mm) to 2" (50 mm)
6	Highway 401 & Allen Road	Root Zone Mix	6" (150 mm)	≤2	1.36-1.72	6.0-7.0	6.4-6.86	Generic Hardwood Chips	(3/4")20 mm to 2" (50 mm)

Thirty-three species of deciduous trees are planted at the six sites. Not all species were planted at all sites (Table 2). Trees were provided by four nurseries, and not all species were provided by all nurseries (Table 2). Four source nurseries included, Vineland Research and Innovation Centre (Vineland), Vineland Station, Ontario, Willowbrook Nurseries Inc. (Vineland), Fenwick, Ontario, Earthgen International Ltd. (Earthgen), Mississauga, Ontario, and Braun Nursery Ltd. (Braun), Mount Hope, Ontario. Trees with the nursery label "Unknown" were trees chosen by the landscape contractor from various nurseries in and around the greater Toronto area. For consolidation purposes trees produced by either Vineland or Willowbrook have been noted as 'Vineland' in Table 2. Each nursery had a different production method. Vineland and Willowbrook produced *Acer x freemanii* 'Jeffersred', Autumn Blaze Maple, *Betula jacquemontii,* Whitebarked Himalayan Birch, and *Gleditsia triacanthos,* Honeylocust. Production of these trees were duplicated with the exception that Vineland used a retractable roof greenhouse (RRG) where as Willowbrook's trees were produced in a vented roof greenhouse (VRG). Earthgen produced plants using a poly house method (Poly). Braun's trees were grown in field conditions (Field). Trees produced by Vineland or Willowbrook were amended with a water stress reducing material, Geohumus® at four percentages by container volume: 0%, 0.5%, 1%, and 2%. Geohumus® amendments were incorporated when tree seedlings were initially potted into 3 gallon containers. Trees produced by Vineland or Willowbrook were one year old liners (approximately ½" (12.7 mm) in caliper with 5'-6' (152-182 cm) height) at the time of installation. All sites also included conifers and shrubs, with the exception of site 2 which only had deciduous and coniferous trees. Sites had two predominate planting design schemes (Table 3). Plants, regardless of type were planted in an informal triangulated pattern (Figure 3). Trees were to be planted approximately 5' (1.6 m) on center. Following planting white plastic tree guards were installed for animal protection. Each tree also received 1 bamboo stake, ¾" (19 mm) – 7/8" (22 mm) diameter, for support. Bamboo was attached with tape, by a tapener (Max Tapener HT-B2(N), MAXCO., LTD, Japan). Following planting each bed received mulch treatment (Table 1).

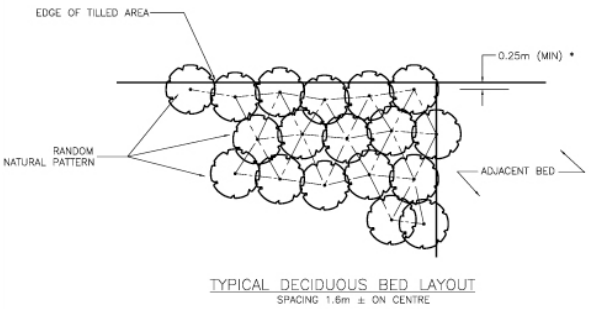

Figure 3. Specified Deciduous Tree Planting Layout, Image: MTO, drawings

Table 2. Deciduous tree species planted at each site.

Botanical Name	Common Name	Site & Quantity						Height	Planting Condition	Nursery
		1	2	3	4	5	6			
Acer freemanii "Autumn Blaze'	Autumn Blaze Maple	40	45	60	20	35	15	1.5 m	Bare root or potted	Unknown
Acer freemannii 'Jeffersred'	Autumn Blaze Maple			70	20	20	30	1.5 m	3 gal	Vineland
Acer ginnala	Amur Maple			30	20	20	30	1.5 m	Bare root or potted	Unknown
Acer platanoides 'Deborah'	Deborah Norway Maple	64	40	55	20	30	25	1.5 m	Bare root or potted	Unknown
Acer platanoides 'Superform'	Superform Norway Maple	60	60	60	20	35	15	1.5 m	Bare root or potted	Unknown
Acer pseudoplatanus	Sycamore Maple	64	60	85	60	45	35	175 cm	3 gal	Earthgen
Acer rubrum	Red Maple	12	20	30			30	1.5 m	3 gal	Earthgen
Acer saccharinum	Silver Maple	64	60	20			10	1.5 m	Bare root or potted	Unknown
Alnus glutinosa	European Black Alder			20			30	1.5 m	Bare root or potted	Unknown
Betula jacquemontii	Whitebarked Himalayan Birch			60	20	20	25	1.5 m	3 gal	Vineland
Betula lenta	Cherry Birch	50	45	80	20	15	35	900 mm	3 gal	Earthgen
Betula papyrifera	Paper Birch	100	60	20	20	40	35	900 mm	3 gal	Earthgen
Celtis occidentalis	Hackberry	70	15	60		20	30	1.5 m	3 gal	Unknown Vineland
Crataegus laevigata	Corkscrew Hawthorn		60	20	40	55	30	1.5 m	Bare root or potted	Unknown
Fraxinus quadrangulata	Blue Ash			30		30	20	1.5 m	Bare root or potted	Unknown
Ginkgo biloba	Maidenhair Tree	114	20	30	20	35	60	500 mm	3 gal	Earthgen
Gleditsia triacanthos	Honey Locust	90	40		20	15	15	1.5 m	3 gal	Vineland
Gymnocladus dioicus	Kentucky Coffeetree	12	40	40		20	30	1.5 m	Bare root or potted	Unknown
Populus deltoides	Eastern Cottonwood	70	50	30	20			1.5 m	Bare root or potted	Unknown
Populus grandidentata	Large Toothed Aspen		40	30				1.5 m	Bare root or potted	Unknown
Populus tremuloides	Trembling Aspen	109	50	100		35	30	1.5 m	Bare root or potted	Unknown
Prunus pensylvanica	Pin Cherry		20				30	1.5 m	Bare root or potted	Unknown
Prunus virginiana	Choke Cherry	32					30	1.5 m	Bare root or	Unknown

									potted	
Quercus bicolor	Swamp White Oak	32	85	75			10	2.0 m	Native Soil Sock	Braun
Quercus coccinea	Scarlet Oak	40	110	60	20	20	15	2.0 m	Native Soil Sock	Braun
Quercus macrocarpa	Bur Oak		50	30			10	1.75 m	3 gal	Earthgen
Quercus robur	English Oak	40	20	40	20	20	35	1.5 m	3 gal	Earthgen
Quercus rubra	Red Oak	40	40	30		20		1.5 m	3 gal	Earthgen
Robinia pseudoacacia	Black Locust	82	80	75	20	20	40	1.5 m	Bare root or potted	Unknown
Syringa reticulata	Japanese Tree Lilac			50			30	1.5 m	Bare root or potted	Unknown
Tilia Americana 'Redmond'	Redmond Linden	57	45	30	20	35	15	1.5 m	Bare root or potted	Unknown
Ulmus japonica x wilsoniana 'Morton'	Accolade Elm			30		20	25	1.5 m	Bare root or potted	Unknown
Ulmus 'Morton Glossy'	Triumph Elm			30		15	10	1.5 m	Bare root or potted	Unknown

This project also included a two year maintenance agreement, including replacement of dead tree material, and general tree health maintenance, re-tying (taping) of trees to bamboo support, trimming of dead branches, mechanical weed removal, herbicide treatment and watering as necessary. No additional fertilization was applied to the plantings to the researcher's knowledge. Initial inventory of site characteristics and individual trees was conducted (Table 3). Site measurements and slope analysis was conducted based off of MTO drawings.

Table 3. Site Characteristics

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
Bed Size	0.32 ha (0.79 ac)	0.31 ha (0.77 ac)	0.59 ha (1.47 ac)	0.18 ha (0.45 ac)	0.30 ha (0.75 ac)	0.32 (0.79 ac)
Bed Layout	NE-SW	N-S	NE-SW	N-S	NW-SE	NE-SW
Average Bed Slope	1.4%	1.9%	8.8%	10.7%	14.7%	5.8%
Aspect	Open	Open	North	Northwest	Northeast	Southeast
Roads Adjacent to Beds	Hwy 401E & Hwy 427S/Hwy 401 E	Hwy 401E & Hwy 427S/Hwy 401 E	Hwy 401E Exp & Hwy 427S/Hwy 401W Coll	Allen Rd N/Yorkdale Rd & Hwy 401W Coll/Allen Rd N & Hwy 401W Coll/Allen Rd S	Hwy 401W Coll/Allen Rd S & Hwy 401E Coll/Allen Rd S	Hwy 401E Coll/Allen Rd S & Hwy 401W Coll & Hwy 401E Coll/Yorkdale Rd
Average Distance Middle of Bed to Road Surface	401E: 38.8 m (127.3 ft) 427S/401E: 54.6 m (179.1 ft)	401E: 61.1 m (200.4 ft) 427S/401E: 100.6 m (330 ft)	401E Exp: 39.5 m (129.6 ft) 427S/401W Coll: 40.1 m (131.5 ft)	Allen/Yorkdale: 26.62 m (87.3 ft) 401W Coll/Allen N: 50.1 m (164.3 ft) 401W Coll/Allen S: 22.1 m (72.5 ft)	401W Coll/Allen S: 22 m (72.2 ft) 401E Coll/Allen S: 19.9 m (65.3 ft)	401E Coll/Allen Rd S: 29.5 m (96.8 ft) 401W Coll: 41.2 m (135.1 ft) 401E Coll/Yorkdale: 25.2 m (82.7 ft)
Speed Limit of Roadway Adjacent to Site	100 km/hr (62 mph)	100 km/hr (62 mph)	100 km/hr (62 mph)	70-100 km/hr (45-62 mph)	70-100 km/hr (45-62 mph)	70-100 km/hr (45-62 mph)
Observed Drainage	Very Poor: Ponding	Very Poor: Ponding	Poor: Pooling	No Problems Observed	No Problems Observed	No Problems Observed

Soil Major Texture Class	Clay	Clay	Clay	Clay	Clay	Clay
Soil pH	7.6	7.5	7.8	7.3	7.93	7.8
Soil Total Salts	2.6 mS/cm	3.2 mS/cm	0.6 mS/cm	4.3 mS/cm	0.5 mS/cm	0.3 mS/cm
Soil Zinc Levels	24.3 ppm	22.6 ppm	5.8 ppm	18.9 ppm	12.3 ppm	6.6 ppm
Soil Bicarbonate Levels	251.3 ppm	284.0 ppm	17.3 ppm	258.3 ppm	77.5 ppm	37.9 ppm
Weed Pressure	High	High	Low	High	High	Low
Planting Design	West Perimeter: Deciduous Shrubs 39% Site: Mixed Coniferous & Deciduous Trees 61% Site: Deciduous Trees Only	100% Site: Mixed Coniferous & Deciduous Tree Planting	Up-Slope: Conifer Trees Mid-Slope: Deciduous Trees Bottom-Slope: Deciduous Shrubs	Up-Slope: Conifer Trees Mid-Slope: Deciduous Trees Bottom-Slope: Deciduous Shrubs	Up-Slope: Conifer Trees Mid-Slope: Deciduous Trees Bottom-Slope: Deciduous Shrubs	Up-Slope: Conifer Trees Mid-Slope: Deciduous Trees Bottom-Slope: Deciduous Shrubs

Results and discussion.

For this summary a comparison of sites 1 and 4 will be presented. Site 1 is approximately twice the size of site 4. Site 1 has drainage issues, and contractors have constructed drainage channels. In contrast, site 4 has a significant slope. Another notable difference is the total soil salt are twice as high in site 4 compared with site 1.

The species that had the highest survival rates at both sites include *Acer platanoides* 'Deborah', *Acer platanoides* 'Superform' & *Gleditisia triacanthos* (Figure 4). These species are well-known for their vigorous growth habits and adaptability to various soils, site and climatic conditions (6). Species from the VRG and RRG in site 4 include *Betula jacquemontii, Acer x freemanii* 'Jeffersred' and *Gleditsia triacanthos*. *Betula* and *Acer* had poor survival in site 4; this correlates with lower overall survival for the RRG and VRG in site 4 when compared with site 1 (Table 4). Species having poor survival at both sites include *Acer pseudoplatanus, Betula lenta, Betula papyrifera*, and *Ginkgo biloba*. Generally all of these trees were smaller in stature upon installation and all were produced in a poly-house environment. This correlates with low survival shown with the poly-house production method (Table 4). Under-developed plant material, particularly in terms of root development, out-planted into stressful environments often times results in poor survival & transplant shock (7, 8). *Betula* species generally do best in sites where the root zone temperatures remain cool. Small amounts of drought or heat can affect survival (6). The flat, open landscape of site 1 and western aspect of site 4 may be promoting a dry environment through exposure to winds and afternoon sun. Prevailing winds in the Toronto region are westerly in the winter, summer, and fall (9). Ginkgo does not do well in shade (6), with the high weed pressure in both sites; competition for light may be a factor in survival rates. Mechanical damage (from weed wackers) to *Ginkgo* was also a factor. *Acer x freemanii* 'Autumn Blaze', *Robinia pseudoacacia, Quercus robur*, & *Tilia americana* 'Redmond' all did significantly better in site 4 versus site 1. Site 1 has serious drainage challenges, further indicated by high soil bicarbonate levels. Clay soils with less than 2% slope have poor drainage. The landscape contractor has also noted a hard clay pan in this site. Previously mentioned

species all prefer well drained conditions (6). *Quercus coccinea* had a significantly better survival rate in site 1 versus site 4. *Quercus coccinea* is known to be sensitive to salts (10). Survival difference correlates with the higher total salt levels in site 4. Salts are most likely derived from the soil amendment, type of mulch, and the proximity of site 4 to roads which receive de-icing salts in the winter. Salt levels may also be a factor with *Acer x freemanii* 'Autumn Blaze' in site 4, as survival was better than site 1, but did not survive as well as other species in site 4.

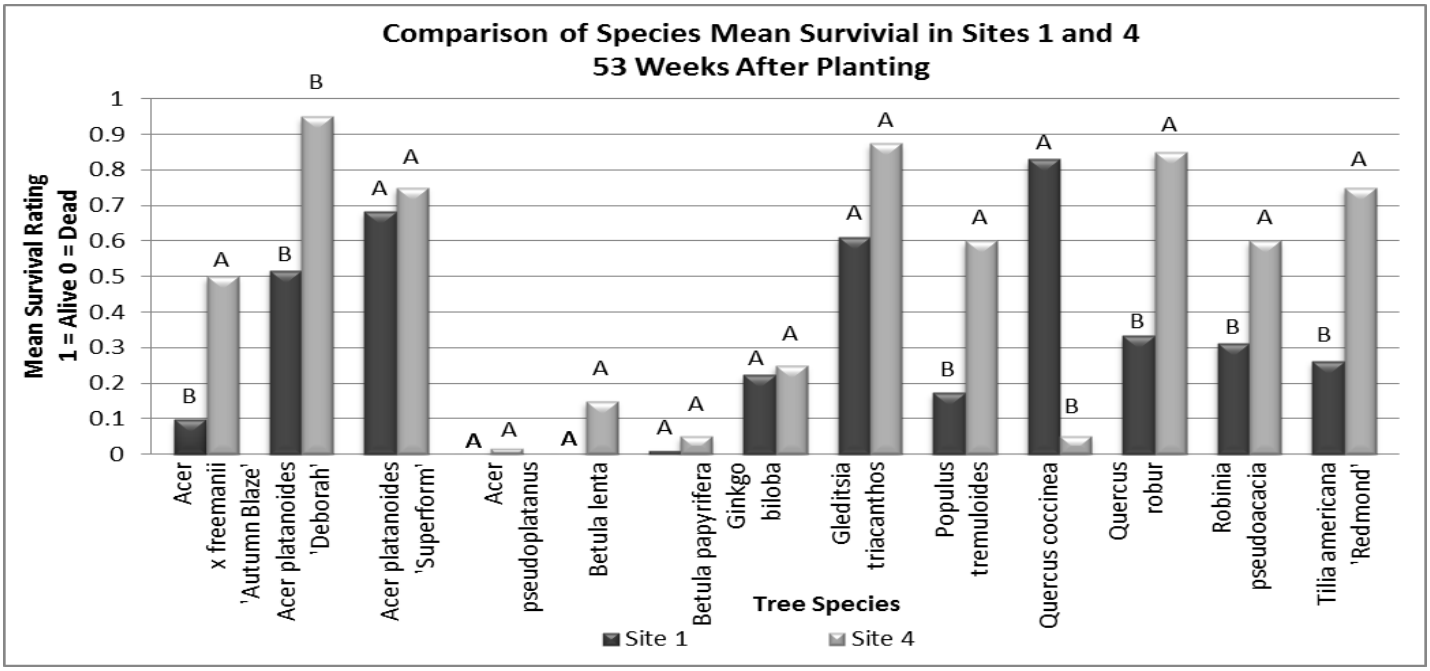

Figure 4. Visual survival mean rated score within species by site. Plants were installed June 2010. Site 1 is located at the intersection of Highway 401 and Highway 427. Site 4 is located at the intersection of Highway 401 & Allen Road. Both sites are in Toronto, Ontario Canada. Ratings were taken May 15 – June 15, 2011, approximately 53 weeks after planting (WAP). Trees were visually assessed for survival by a rated score 1 or 2 (1=plant was alive and had < 50% dieback, 2 = >50% dieback or complete death). Visual assessment was for the total above ground plant. Visual survival mean rated score (number of plants that were alive, having a score of 1 per species/total number of plants per species). Only species in both sites are presented. Means are pooled over treatment and production method. Bars with different letters represent significant statistical differences by Fisher's Least Significant Difference (LSD) at $\alpha = 0.05$ level using ANOVA. Comparisons were made between sites within similar species.

Production Method	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6
VRG	0.79-A	0.93-A	0.25-C	0.33-BC	0.7-AB	0.97-A
RRG	0.51-B	N/A	0.53-B	0.46-AB	1.0-A	0.91-AB
Poly-	0.17-D	0.32-C	0.36-C	0.19-C	0.74-	0.61-C

House					AB	
Field	0.79-A	0.67-B	0.70-A	0.05-C	0.4-ABC	0.85-AB
Unknown	0.34-C	0.65-B	0.44-B	0.70-A	0.94-A	0.80-B

Table 4. Visual survival mean rated score was conducted within production method by site in 2011. Trees were visually assessed for survival by a rated score 1 or 2 based on above ground portions (1=plant was alive and had < 50% dieback, 2 = >50% dieback or complete death). Means are pooled over species and treatment. Means followed by different letters in the same column are significantly different using Fisher's Least Significant Difference (LSD)($\alpha = 0.05$).

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Midwestern Tree Liner Production with Technologies new to the Nursery Industry

Principal investigators: Phoebe Gordon and Dr. Hannah Mathers

Significance to Industry: Caliper trees are produced and planted throughout Ohio; however, in most cases the liners (or sometimes referred to as "whips") that they are grown from are produced in the Pacific Northwest. Liners are trees that are between 120 to 240 cm in height and a caliper of 12.7 to 19.1 mm. This import puts a strain on the Ohio nursery industry as it reduces the variety of native trees growers can select in addition to the fact that liners can be dead or damaged upon arrival, particularly in valuable native species such as oaks. This dependence on tree liners from the Pacific Northwest is due to the shorter growing season in Ohio, as well as the attitude that growers in Ohio cannot compete with growers in the Pacific Northwest in production costs. Retractable Roof Greenhouses have been shown to improve growth in woody shrubs (Mathers, 2003; Schuch, 2008) via mediation of environmental extremes, particularly in shading. Root pruning, which works by destroying root tips due to air exposure, chemicals, or physical removal during the seedling stage has been shown to improve root morphology via an increase in the number of lateral roots, which is important for tree survival, and fewer malformed roots, which decrease stability and could girdle the tree (Ortega, 2006). In one case above ground biomass of the plant was increased over those grown in more traditional plastic pots. (Maguire, 2007). Increasing the quality and decreasing the production time of tree liners could enable Ohio growers to produce their own tree liners cheaply, improving the quality and selection available for local caliper production. The objectives of this study are to evaluate the Retractable Roof Greenhouse and various air pruning pots on the growth rate of tree liners.

Materials and Methods: Two separate trials were conducted at The Ohio State University in Columbus, Ohio, between spring 2010 and fall 2011. The plants were either grown in a retractable roof greenhouse (RRG) produced by Cravo Equipment, Ltd. (Brantford, Ontario, Canada) and outside in an uncovered hoop house. During the growing season the RRG was set to close completely below 70 ºF during the day and below 50 ºF at night.

Gleditsia triacanthos var. *inermis*, *Quercus shumardii*, and *Platanus occidentalis* were started from seed in spring of 2010 and germinated in flats. These species were picked because they are native to the region and easily available for seed collection. In 2011 *Quercus rubra* was used instead of *Q. shumardii* due to the low germination rates of the *Q. shumarii* acorns. In order to induce germination in May 2010 and February 2011, the *G. triacanthos* var. *inermis* seeds were placed in boiling water and allowed to sit overnight with no additional heat and then planted the next morning. The *P. occidentalis* seeds were sewn directly into flats in February 2010 and 2011. Both species were placed in a propagation chamber and allowed to grow until they started to develop true leaves, which took approximately one month. In March 2010 and 2011 the *Quercus* seeds were removed from the coolers they were being overwintered in and placed in flats with germination paper on top and placed under intermittent mist until the radicle started to extend. At this point the plants were planted into one of four air pruning pots or left in trays with potting media that did not allow air pruning for one month.

The air pruning pots were a Rootmaker® (8 cm x 10 cm square, 410 cm^3) (big RM) , Root Accelerator® (RAC) (8 cm x 10 cm round 230 cm^3) , Jiffy (12 cm x 10 cm round, 1230 cm^3) , or Elle (7 cm x 7 cm round, 270 cm^3). In 2011 an additional RM size was added, (small RM) (5.5 cm x 10 cm, 180 cm^3) in order to look at differences in root volume. All air pruning pots except for the Elle pot,

which came with its own media, were filled with the same media that the trays were filled with. Once in the air pruning pots, the plants were grown in a vented polyhouse in 2010 and a glasshouse in 2011. After one month of growth in the air pruning pots or flats all plants were transplanted into Classic 1200 three gallon pots (Nursery Supplies, Inc.) and left there for the remainder of the season. Separation between environments was delayed in 2011; the roof on the RRG structure needed to be replaced and was delayed due to extreme weather. The media was aged pine bark fines with 3-5% pea gravel (Kurtz Brothers, Inc). Once in the three gallon pots, the plants were divided into their respective environments. Experimental design in 2010 was a completely randomized design; in 2011 they were organized into a randomized complete block design due to suspected environmental differences in the RRG. At transplanting, all pots received three tablespoons of 19-5-8 Osmocote Pro with Minors. In 2010 a 4-5 month fertilizer was used and reapplied in July. In 2011 a 8-9 month was applied at transplant and was not reapplied. Plants were watered to excess in both environments two times a day via spot spitters (John Deere Landscaping), which was increased to three in mid-July both years.

In 2010 the plants were harvested at the end of the growing season when the leaves had senesced. In 2011 the plants were harvested during senescence. Heights, shoot weight, and root weight were obtained in 2010 and in 2011, due to the leaves still being on the plants, leaf number, leaf area, and leaf weights were obtained. There are several cases in which treatments were omitted. In 2010 several *G. triacanthos* seedlings died while still in the Ell pots due to extremely hot conditions. Herbivory was a problem both years, and several treatments in *Q. shumardii* were wiped out due to squirrels in 2010. In the cases where no trees were left in one treatment, the corresponding treatment in the other environment was removed for comparisons. Treatment differences have yet to be analyzed; however, preliminary data without significance are shown.

Results:

2010. Quercus shumardii had the highest root dry mass from the RM pots in the RRG and from 3 gallon pots outside (Figure 1). Type of environment also influenced growth of *Quercus* in 2010; those grown in the RRG had larger root masses in comparison to the trees grown in the respective pots outside (Figure 1). *Gleditsia* did not behave similar to *Quercus*; there was a pot type x environment interaction. *Gleditsia* grown in the RRG had the highest root masses from the RA pots, while those grown outside benefitted the best from the RM pots. When comparing environments, *G. triacanthos* var. *inermis* was on average taller and had more root biomass in grams when grown in the RRG, but caliper and shoot biomass in grams were larger when grown outside (data not shown).

2011. There were very few differences in height and caliper between environments when averaged over pot types for *Gleditsia* and *Plantanus* in 2011 (Figures 3 and 4). For *Gleditsia*, averaged over environments, those grown in the 3-gallon pots had the greatest heights, while *Platanus* grew the best from Jiffy pots (Figure 5). For caliper growth, *Platanus* again had the greatest growth from the Jiffy pots, while the *Gleditsia* had the best caliper from the 3-gallon pots (Figure 6).

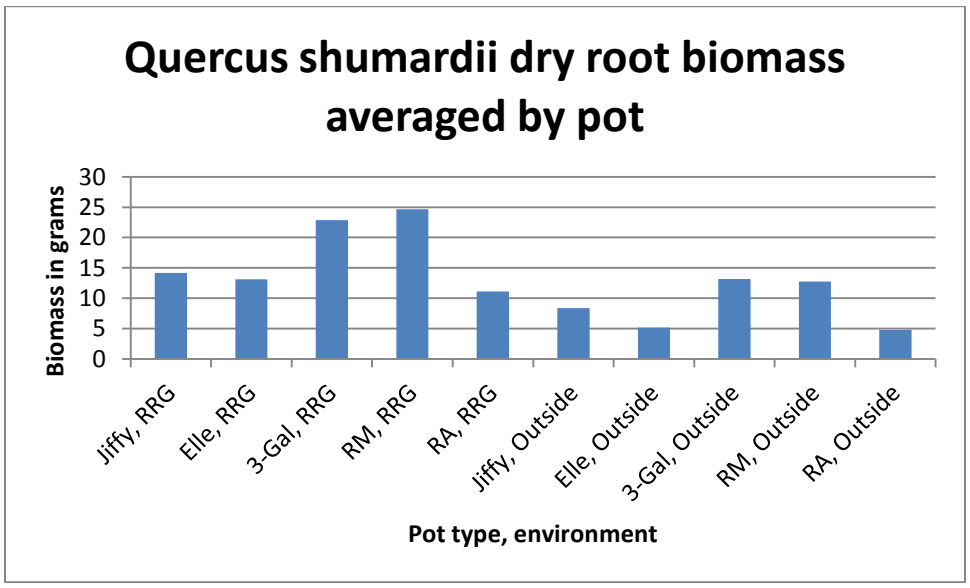
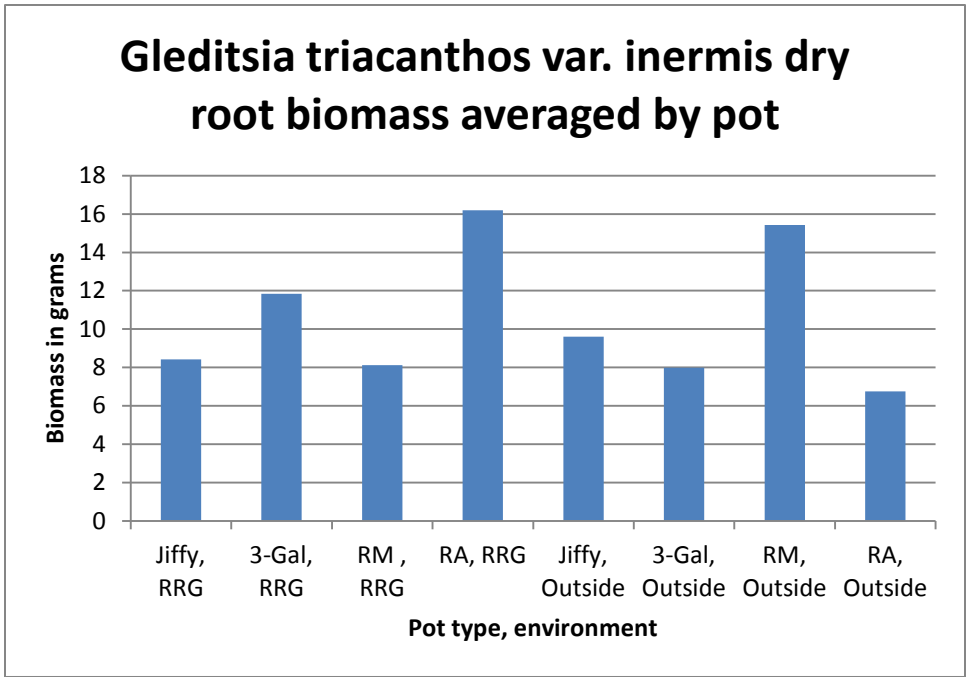


Figure 1 (above) and 2 (below): Reported biomass averaged by species within each environment using Minitab. Abbreviations are as follows: 3 Gal; 3 Gallon. B RM; 'Big Rootmaker', the only Rootmaker used in 2010. Jif; Jiffy pot. L RAC; Root Accelerator.



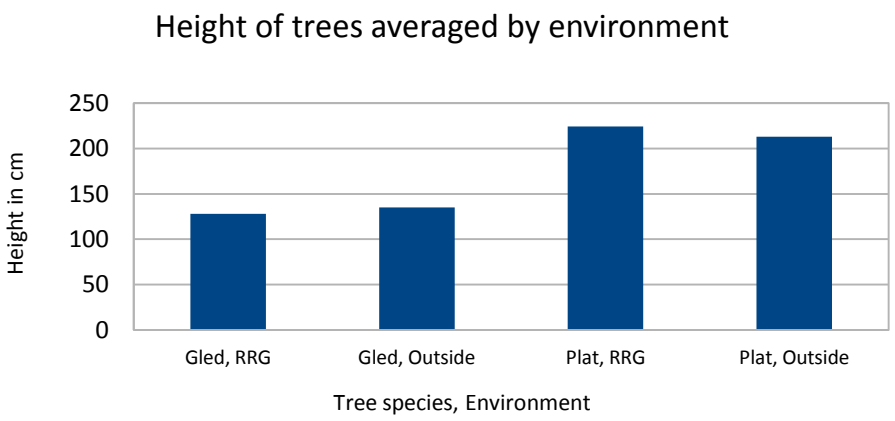
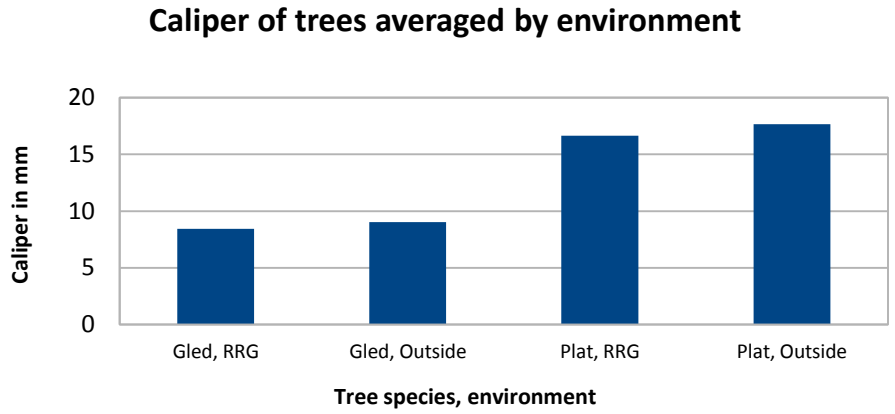


Figure 4: Reported heights are averaged by species within each environment during 2011. Abreviations are as follows: Gled; *Gleditsia triacanthos* var. *inermis*. Plat; *Platanus occidentalis*. RRG – Retractable Roof Greenhouse.



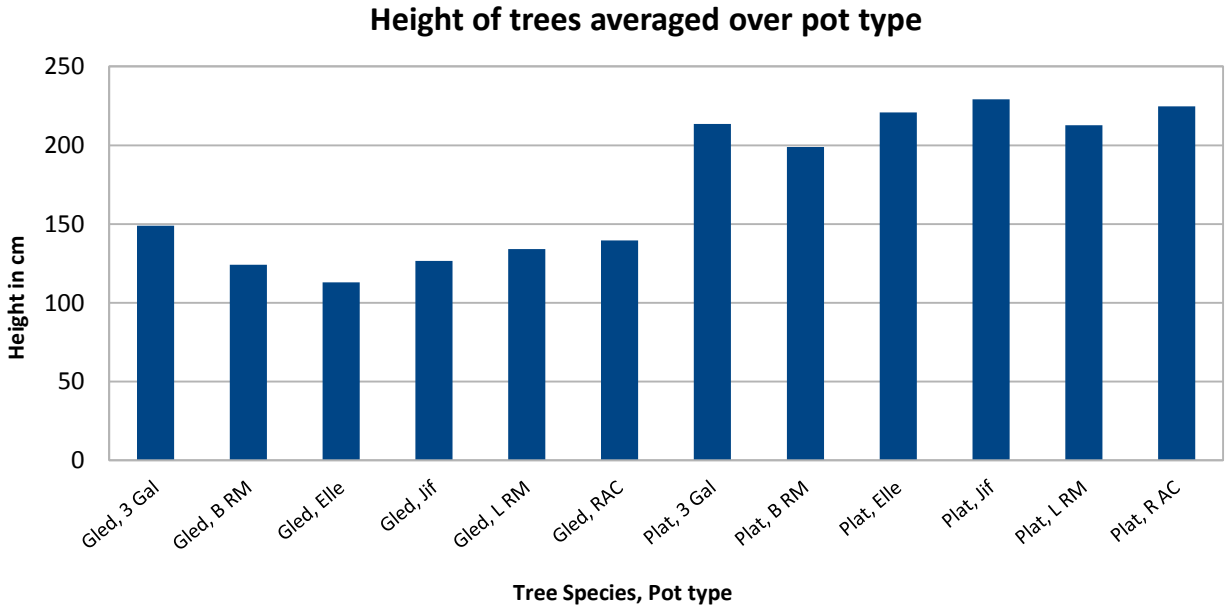


Figure 5: Reported heights are averaged by species within pot type during 2011. Abbreviations are as follows: Gled; *Gleditsia triacanthos* var. *inermis*. Plat; *Platanus occidentalis*. 3 Gal; 3 Gallon. B RM; 'Big Rootmaker'. Jif; Jiffy pot. L RM; 'Little Rootmaker'. RAC; Root Accelerator.

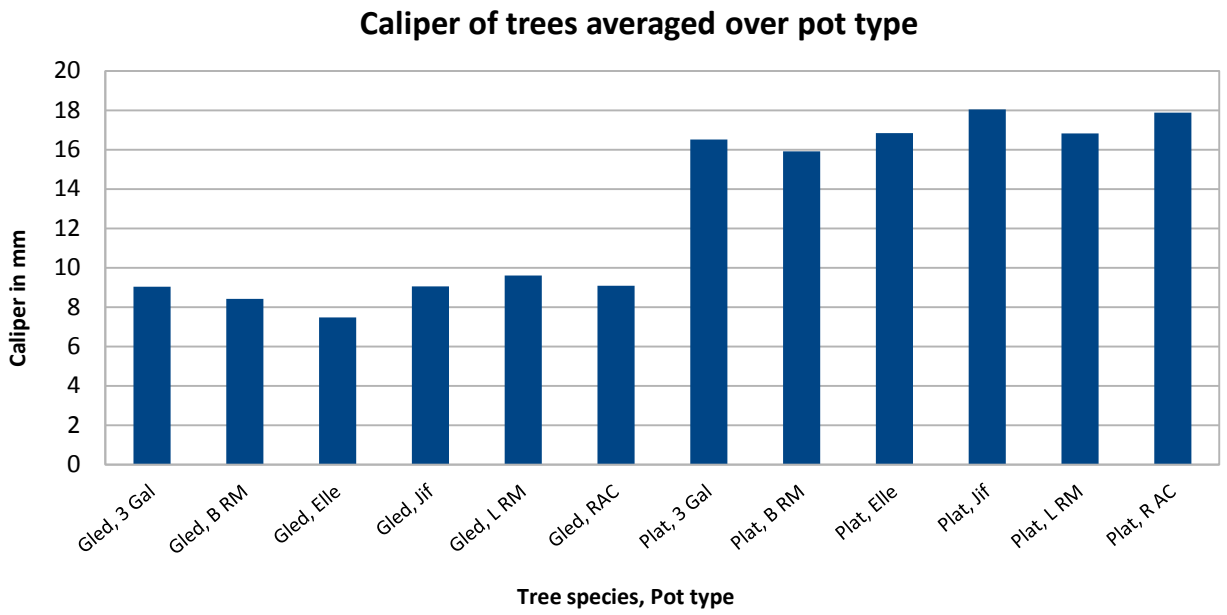


Figure 6: Reported calipers are averaged by species within pot type using Minitab. Error bars are Standard Error. Abreviations are as follows: Gled; *Gleditsia triacanthos* var. *inermis*. Plat; *Platanus occidentalis*. 3 Gal; 3 Gallon. B RM; 'Big Rootmaker'. Jif; Jiffy pot. L RM; 'Little Rootmaker'. RAC; Root Accelerator.