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Final Performance Report

February 1, 2012

Title: ADRESSING FOREMOST WEED CONTROL ISSUES FOR THE MICHIGAN NURSERY AND LANDSCAPE INDUSTRIES

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Contracting of this project with:

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Project Summary*:*

Initial purpose: New weed control methods that are effective, economical and have reduced environmental impact are required. Access to the latest herbicides and comprehension of up to date practices and systems are essential to ensure the economic survival of the Michigan nursery and landscape industry. The main purpose of this 2010-11 Specialty Crop Block Grant (SCBG) project was to build on the previous SCBG by evaluating a variety of preemergence herbicides alone, or in combination, to control the problematic weed species identified in2009-10 without causing phytotoxicity to commonly grown MI nursery crops.

Timeliness: Weed control is becoming even more important in this economy as growers are looking to cut costs, hold crops longer and reduce labor. In addition, bio-rationale and alternative control programs are of increasing interest to nursery growers.

Build on previous funding: In the previous SCBG funded in 2009-10 we conducted propagule bank research at MI nurseries. We identified major weeds that were inadequately controlled with then current herbicide programs. In addition, we found that the standard weed control programs were actually increasing weed populations of difficult weed species by releasing them from competition from other weeds. The 2010-11 SCGB enhanced the previous work by demonstrating that four new herbicides can be used in rotation or as replacements for standard herbicides to accomplish the purpose of this grant in containers and field: 1) indaziflam (registered as Alion® in citrus, tree nut, grapes, pome and stone fruit) (Bayer Corp. Monheim, Germany) at 0.11 lb ai/ac; 2) dimethenamid-p (Tower) + Pendulum (BASF Corp., Florham Park, NJ) at 0.97 + 2.0 lb ai/ac, respectively; 3) oxyfluorfen + prodiamine, (Biathalon) (OHP, Inc., Mainland, PA) at 2.75 lb ai/ac; and, 4) sulfentrazone + prodiamine (F6875, registered as Echelon in turf) (FMC Corp., Fresno, CA) granular and liquid formulations at 0.375 lb ai/ac. In addition we identified three chemicals with potential to control liverwort with no to minimal crop damage: 1) Flumioxazin, (SureGuard), (Valent BioSciences Corp., Libertyville, IL) at 4 oz/ac (1/3 or normal rate); 2) 20% acetic acid (WeedPharm™) (Pharm Solutions Inc., Port Townsend, WA) at 10% v/v); and, 3) sodium bicarbonate (Baking soda) applied as a dusting (per Northland Farms, West Olive, MI). Baking soda is not registered for moss control. However, further work with rates and application methods are planned in the 2012 SCBG to have this product added to IR-4 protocols in 2013.

Project Approach:

Before this project, the four new products indaziflam, Tower + Pendulum, Biathalon and F6875 were not used in MI nurseries. Herbicide active ingredients and modes of action must be rotated to prevent herbicide-resistant weed populations from developing. These four new herbicides not only represent new active ingredients but most importantly new modes of action for MI nursery growers. We are actively advocating rotating (as a result of this SCBG) the Tower + Pendulum combination with SureGuard and Gallery/Barricade for field weed control. Each of the three host nurseries for the 2010-11 SCBG weed control trials [Berryhill Family of Nurseries (BFN), Grand Haven, MI (BFN, formerly Zelenka Nursery), Spring Meadow Nursery, Inc., Grand Haven, MI and Northland Farms Nursery, LLC, West Olive, MI) contributed in-kind donations of plant materials, facilities for herbicide testing (such as nursery fields, polyhouses and container yards), plant material maintenance and supplies (such as fertilizer, insecticides, pots and media) totaling approximately $4,000 per site. They also absorbed any costs regarding plant damage or losses caused by herbicides being tested at their sites. Two of the sites (BFN and Northland Farms) also served as hosts for a bus tour on August 17, 2011 highlighting this SCBG project.

A. Goals and Outcomes Achieved:

Accomplishing Objectives 1, 2 and 3: Preemergence herbicide efficacy, phytotoxicity and control of liverworts:

Three cooperating nurseries were selected as sites for the liverwort control studies; two were located near Grand Haven, MI (BFN and Spring Meadow Nursery, Inc) and one in West Olive, MI (Northland Farms). Phytotoxicity and efficacy evaluations were conducted. 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'). Phytotoxicity at Spring Meadow was studied on 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™ (Ammonium nononanoate) at 10% v/v, SureGuard (flumioxazin) at 4 oz/ac, GreenMatch (d-limonene) (an extract of lemon grass) at 20% v/v, Bryophyter (Oregano Oil Extract) at 2% v/v, WeedPharm (20% acetic acid) 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 applied at Spring Meadow Nursery. The granular form has larger pellets than the more common form used for baking purposes. Terracyte Pro G (Sodium carbonate peroxyhydrate) at 10 lb/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 weeks after initial treatment (WAIT). Phytotoxicity was evaluated on a scale of 0-10 with 0 being no phytotoxicity and 10 death and ≤3 commercially acceptable. Efficacy was evaluated on a scale of 0-10 with 0 being no control, 10 perfect control and ≥7 commercially acceptable.

Results and discussion.

Efficacy. Marchantia polymorpha L., a thalloid liverwort is a common plant pest in nursery and greenhouse production systems. The rapid growth and dissemination of this pest can result in heavy thallus mats on the surface of pots that restrict water penetration, compete for nutrients, and provide habitat for other pests and disease vectors. To date, there are no registered products that are used by nursery growers for effective liverwort control in enclosed structures. Lack of registered control products leaves growers with few options beyond hand removal for liverwort. The labor costs for hand removal are prohibitive for most nurseries in the current economy. Insecticide and fungicide sprays are needed to reduce populations of fungus gnats (*Bradysia* spp.), snails (e.g. *Helix* spp.), slugs (e.g. *Deroceras* spp.), *Fusarium* spp., and *Pythium* spp. (Svenson et al., 1997) that are harbored by the thallus mat that develops on the container surface. Additional costs associated with production losses from these pests also occur. The impediment to water and nutrient infiltration into the root zone reduces growth and value of the crop (Svenson et al., 1997). The result of this diversion is higher water and fertilizer demand, which translates to greater production costs, reduced productivity, and adverse environmental impacts. A fourth impact of liverwort is realized once a potted crop reaches marketable size. The presence of liverwort is considered unsightly and is often taken as an indication of reduced quality or plant vigor, all of which impacts the final valuation of the crop. An estimated $650,000 is lost annually in MI nurseries due to ineffective liverwort control. The losses are highest at propagation nurseries, such as Spring Meadow Nursery, Inc. (personnel communication). In this SCBG, all treatments tested provided some level of control of liverwort in enclosed structures compared to the untreated pots at each location; however, due to the control achieved by the WeedPharm at Spring Meadow, vinegar has become their new standard control practice, representing $60,000 in annual savings due to reduced weed costs, lower production costs and less cull of crop plants. Variability existed with other products between sites (Tables 1-3) due to environmental differences and species being controlled.

At BFN, daytime temperatures were generally around 60 °F (heated greenhouse) with high relative humidity. At Spring Meadow, daytime temperatures were generally around 65-70 °F (heated greenhouse) with moderate relative humidity. At Northland Farms, daytime temperatures were generally around 50-55 °F (supplemental heated hoop house) with high relative humidity. Spring Meadow sells most of their product as propagated material requiring higher temperatures for production. 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 began to die off in part due to competition of water and nutrients from the crop. By the end of the experiment, even the untreated controls 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- 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. The quickness of the herbicide is somewhat inversely related to the amount of residual control the product provides. Tower is the slowest acting herbicide, and control increased gradually until the end of the experiment at each location. However, it did not provide acceptable ratings at any of the evaluations even when two applications at BFN and Northland Farms were applied (Tables 1 - 2). SureGuard was applied only once, and by 4 WAIT provided commercially acceptable ratings at each location for the duration of the experiment (Tables 1-3). 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). Liverwort came back very quickly after applications of Racer and appeared to be even more abundant than the original infestation before the initial application (Fig. 1). An increase in nitrogen from the ammonium in Racer may have occurred stimulating an increase in liverwort growth. GreenMatch was not reapplied; however, visual ratings at BFN indicate that a reapplication was 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 provides excellent control of liverwort (Tables 1-3). The baking soda treatment was a suggestion made by some Michigan growers at the Weed Control Workshop held in West Olive, MI in February, 2011. Application rate was unknown. We used different rates at each location. It was determined that only a "dusting" (as used at Northland Farms) was required for control. A dusting provided at least four weeks of control (Table 3). In further studies in 2012, the rate that approximates "a dusting" and various application methods will be evaluated so that sodium bicarbonate or similar products can be added to IR-4 protocols.

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 after application. Normal use rates over ornamentals are 8-12 oz/ac, but because the product is so efficacious on liverwort, the use rate could be reduced to 4 oz/ac. This was also done to reduce phytotoxicity issues to the crop plants. 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 at the time SureGuard was applied. Those that had broken dormancy were severely injured or even killed, while those that had not broken dormancy were not injured at all (Table 1, Fig. 2A). The higher visual ratings in comparison to the control are because there are more dead plants in the SureGuard treated flats. The dormancy requirement at application can also be seen with 'My Monet' weigela at BFN (Fig. 2B) (normally SureGuard is injurious to weigela, see Table 2), and hosta and barberry at Northland Farms (Table 3). There was 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 bud break or to species that have just leafed out, and this was 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. 3). 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 of a 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 but also caused phytotoxicity. More research needs to be conducted with SureGuard in relation to dormant applications. One advantage of using SureGuard is that it controls other weed species as a preemergence herbicide. Many of the products tested in these trials have no preemergence efficacy. 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 was also the least phytotoxic of the “contact” herbicides to Dappled willow, ‘Black Lace’ 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 that a rate can be established and phytotoxicity can be determined for more species.

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 lb/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 lb/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 lb/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	

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 lb/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 lb/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).

Fig. 1. Racer over top of Hydrangea 'Forever pink' at 2 weeks after 2nd application. Notice abundance of liverwort.

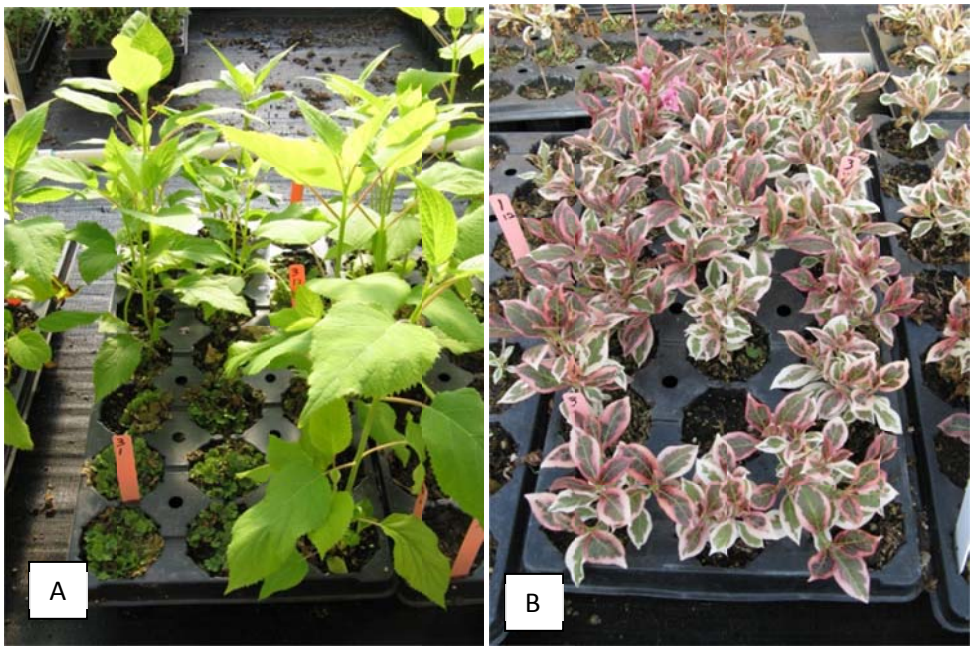

Fig. 2 A and B. A. SureGuard over top of hydrangea 'Annabelle' at 9 weeks after treatment. Injury only occurred to plants that had broken dormancy. At this point, liverwort had started to come back. **B.** SureGuard over 'My Monet' weigela at BFN at 9 WAT with no phytotoxicity and looking better even than the control.

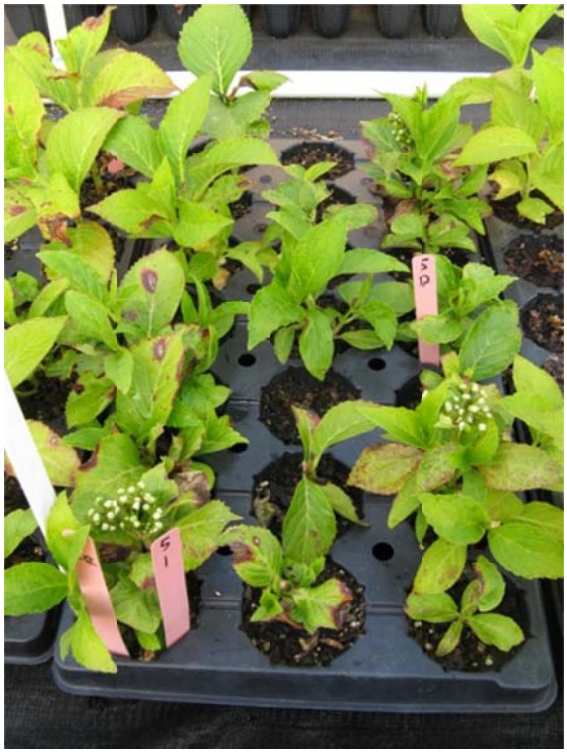

Fig. 3. Terracyte Pro G over hydrangea 'Forever pink' at 5 WAT. Spotting and leaf necrosis on edges of leaves contribute to phytotoxicity ratings above commercially acceptable.

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 lb/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 lb/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).

B. Goals and Outcomes Achieved:

Accomplishing Objective 1, 2 and 3: Preemergence herbicide efficacy, phytotoxicity and specific weeds in MI container and field nurseries:

Three cooperating nurseries located near Grand Haven, MI were selected as sites for the container and field 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 (dimethenamid-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 nozzle 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 nozzle 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 nozzle 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 4 for all results discussed below for the container grown portion of these trials.

2011 Container evaluations

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* (Fig. 7A and 8).

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 (Fig. 7B).

Echinacea purpurea. *Echinacea* is one genus that has relatively few herbicides labeled; this genus is very sensitive to many herbicides. FreeHand was tested on *Echinacea purpurea* 'Magnus' at Northland Farms (Fig. 4A). 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 (Fig. 4A).

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 (Fig. 4B). 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 (Fig. 5 A). 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 (Fig. 5 B); 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 (Fig. 5B). 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. 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.

Table 4. 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).

Table 4, 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).

Table 4, 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.

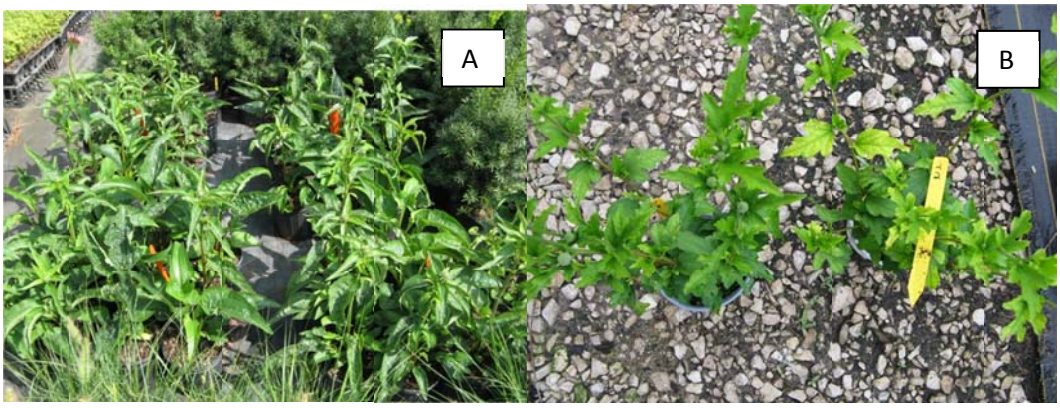

Fig. 4 A and B: A. Damage to *Echinacea purpurea* 'Magnus from FreeHand at Northland Farms showing typical point of contact leaf puckering of a mitosis inhibitor mode of action herbicide with most plants growing out of the injury by

4WA2T (Table 4). Rates going clockwise from top left: 4X, 2X, 1X, Untreated control. **B.** Damage to *Hibiscus* 'Chiffon China from Snapshot at Spring Meadow Nursery showing typical injury from a cell wall inhibitor mode of action herbicide (the isoxaben or Gallery portion of the Snapshot) of random leaf and partial leaf chlorosis. Notice yellowing of leaves on plant on the right in comparison to control on left.

Fig. 5 A and B: A. Damage from FreeHand on 'City of Vienna' Hydrangea again a mitosis inhibitor mode of action herbicide stunting and leaf distortion. Untreated is on left followed by 1X, 2X, and 4X rates, respectively. **B.** Damage from 2X rate of Indaziflam on left 'Forever and Ever' Hydrangea in comparison to untreated control, right top view at BFN 2WA1T.

Fig. 6. Damage from 0.11, and 0.44 lb ai/ac of Indaziflam compared to untreated control, left on 'Forever and Ever' Hydrangea at BFN 2WA2T showing the random and partial leaf chlorosis and shortened internodes typical of a cellulose inhibitor herbicide.

Fig. 7. A and B: A. Gallery injury on Buddleia davidii 'Nanho Blue' at BFN 4WA1T at the 1X rate of typically mottling and random leaf chlorosis of a cell wall inhibitor herbicide. **B.** Certainty damage of Cornus 'Variegated' at 1X, 4X, 2X and control (from right to left) at Northland Farms 2WA1T. The damage is typical of an ALS inhibitor herbicide of meristem death and stunting. Death is slow with an ALS herbicide by 4WA2T also all the 4X and 60 to 50% of the 1x and 2X rate plants were dead.

Fig. 8. Gallery injury on *Buddleia davidii* 'Royal Red' at Northland Farm 4WA1T at the 4X, control, 1X and 2X rates (left to right). By the end of the trial 80% of the 4X plants were dead and 50% of the 1X and 2X plants.

2011 Field Trials. Refer to Table 5 for all results discussed below for the field grown portion of these trials.

Tower was applied over *Taxus* 'Hicksii' and 'Runyon' at Northland Farms with no injury at any rate on either cultivar (Fig. 11). A combination of Tower + Pendulum was applied at BFN over *Potentilla* 'Mckays White', *Prunus glandulosa, Forsythia* 'Lynwood Gold', and *Lilac* 'Common purple' as a dormant application with no phytotoxicity to any cultivar and at any evaluation date or rate tested (Fig. 9). The combination of Tower + Pendulum is a welcome addition to weed control programs over these species as dormant applications and the two herbicides together picked up control of a very

difficult species Kik (Fig. 10 A and B). 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 (2010 OSU Yearly Research Summary Reports) with no phytotoxicity. Tower alone was also applied over *Syringa* and *Forsythia* at BFN as a dormant spray with no phytotoxicity (Table 5).

Table 5. Phytotoxicity visual ratings of several species of field grown ornamentals to selected herbicides a Michigan nurseries.

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

Fig. 9. *Forsythia* 'Lynwood Gold' 8WAT indicating no injury from a Tower + pendulum application at BFN.

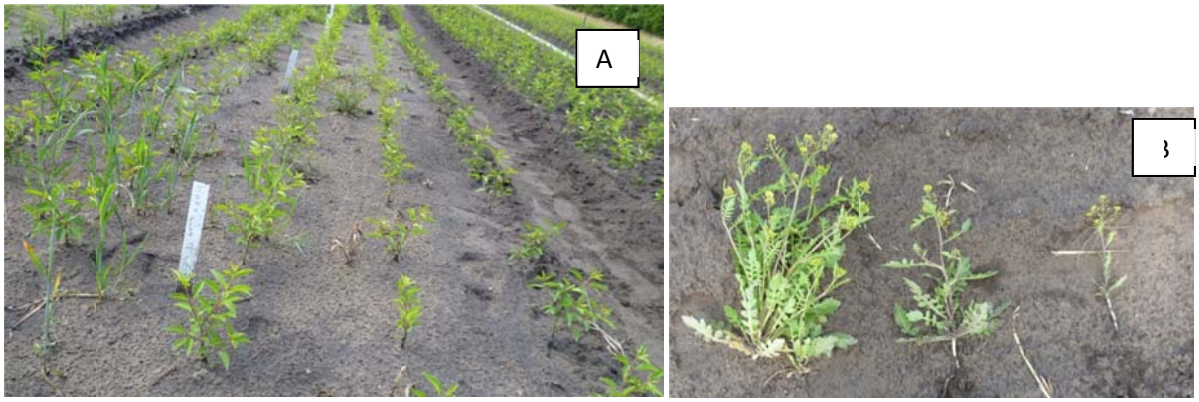

Fig. 10 A and B: ***A.*** *Forsythia* 'Lynwood Gold' 8WAT indicating no injury from a Tower + pendulum application foreground and Tower second stake (background) at BFN. The herbicides were applied to the two rows on the right hand side of liner bed planting. A nurse crop of rye grass is planted at the nursery each fall to prevent sand blasting of the plants during the winter. The control of the grass is evident with Tower and the Tower + pendulum aqua cap. **B.** To pick up control of the *Rorippa sylvestris (*Creeping Yellow Field Cress or Kik) the pendulum had to be added to the Tower.

Fig. 11. No damage with Tower with two cultivars of *Taxus* at Northland Farms.

Beneficiaries

There was two weed workshop organized in West Olive and Ann Arbor, MI in February 2011 over 130 MI nursery growers attend these workshops which offered 24 hours of contact time regarding weed control issues and information gathered from this SCBG.

Listed below in table 6 and 7 are 28 presentations that were given to various international (in blue), national and regional audiences regarding weed control during 2011. Over 1447 people benefited from 18 out-of-state presentations provided to groups ranging from professional association (ASHS), government organizations (USDA/ IR-4), industry supply companies (BFG), five nursery grower trade associations (Michigan Nursery and Landscape Association, Oregon Association of Nurseries, Landscape Alberta Nursery Trades Association, Saskatchewan Nursery and Landscape Association and MD, DC, and VA Landscape Contractors Association. In addition nine presentations were provided to MI Nursery growers via Michigan State University Extension organized bus tour or workshops (Table 6). 2075 people benefited from this SCBG by attending 10 in-state presentations in 2011 regarding weed control. The groups benefiting from these presentations ranged from professional associations such as Ohio Turfgrass Foundation and the Ohio Nursery and Landscape Association, industry supply companies BASF and BPS, private nurseries and Master Gardeners. Quantitative data is listed in Table 6 and 7. The qualitative data regarding these outreach efforts is indicated by the large number of attendees and programs offered. In addition to the economic impact rendered to each group sponsoring the programs, growers and landscapers attending receive information regarding new herbicides to rotate with existing herbicides but also alternative control methods. If each of the 3522 people who attend presentations regarding this SCBG in 2011 got only one new idea, weed control approach or new herbicide out of each program we estimate the impact of this SCBG to be $3,552,000.00. However, this is a conservative estimate and the real impact is probably more like 6 Mn.

Table 6. List of Extension Presentations Out-of-State by Dr. Hannah Mathers associated with this SCBG:

Nov. 18, 2011	Speaker (100%)	Edmonton, AB	Landscape Alberta Nursery Trades Association. *Landscape Weed Control: More Bite to Bark*	Industry	1.0	75	75	Invited	Provincial
October 5, 2011	Speaker (100%)	Sacramento, CA	USDA/IR-4 Ornamental program Meeting. *Crop Safety IR-4 Update in Nursery*	USDA-IR4	0.25	60	15	Invited	International
Sept. 27, 2011	Co-Speaker (50%) Res. Assoc. pres.	Waikelea, Hawaii	American Society for Horticultural Science Annual Conference. *Phytotoxicity effects of several liverwort products.*	Professional Society	0.25	30	7.5		National
Sept. 26, 2011	Speaker (100%)	Waikelea, Hawaii	American Society for Horticultural Science Annual Conference. *Bioherbicide treated mulches.*	Professional Society	0.25	30	15		International
August 30, 2011	Speaker (100%)	Minneapolis, MN	BFG Supply Co. Horticulture Expo. *Nursery Weed Control*	Industry	1.0	15	15	Invited	Multi-state
August 25,	Speaker	Portland, OR	Oregon Association of	Industry	1.0	250	170	Invited	International

2011	(100%)		Nurseries, Farwest Show Seminars. *Environmentally Friendly: Alternative Container Weed Control*						
August 17, 2011	Speaker (100%)	West Olive, MI	MSUE Bus Tour of Weed Research Trials: *Trial Report at Northland Farms*	University	0.25	42	10.5	Invited	State
August 17, 2011	Speaker (100%)	Grand Haven, MI	MSUE Bus Tour of Weed Research Trials: *Trials at BFN*	University	0.25	42	10.5	Invited	State
July 7, 2011	Speaker (100%)	West Olive, MI	2011 Summer Nursery Discussions: *Weed control update for nurseries*	University	1.5	35	53	Invited	State
March 17, 2011	Speaker (100%)	Saskatoon, SK, Canada	Saskatchewan Nursery and Landscape Association (SNLA*). Landscape Weed Control: More* Bite to Bark	Industry	1.0	65	65	Invited	Regional
February 24, 2011	Speaker (100%)	Chevy Chase, MD	Pesticide Recertification Conference. MD, DC, and VA Landscape Contractors Association. *Going Greener*	Industry	0.75	375	281	Invited	Multi-state
February 15, 2011	Speaker (100%)	Ann Arbor, MI	MSUE – East MI Weed Workshop. *Nursery Field Weed Control*	University	1.0	30	30	Invited	Multi-state
February 15, 2011	Speaker (100%)	Ann Arbor, MI	MSUE – East MI Weed Workshop. *Alternative Ornamental Weed Control*	University	1.0	30	30	Invited	Multi-state
February 14, 2011	Speaker (100%)	West Olive, MI	MSUE – West MI Weed Workshop. *Nursery Field Weed Control*	University	1.0	96	96	Invited	Multi-state
February 14, 2011	Speaker (100%)	West Olive, MI	MSUE – West MI Weed Workshop. *Alternative Ornamental Weed Control*	University	1.0	96	96	Invited	Multi-state
February 10, 2011	Speaker (100%)	Ann Arbor, MI	MSUE – East MI Weed Workshop. *Container Weed Control*	University	1.0	30	30	Invited	Multi-state
February 9, 2011	Speaker (100%)	West Olive, MI	MSUE – West MI Weed Workshop. *Container Weed Control*	University	1.0	96	96	Invited	Multi-state
January 10, 2011	Speaker (100%)	Grand Rapids, MI	Great Lakes Trade Exposition. MNLA. *All Gods Weeds: Vascular and Non-Vascular*	Industry	1.0	50	50	Invited	Multi-state

Table 7. List of Extension Presentations In -State by Dr. Hannah Mathers associated with this SCBG:

December 7, 2011	Speaker (100%)	Columbus, OH	Ohio Turfgrass Foundation (OTF). *Landscape Bed Weed Control: What's New!*	Industry	1.0	120	120	Invited	Multi-state
Sept. 28, 2011	Speaker (100%)	Avon, OH	Willowbrook Nursery. *Crop Safety Update in Nursery*	Industry	1.0	50	50	Invited	State
Sept. 15, 2011	Speaker (100%)	Mentor, OH	BASF Nursery Meeting: *Weed Control Update*	Industry	1.0	60	60	Invited	State
March 9, 2011	Speaker (100%)	Akron, OH	OSU Extension and ODA Recertification Conference 2010, Columbus Conference Center, *Landscape Weed Control.*	University/ ODA	0.5	300	150	Invited	State
March 2, 2011	Speaker (100%)	Akron, OH	OSU Extension and ODA Recertification Conference 2010, Akron Conference Center, *Landscape Weed Control.*	University/ ODA	0.5	420	210	Invited	State
March 1, 2011	Speaker (100%)	Lancaster, OH	Master Gardeners, FairField, Co. *Traditional and*	University Extension	1.0	20	20	Invited	Local

			Non-traditional weed control						
February 18, 2011	Speaker (100%)	Columbus, OH	Buckeye Power Sales (BPS) Turf Clinic. *Managing and Controlling Weeds in Landscape Ornamentals with Herbicides*	Industry	1.0	65	65	Invited	State
February 16, 2011	Speaker (100%)	Dayton, OH	OSU Extension and ODA Recertification Conference 2010, Dayton Conference Center, *Landscape Weed Control.*	University/ ODA	0.5	420	210	Invited	State
January 25, 2011	Co-Speaker (100%)	Columbus, OH	2010 OSU Nursery Short Course. ONLA. *Environmentally Friendly Alternative Herbicides"*	University	1.0	200	100	Co-chair	International
January 11, 2011	Speaker (100%)	Sandusky, OH	OSU Extension and ODA Recertification Conference 2010, Kalahari Conference Center, Sandusky, OH. *Landscape Weed Control.*	University/ ODA	0.5	420	210	Invited	State

Lessons Learned

One unexpected result has been the tremendous response and interest in weed control that this project has generated. Many additional nurseries in MI have wanted to conduct on-site trials and a similar program has been started for 2012 in Ohio nurseries. The approach of conducting trials at the nurseries and providing first-hand exposure to a diverse audience of nursery employees regarding the importance of alternating herbicide chemistries, participation in the IR-4 program and the need for label expansion, targeted control practices specific to their weeds and crops, new products available in the industry, and bio-rationale and alternative approaches has been a tremendous success. The response has been so strong that one negative outcome has been our inability to keep up for the demand either for the on-site trials or for the extension of the information. In future proposals to SCBG we will try to learn from the demand by budgeting for additional people to help conduct the trials. Another unexpected result has been the development of herbicide injury pictures and symptoms by mode of action of herbicides and illustrating how few alternative modes of actions are available in the ornamental industry. We also learned we were ambitious for objective four regarding bark cracking. No nurseries were willing to submit their trees to glyphosate applications knowing it would cause loss of a saleable tree. Therefore, we had to set up a trial at Ohio State University, since the experiment requires caliper trees, the trees planted in 2011 need to grow for at least one more year before treatments can be applied. We will report on our progress with this objective in the 2012-13 final report.

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Expenses for reimbursement

Date	Activity	Hotel	Salary	Mileage	Meals	Total
Summer 2011	Advance to MESS from MNLA					**$ 5,000.00**
Jan. 7 and 8, 2011	Presentation at GLTE and grower discussions	Pd. 3rd party	$1640.00	Pd. 3rd party	Pd. 3rd party	$1640.00
Feb. 24, 2011	Trial initiation	2 rooms 147.77 X 2 = $295.54	$3280.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	80.00	$3995.54
Mar 3, 2011	1 WAT evaluation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
Mar. 10, 2011	2 WAT evaluation	1 room X 80.00 = $80.00	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2110.00
Mar. 24, 2011	4 WAT evaluation and 2nd application initiation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids	50.00	$2030.00

				and Grand Haven, MI		
Mar. 31, 2011	2nd application 1 WAT evaluation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
April 7, 2011	2nd application 2 WAT evaluation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
April 21, 2011	2nd application 4 WAT evaluation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
Data analyses, reporting re liverworts		N/A	$2720.00	N/A	N/A	$2720.00
Sub-total for Liverwort trials		**$375.54**	**$17,480.00**	**$2380.00**	**$380.00**	**$20615.54**
Feb. 9 and 10, 2011	Weed Workshop (West Olive, MI and Ann Arbor, MI)	2 rooms X 90.00 X 2 nights = $360.00	$3280.00	705.12 miles x 0.50 = $352.56	$65.00	$4057.56
Feb. 14 and	Weed	2 rooms	$3280.00	705.12	$65.00	$4057.56

15, 2011	Workshop (West Olive, MI and Ann Arbor, MI)	X 90.00 X 2 nights = $360.00		miles x 0.50 = $352.56		
May 20, 2011	Trial initiation	2 rooms X 85.00 X 2 nights = $340.00	$3280.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	80.00	$4040.00
May 26, 2011	1 WAT evaluation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
June 2, 2011	2 WAT evaluation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
June 16, 2011	4 WAT evaluation	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
June 30, 2011	6 WA1T and	1 room	$3280.00	340.00 X	80.00	$3820.00

	2nd application	X 120.00 = $120.00		2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI		
July 6 and 7, 2011	1 WA2T – AM MSU extension presentation to growers - PM	1 room X 120.00 X 2 nights = $240.00	$3280.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	80.00	$3940.00
July 14, 2011	2 WA2T	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
July 28, 2011	4 WA2T	N/A	$1640.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	50.00	$2030.00
August 16 and 17, 2011	MSU Extension Bus Tour	2 rooms X 80.00 X 1 night = $160.00	$5280.00 (preparation time included)	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and	80.00	$5860.00

				Grand Haven, MI		
Sub-total of container and field preemergence trials		**$1580.00**	**$29,880.00**	**$3765.12**	**$700.00**	**$35925.12**
Sept. 14-15, 2011	Collection of soil samples, evaluations and counting collected at two nurseries and wild areas	2 rooms X 85.00 X 2 nights = $340.00	$3280.00	340.00 X 2 X 0.50 = *$340.00* to Grand Rapids and Grand Haven, MI	80.00	$4040.00
Sept. 14-15, 2011	Potting of soil samples, evaluations and counting collected at two nurseries and wild areas	N/A	$3280.00	N/A	N/A	$3280.00
Nov. 19-23, 2011	Technical draft	N/A	$ 3,200.00	N/A	N/A	3200.00
January 10, 23, 30, and February 1, 2012	Report writing	N/A	$ 2939.34	N/A	N/A	2939.34
Sub-total of sampling, analyses and report writing		**$340.00**	**$12699.34**	**340.00**	**80.00**	**$13,459.34**
Sub Total MESS Summer Advance	Planning meetings with growers (3 days)	4 nights X 160.00 =	$3,560.00	$680.00	$120.00	**$ 5,000.00**

	January 9-11	$640.00				
Grand Total		**$2935.54**	**$63,619.34**	**$7,165.12**	**1,280.00**	**$75,000.00**

Payable: $75,000.00

$ 5,000.00 – payable to Michigan Nursery and Landscape Association for advance given MESS
$ 20,000.00 -- payable to Hannah Mathers, Mathers Environmental Science Services
$ 20,000.00 -- payable to James Beaver, Mathers Environmental Science Services
$ 30,000.00 -- payable to Ohio State University