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Final Performance Report

February 1, 2013

Title: MAJOR WEED CONTROL ISSUES IN MICHIGAN NURSERIES

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Contracting of this project with:

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Project Summary*:*

Initial purpose: With Michigan nurseries geographically unique weed problems, weed with high reproductive potential and biomass production have been found through previous years of SCBG research. Estimates of 30,000 lb. /ac of weeds removed in hand weeding operations taking 1200 man hours/ac, at a cost of $18,000 have been calculated. Effective preemergence herbicide applications have been shown to cut these costs by 66% to $6,000/ac. Further research with difficult weed species such as Kik, marestail, mugwort and wild garlic is required to reduce these costs further and deplete the seed bank. Objectives of this proposal were to help growers understand what their current weed control program is really costing, how to decrease their weed control costs but increase their success, and why cutting weed control should be the last consideration for reducing production costs in these challenging economic times.

Timeliness: Sustainability is a common phrase in agriculture and horticulture today. Although the word sustainable often conjures thoughts of organic operations – this project focused on bio-rationale approaches with synthetic herbicides with the evaluation of new herbicides that have extended efficacy and require minimal applications. We also focused the project on other sustainable weed management features such as what causes nursery weed problems, what weeds growers had, an integrated system of prevention and bio-controls (especially for liverwort problems). Principles of crop rotation, herbicide rotation and MoAs, cover cropping, weed seed bank management, allelopathy and most fundamental good soil quality, fertility and drainage for a competitive crop have also been stressed in all presentations and literature that has come out of the project. We also emphasized what is not sustainable such as over use and misuse of postemergence herbicides. This project has been very timely as there is little research conducted in ornamental sustainable weed management although public pressure is requiring the nursery and landscape industries to use more sustainable practices.

Build on previous funding: Due to previous SCBG projects funded in 2009-10 and 2010-11 and now 2011-12, we were able to provide data to assist in the registration of two new herbicides for the ornamental industry. In addition to the registration of these

two new product we showed growers the utilization of indaziflam (registered January 2013, as Marengo (OHP, Inc., Mainland, PA) at 0.11 lb. ai/ac and oxyfluorfen + prodiamine (registered as Biathlon) (OHP) at 2.75 lb. ai/ac in field and container operations as extended efficacy products and replacements to less sustainable preemergence herbicides currently used. In addition we also built on our research from previous SCBGs in liverwort control and were able to expand our research with sodium bicarbonate (Baking soda) to explore potassium bi-carbonate applied as a dust application, show it superior efficacy to anything currently on the market and submit an invention disclosure in 2012. The development of this new control has already generated tremendous demand inside and outside MI and would have never been discovered without these MI SCBGs.

Project Approach:

One hundred and fifty-seven trials were conducted in MI in 2012 at the three sites listed above, 75 liverwort, 59 container in-season and 23 field trials. Before this project, MI Nurseries had never used Biathlon or Indaziflam commercially. Indaziflam not only represents a new active ingredient but most importantly a little used mode of action for MI nursery growers. As a result of this project and building on past SCGBs we are actively advocating rotating Tower + Pendulum combination with SureGuard and Gallery/Barricade (Indaziflam) 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 in August, 2012 highlighting this SCBG project.

A. Goals and Outcomes Achieved:

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

Marchantia polymorpha L. (a thalloid liverwort) is a common plant pest in nursery and greenhouse production systems and one of the major weed issues we are addressing in this Specialty Crop Block Grant (SCBG). 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. It is estimated $650,000 is lost annually in MI nurseries due to ineffective liverwort control. In MI, the rapid growth and dissemination of liverwort has resulted in heavy thallus mats on the surface of pots, restricting water penetration, competing for nutrients, and providing 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. In our past SCBG we have also examined liverwort controls and found in the 2010-11 SCBG that Baking Soda (sodium bicarbonate) had potential for control and 1/3 the normal rates of

SureGuard (flumioxazin, Valent U.S.A.) reduced phytotoxicity to the crop experienced at the full rate but still controlled liverwort. In this 2012 SCBG, we have evaluated SureGuard at ¼ the normal rate in an attempt to reduce phytotoxicity further but maintain liverwort control. We have also examined MilStop® (Potassium Bicarbonate 85%, BioWorks®, Victor, NY) because it is similar chemically to Baking Soda but may have potential to be registered as a herbicide; whereas, Baking Soda (a household product) may not.

We have identified SureGuard at 3 oz./ac (1/4 normal rate); WeedPharm™ (20% acetic acid) at 10% v/v (Pharm Solutions Inc., Port Townsend, WA), MilStop® (5 g/ ft^2) and Baking soda applied as a dusting (2.24 g/ ft^2)(per Northland Farms, West Olive, MI) can all be effective in controlling liverwort. However, WeedPharm will cause phytotoxicity as will SureGuard if not applied dormant. MilStop® is an OMRI listed sprayed broad spectrum fungicide (with **no** registration as an herbicide). Used as a spray MilStop® was non-effective for liverwort control. Baking soda is not registered for moss control. However, applications made at Northland Farms with a handheld crop duster (Fig. 1 A-C) were very efficacious with no phytotoxicity noted. The duster used at Northland Farms is quite old (Fig. 1. C); however, it is similar to a Dustin Mizer (Nitron Industries) that will be used in subsequent trials. Further work with rates of MilStop® and Baking Soda are warranted from this trial. Application made by hand at 10g/ ft^2 of Baking Soda at Spring Meadow Nursery were 4.5 times higher and far more phytotoxic than the duster application method at Northland Farms.

Fig.1 A. Application of Baking Soda with Duster at 2.24g/ ft ^{2} Northland Farms, MI Feb. 7, 2012

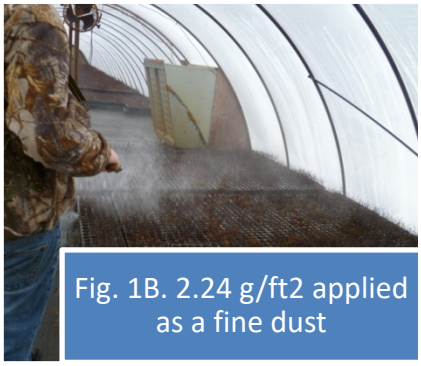

Fig. 1B. 2.24 g/ft2 applied as a fine dust

Fig. 1C. Baking Soda - 10g/ ft ^{2} Spring meadow Nursery, MI, Feb. 7, 2012

Fig.1D. Duster used at Northland Farms, MI

Liverwort product efficacy and phytotoxicity trials were initiated on dormant plant material on 7 February, 2012 at two nurseries; Spring Meadow Nursery, Grand Haven, MI (Fig. 2A) in a heated open-roof greenhouse (60°F) and Northland Farms, West Olive, MI (Fig. 2B) in an unheated polyhouse (34°F). Data has been collected from 3 evaluations; 1, 2, and 4 WAT (weeks after treatment). At Spring Meadow Nursery, treatments included MilStop® at 2.5 lb./100 gallons applied as a spray, MilStop® applied as a powder at 2.5 tsp./flat (5g/ft^2), SureGuard (flumioxazin, Valent U.S.A., Walnut Creek, CA) at two rates; 3 oz./ac (1/4 rate) and 4 oz./ac (1/3 rate), WeedPharm™ (Pharm Solutions, Inc., Port Townsend, WA) at two rates 5% and 10% v/v and baking soda at 10 gram/ft^2. The MilStop® powder application rate was calculated to apply a similar amount of product as applied for the registered fungicide spray rate. At Northland farms, treatments included SureGuard at 3 oz./ac (1/4 rate), WeedPharm™ at 5%, MilStop® at 5 gram/ft^2 and baking soda applied at 2.24 grams/ft^2 with a crop duster (Fig. 1D.). Liquids were applied in a spray volume of 100 gal/ac delivered with a CO_2 backpack sprayer equipped with 8003XR nozzles (Teejet, Inc., Wheaton, IL). All treatments were watered in according to IR-4 protocols within four hours after application.

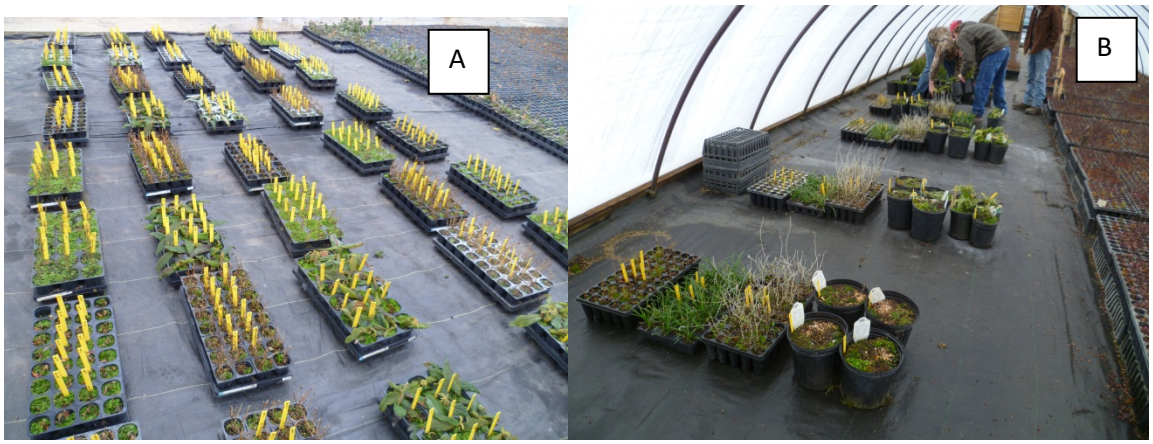

Fig. 2 (A and B). **A.** Liverwort trial initiation at Spring Meadow Nursery, Grand Haven, MI on Feb. 7, 2012 on dormant plants in trays of 4" containers of various species. **B.** Liverwort trial initiation at Northland Farms, West Olive, MI on Feb. 7, 2012 on dormant plants in trays of 2 1/4", 1 and 3 gallon containers of various species.

At Spring Meadow Nursery phytotoxicity was evaluated using hydrangea (*Hydrangea* 'Invincibelle spirit'), winterberry (*Ilex verticillata* 'Winter red'), dwarf burning bush (*Euonymus alata* 'Unforgettable fire'), lilac (*Syringa patula* 'Miss Kim') and viburnum (*Viburnum rhytidophyllum* 'Cree'). Viburnum and Hydrangea are key species we identified in our objectives to utilize in this SCBG. At Northland Farms phytotoxicity included hosta (*Hosta* 'Halcyon'), Autumn fern (*Dryopteris erythrosora*), liriope (*Liriope spicata*), Russian sage (*Perovskia atriplicifolia)*, and Dwarf Korean lilac (*Syringa meyeri* 'Palibin'). Only the fern and liriope will be discussed as the hosta, Lilac and the Russian sage had not broken dormancy when this report was compiled.

Evaluations of control and phytotoxicity were taken at 1 WA1T, 2 WA1T, 4 WA1T, 1 WA2T (weeks after second treatment), 2 WA2T, and 4 WA2T. Phytotoxicity visual ratings were based on a 0-10 scale with 0 being no phytotoxicity, 10 death and ≤3 commercially acceptable. Liverwort control ratings were based on a 0-10 scale with 0 being no control, 10 perfect control and ≥7 commercially acceptable. The trials were set up in a completely randomized design for each species with 12 replications /treatment at Spring Meadow and 4 replications /treatment at Northland Farms. For phytotoxicity, treatments were compared to the untreated control using Dunnett's t-test with $\alpha = 0.05$ and 0.10. For liverwort control, treatment means were separated using lsmeans with $\alpha = 0.05$. Statistics were analyzed using SAS® software using the Proc Mixed method.

Liverwort control. All treatments with the exception of the MilStop® applied as a liquid provided some level of liverwort control (Table 1). MilStop® is marketed as a fungicide when applied as a liquid at the tested rates, and in this trial, it was not an effective treatment to control liverwort. On the contrary, when MilStop® is applied without water, right out of the bag, it controlled liverwort very well (Table 1) (Fig. 3 A and B). MilStop® in its granule form has an inhalation hazard and is NOT labeled to be applied in this form. WeedPharm™ will control liverwort; both at 5% and 10%, with the 10% solution having better control, but in most cases the two are not significantly different from each other. From this trial, the 5% solution would be a better choice, especially in terms of economics. However, with WeedPharm™, just like many other "contact" control herbicides, thorough coverage is necessary, and whenever the liverwort was covered by plant foliage, control decreased. WeedPharm™ also seems to work better under higher temperatures, as seen with the differences between Spring Meadow and Northland Farms (Table 1), and from the first application to the second application at Northland Farms (Table1). Although baking soda does not have a label for weed control, a few nurseries use it for liverwort control, and thus we added to the trial.

Baking soda provides exceptionally liverwort control (Fig. 4B), although residual is limited. SureGuard has shown to control liverwort in previous SCBGs. The IR-4 protocol suggested using a rate of 4 oz. /ac; a rate. The 3 oz. /ac was added in this SCBG trial. In terms of control, the two rates were *not* significantly different from each other at any evaluation (Table 1). SureGuard is slow to control liverwort but is the only product we have tested that provides residual control for liverwort (Table 1). For this reason it remains of high interest in these SCGB grant evaluations.

Phytotoxicity. All species were dormant at the first application at Spring Meadow, and all but *Dryopteris* and *Liriope* were dormant at Northland Farms (NF) at the first application. Thus, there are no ratings for the first two evaluations except for those two species at NF (Table 2). When applied at 10 g/ft^2, baking soda is phytotoxic to all five of the species tested at Spring Meadow Nursery (Table 2). However, when applied at 2.2 g/ft^2, phytotoxicity was only noticed on *Liriope* at Northland Farms, and the damage was still commercially acceptable (Fig. 4A). After the first application, SureGuard at both rates provided significant damage on only *Hydrangea* and *Ilex* at Spring Meadow, but the damage was still commercially acceptable (Table 2). The damage that SureGuard provided at both rates after the second application is quite noticeable in many of the

species tested (Table 2), which provides evidence that SureGuard may be applied as a dormant application on many species that are normally injured by SureGuard when applied during the growing period. Even after the second application, SureGuard did not injure *Viburnum* or *Dryopteris* at the 3 or 4 oz. rate. When applied as a liquid, MilStop® provided no real damage on any of the species tested at Spring Meadow, which is not surprising. MilStop® did cause damage to 6 of the 10 species tested when applied as a granular (Table 2). Baking Soda was phytotoxic on active growth with 8 of 10 species. WeedPharm caused significant damage, with the higher rate causing more damage than the lower rate (Table 2). *Dryopteris* and *Viburnum* were the only species not significantly damaged by WeedPharm™. WeedPharm™ is acetic acid, which causes leaf burning, but eventually many plants will grow out of the damage if not too severe.

From these trials, it can be concluded that when applied as a dormant application, SureGuard can be an effective product for control of liverwort with a lasting residual when applied at 3 or 4 oz. /ac. Lower rates should be evaluated. Residual control at these lower rates may not last as long with higher rates; however, they provided exceptional control of the life of these evaluations. SureGuard should NOT be applied to actively growing material unless the species is already on the product label as safe. MilStop® and baking soda are two other materials that warrant further consideration for liverwort control. However, both products are not currently labeled, so any application would be considered off label. MilStop® also has some applicator exposure issues as a granular formulation, so this would also have to be taken into consideration. However, both products are very effective for liverwort control, and further research is needed for MilStop® to get a good rate for lowered phytotoxicity. At approximately 2 g/ft^2, baking soda is quite effective with low phytotoxicity, but more species need to be tested at this rate. WeedPharm™ could also be applied to many species in the dormant stage, but even at 5%, it will cause leaf burning on many crop species. The trial also provided evidence that liverwort infestations do cause growth reduction due to the thick thallus mat (Fig.5 B) and thus control is important (Fig. 5A).

Table 1. Liverwort control from various products at Spring Meadow Nursery and Northland Farms near Grand Haven, MI.

Spring Meadow							
Treatment	Rate	1 WAT[z]	2 WAT	4 WAT	1 WA2T	2 WA2T	4 WA2T
Baking Soda	10 g/ft^2	9.6[yx] a	9.6 ab	9.8 a	10.0 a	10.0 a	10.0 a
MilStop	2.5 lbs./100 gal	4.0 c	4.1 c	4.8 c	4.6 b	5.1 b	4.5 b
SureGuard	3 oz./ac	6.7 b	8.5 b	10.0 a	10.0 a	10.0 a	10.0 a
SureGuard	4 oz./ac	6.3 b	8.6 b	9.9 a	10.0 a	10.0 a	10.0 a
WeedPharm	5%	9.0 a	8.8 b	7.9 b	9.2 a	9.3 a	9.1 a
WeedPharm	10%	9.7 a	9.8 a	9.3 a	10.0 a	9.9 a	9.7 a
MilStop	2.5 tbsp./flat	9.8 a	9.9 a	9.3 a	9.9 a	10.0 a	9.6 a
Untreated	--	3.5 c	3.2 c	3.9 d	4.5 b	4.6 b	4.6 b
Northland Farms							
Treatment	Rate	1 WAT	2 WAT	4 WAT	1 WA2T	2 WA2T	4 WA2T
SureGuard	3 oz./ac	5.3 cd	5.9 b	7.2 b	8.2 a	8.4 a	9.1 a

WeedPharm	5% v/v	6.8	bc	6.6	b	7.9	b	9.2	a	9.0	a	8.8	a
MilStop	5 g/ft^2	9.8	a	9.8	a	9.5	a	9.1	a	9.5	a	9.6	a
Baking Soda	2.2 g/ft^2	8.0	ab	8.5	a	7.9	b	5.2	b	5.1	b	--	
Untreated	--	3.7	d	3.5	c	3.2	c	2.0	c	2.1	c	1.5	b

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

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

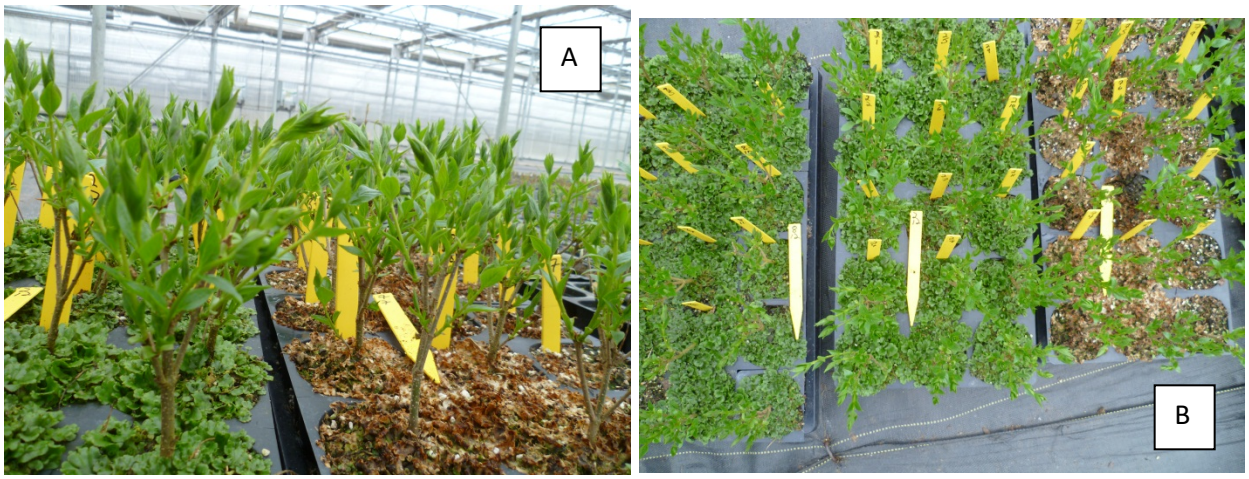

Fig. 3. (A and B). **A.** Side view of liverwort control with Dwarf Korean lilac (*Syringa meyeri* 'Palibin') at Spring Meadow Nursery at 2WAT left to right, MilStop® spray (2.5 lb./100 gallons) treatment and MilStop® powder (5g/ft^2) treatment. **B.** Top view of liverwort control with Dwarf Korean lilac (*Syringa meyeri* 'Palibin') at Spring Meadow Nursery at 2WAT left to right, Control, MilStop® spray and MilStop® powder.

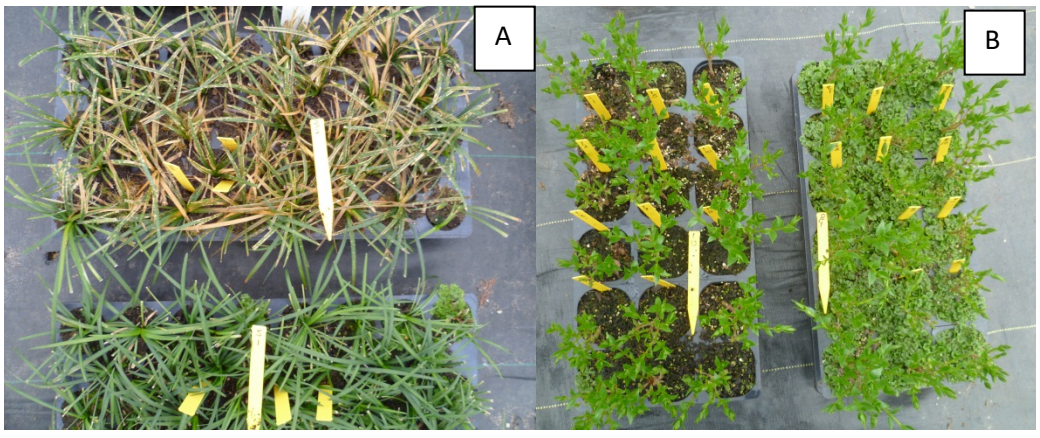

Fig. 4 A. Liriope (*Liriope spicata*) at Northland Farms 2 WAT showing contact burn symptoms from MilStop® powder application (top) versus control (bottom). **B.** Baking soda application at 10 g/ ft^2 at Spring Meadow Nursery 2WAT on Dwarf Korean lilac (*Syringa meyeri* 'Palibin') (left) versus control (right).

Table 2. Phytotoxicity of several ornamental species from various liverwort control products at two nurseries near Grand Haven, MI.

Hydrangea 'Invincibelle Spirit'							
Treatment	Rate	1 WAT[z]	2 WAT	4 WAT	1 WA2T	2 WA2T	4 WA2T
Baking Soda	10 g/ft^2	--	--	7.8[yx] **	7.8 **	8.3 **	8.7 **
MilStop	2.5 lbs./100 gal	--	--	0.1	2.9 *	2.3	0.0
SureGuard	3 oz./ac	--	--	2.4	6.2 **	9.5 **	9.6 **
SureGuard	4 oz./ac	--	--	2.9 *	5.7 **	9.3 **	8.2 **
WeedPharm	5%	--	--	1.0	4.6 **	4.5	1.3
WeedPharm	10%	--	--	1.2	4.3 **	3.7	3.0 **
MilStop	2.5 tbsp./flat	--	--	1.0	3.0 **	3.9	2.2 **
Untreated	--	--	--	0.8	0.8	2.8	0.0
Ilex verticillata 'Winter red'							
Treatment	Rate	1 WAT	2 WAT	4 WAT	1 WA2T	2 WA2T	4 WA2T
Baking Soda	10 g/ft^2	--	--	3.0 **	4.3 **	4.9 **	4.5 *
MilStop	2.5 lbs./100 gal	--	--	1.9 *	4.4 **	4.0 **	2.2 **
SureGuard	3 oz./ac	--	--	2.0 *	5.4 **	9.9 **	7.2
SureGuard	4 oz./ac	--	--	1.9 *	5.9 **	9.7 **	6.2
WeedPharm	5%	--	--	0.4	4.7 **	4.8 **	4.5 *
WeedPharm	10%	--	--	1.3	4.9 **	4.8 **	7.3
MilStop	2.5 tbsp./flat	--	--	3.3 **	4.7 **	4.6 **	7.7
Untreated	--	--	--	0.0	0.1	1.8	7.9
Viburnum rhytidophyllum 'Cree'							
Treatment	Rate	1 WAT	2 WAT	4 WAT	1 WA2T	2 WA2T	4 WA2T
Baking Soda	10 g/ft^2	--	--	10.0	8.9	--	10.0 **
MilStop	2.5 lbs./100 gal	--	--	0.0	1.5 **	--	0.6 **
SureGuard	3 oz./ac	--	--	4.3	6.9	--	7.1
SureGuard	4 oz./ac	--	--	6.0	6.4	--	6.5
WeedPharm	5%	--	--	4.0	5.8	--	5.7
WeedPharm	10%	--	--	4.8	7.3	--	7.1
MilStop	2.5 tbsp./flat	--	--	--	8.7	--	9.2
Untreated	--	--	--	5.0	5.8	--	5.9
Euonymus 'Unforgettable fire'							
Treatment	Rate	1 WAT	2 WAT	4 WAT	1 WA2T	2 WA2T	4 WA2T
Baking Soda	10 g/ft^2	--	--	4.7	4.4 **	4.3 **	5.3 **
MilStop	2.5 lbs./100 gal	--	--	3.5	0.1 **	2.3 **	3.3
SureGuard	3 oz./ac	--	--	4.3	7.4	7.7	8.8 **
SureGuard	4 oz./ac	--	--	4.4	6.4	6.8	9.5 **
WeedPharm	5%	--	--	1.9	5.3 **	5.2 **	4.3
WeedPharm	10%	--	--	4.3	7.8	7.9	4.3
MilStop	2.5 tbsp./flat	--	--	4.8	7.1	7.0	4.2
Untreated	--	--	--	3.7	8.8	9.0	2.9
Syringa patula 'Miss Kim'							
Treatment	Rate	1 WAT	2 WAT	4 WAT	1 WA2T	2 WA2T	4 WA2T

Baking Soda	10 g/ft^2	--		--		0.0		3.7	**	4.8	**	8.4	**
MilStop	2.5 lbs./100 gal	--		--		2.8	**	0.9		1.8	*	1.5	
SureGuard	3 oz./ac	--		--		0.0		4.8	**	9.0	**	6.0	**
SureGuard	4 oz./ac	--		--		0.0		5.2	**	9.0	**	6.3	**
WeedPharm	5%	--		--		0.0		0.0		3.5	**	3.0	**
WeedPharm	10%	--		--		0.8	*	3.8	**	5.4	**	5.0	**
MilStop	2.5 tbsp./flat	--		--		0.0		1.3		1.3		0.2	
Untreated	--	--		--		0.0		0.0		0.0		0.0	
Hosta 'Halcyon'													
Treatment	Rate	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
SureGuard	3 oz./ac	--		--		--		3.3	**	3.5	**	5.0	**
WeedPharm	5% v/v	--		--		--		4.0	**	3.0	**	2.0	
MilStop	5 g/ft2	--		--		--		3.0	**	2.8	**	2.8	
Baking Soda	2.2 g/ft2	--		--		--		0.0		0.0		--	
Untreated	--	--		--		--		0.0		0.3		0.8	
Dryopteris erythrosora Autumn Fern													
Treatment	Rate	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
SureGuard	3 oz./ac	0.0		0.0		0.0		0.8		1.5		3.0	
WeedPharm	5% v/v	0.8		1.3		2.3		2.8		2.3		0.8	
MilStop	5 g/ft2	3.0	**	2.8	**	5.3	**	5.0	**	5.0	*	6.3	**
Baking Soda	2.2 g/ft2	0.3		0.5		2.3		1.3		0.3		--	
Untreated	--	0.0		0.0		2.0		1.5		2.0		2.0	
Perovskia atriplicifolia Russian sage													
Treatment	Rate	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
SureGuard	3 oz./ac	--		--		--		5.8	*	7.3		6.5	*
WeedPharm	5% v/v	--		--		--		7.0	**	6.5		6.0	*
MilStop	5 g/ft2	--		--		--		8.5	**	8.3		5.0	
Baking Soda	2.2 g/ft2	--		--		--		0.0		2.5		--	
Untreated	--	--		--		--		0.0		2.5		0.0	
Liriope spicata													
Treatment	Rate	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
SureGuard	3 oz./ac	0.0		0.0		0.0		4.5	**	4.3	**	4.0	**
WeedPharm	5% v/v	0.0		0.0		0.0		2.8	*	3.5	**	3.0	*
MilStop	5 g/ft2	5.5	**	7.5	**	6.8	**	5.8	**	5.8	**	6.3	**
Baking Soda	2.2 g/ft2	1.5		2.8	**	1.8	**	1.0		2.0		--	
Untreated	--	0.0		0.0		0.0		0.0		0.0		0.0	
Syringa meyeri 'Palibin'													
Treatment	Rate	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
SureGuard	3 oz./ac	--		--		--		7.5	**	9.8	**	9.8	**
WeedPharm	5% v/v	--		--		--		4.3	**	6.0	**	5.3	**
MilStop	5 g/ft2	--		--		--		3.3	**	3.0	**	2.5	**
Baking Soda	2.2 g/ft2	--		--		--		0.0		0.0		--	

Untreated	--	--		--		--		0.0		0.0		0.0	
z = WAT: weeks after first treatment; WA2T: weeks after second treatment													
y = Phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable													
x = Treatment means followed by *,** are significantly different from the control, based on Dunnett's t-test (α = 0.10 and 0.05, respectively)													

Fig. 5 (A and B). A. SureGuard at 3 oz. /ac (left) compared to the untreated control (left) showing a dramatic decrease in growth caused by the liverwort infestation 10 WAT on *Hydrangea* Invincibelle Spirit.' **B.** The thick thallus mat of a liverwort infestation is the cause of the growth reduction.

Accomplishing Objectives 1, 2 and 3: Preemergence herbicide efficacy, phytotoxicity from in-season container and field nursery trials:

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, containerized and field trials were carried out, while at Spring Meadow and Northland Farms, only containerized trials were performed. The trade and common names and manufacturers of the herbicides used are as follows: Tower (dimethenamid-p) + Pendulum (pendimethalin, BASF Corp.), FreeHand (dimethenamid-p + pendimethalin, BASF Corp.), Biathlon (oxyfluorfen + prodiamine, OHP, Inc.), F6875SC (sulfentrazone +prodiamine, FMC), Gallery (isoxaben, Dow Agro Sciences + Barricade (prodiamine, Syngenta), SureGuard 51 WDG (flumioxazin, Valent U.S.A) + Surflan (oryzalin, Dow Agro Sciences) and Indaziflam G (Bayer Corp.). Phytotoxicity evaluations were performed at 1 WA1T (week after first treatment), 2 WA1T, 4 WA1T, 1 WA2T (weeks after second treatment), 2 WA2T, and 4WA2T. 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 20 gal/ac using nozzles delivering 0.15 gal/ min/ nozzle and the nozzle spacing at 12 inches. Field plots included 3X 3 ft. areas for liner beds in each replication, with 4 replications/ rate for each variety.

For the containerized portion at BFN, species selected included: daylily, (*Hemerocallis* 'Stella d'Oro'), elderberry (*Sambucus nigra* Blacklace™), barberry (*Berberis thunbergii* 'Crimson Pygmy'), purple coneflower (*Echinacea purpurea* 'Purple Magnus'), and euonymus (*Euonymus fortunei* 'Emerald & Gold'). The species selected for the field trial at BFN included common lilac (*Syringa* 'Common Purple') and compact euonymus (*Euonymus alatus* 'Compacta'). For the containerized portion at Northland Farms, species selected included daylily (*Hemerocallis* 'Stella d'Oro'), elderberry (*Sambucus nigra* Blacklace™), barberry (*Berberis thunbergii* 'Crimson Pygmy'), purple coneflower (*Echinacea purpurea* 'Purple Magnus'), and euonymus (*Euonymus fortunei* 'Emerald & Gold'). Species selected at Spring Meadow included rose (*Rosa* 'Home Run RED'), barberry (*Berberis thunbergii* Sunjoy® Gold Beret *'Talago'),* azalea *Azalea* Bloom-a-thon® Pink Double and viburnum (*Viburnum* Red Balloon™ 'Redell').

Herbicides selected for the containerized portion included: Indaziflam (Bayer Corp.) at 0.11, 0.22, and 0.44 lb. ai/ac on daylily; Tower + pendulum at 21 oz./ac + 2qt/ ac on daylily and viburnum; Gallery + Barricade at 1.0 lb. ai/ac + 0.66 lb. ai/ac on daylily, euonymus, elderberry and coneflower; FreeHand at 2.65, 5.3, and 10.6 lb. ai/ac on elderberry, viburnum, azalea and coneflower; Biathlon at 2.75 lb. ai/ac on azalea, coneflower, daylily and viburnum and F6875 at 0.375, 0.75, 1.5 lb. ai/ac on barberry, euonymus and daylily. The containerized trials were initiated on March 27, 2012 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 one-gallon trade pots at BFN and Northland Farms and at Spring Meadow 4 inch pots were used.

Results and discussion.

Container trials: At BFN phytotoxicity occurred with *Berberis* 'Crimson pygmy' with F6875 1 and 2 WA1T at the 2X and 4X rate; however, the plants recovered from the injury by the end of the trial (Table 3 and Fig. 6).

Fig. 6. Damage from F6875 at 4X rate on *Berberis thunbergii* 'Crimson pygmy '2 WAT at BFN Nursery near Grand Haven, MI.

Injury also occurred on *Echinacea* 'Purple Magnus' with FreeHand at BFN and at Northland Farms. At Northland Farms the injury was just above commercially acceptable at the 4X rate 4WA2T (Table 3 and Fig. 7). At BFN the injury occurred after the second application at the 4X rate and at that time was just above commercially acceptable (Table 3). However, pictures taken during on August 12 of the BFN *Echinacea* indicated the stunting effect of the FreeHand had continued for the 3months after the trial ended with severe root stunting also occurring (Fig. 8). Damage also occurred to *Echinacea* with Gallery + Barricade at Northland Farms (Table 3) (Fig. 9). Although the plants were starting to grow out of the injury at 4WAT (Fig. 9 B) the second application increased the injury through to the end of the trial (Table 3). The products that caused no injury are included in Tables 3 and 6.

Fig. 7. (left) Leaf distortion from FreeHand at 600 lbs. / ac on *Echinacea* 'Purple Magnus' at Northland Farms at 4 WA2T. Picture by: Luke Case.

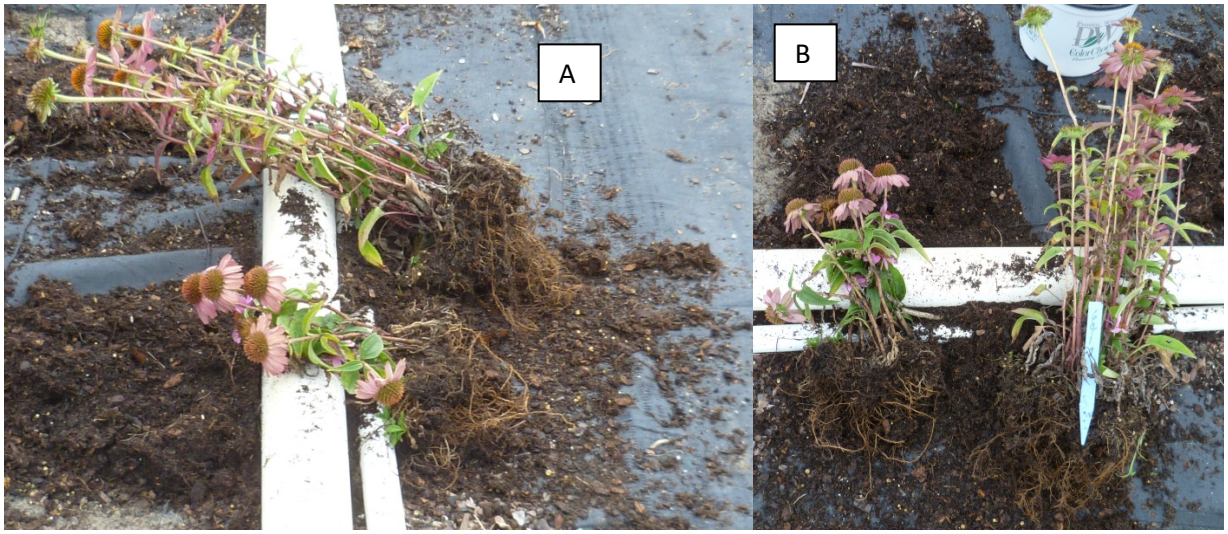

Fig. 8 (A and B). A. Side view of *Echinacea* 'Purple Magnus' at BFN, three months after the trial ended (August 12, 2012) showing severe root inhibition with FreeHand at the 4X rate (foreground) compared to the control (background). **B.** Front view of stunting caused by FreeHand at 4X rate (left) compared to the control (right). Pictures by: Hannah Mathers.

Fig. 9. (A and B). A. Damage from Gallery + Barricade at 1.0 lb. + 0.66 lb. ai/ac, respectively on *Echinacea* 'Purple Magnus' at Northland Farms at 2 WAT. **B.** Damage from Gallery + Barricade at 1.0 lb. + 0.66 lb. ai/ac, respectively on *Echinacea* 'Purple Magnus' at Northland Farms at 4 WAT. Picture A: Luke Case, Picture B: Hannah Mathers.

Hemerocallis was injured at BFN with Biathlon, Tower + Pendulum, Indaziflam at all rates and F6875 at all rates (Table 3). Hemerocallis was also injured at Northland Farms with Indaziflam at the 4X rate (Table 3). The injury from Biathlon, Tower + Pendulum and F6875 at 1 and 2X was transitory and no injury was present by the end of the trial (Table 3). However, the injury from indaziflam at all rates (Fig. 10) and F6875 at the 4X rate persisted (Table 3). The F6875 injury at the 4X rate was still apparent in August 2012 or 3 months after the trail ended (Fig. 11). The products that caused no injury are listed in Tables 3 and 6.

Fig. 10. Damage Indaziflam (left to right) control, 1X, 2X and 4X (800 lb. / ac) on *Hemerocallis* 'Stella d'Oro' at 4 WA2T at Northland Farms. Notice that the new leaves are yellow and drooping down. Picture by: H. Mathers

Fig. 11. (left) Damage on *Hemerocallis* 'Stella d'Oro' from F6875. Picture taken Aug. 12, 2012, three months after the trial ended. From front to back, control, 1X, 2X and 4X. Notice the severe stunting with the 4X rate. Picture by: Hannah Mathers.

Damage also occurred on azalea and viburnum at Spring Meadow from Tower + pendulum (Table 3). The damage on azalea (Fig. 12) was worse than on viburnum (Fig. 13). The products that caused no injury are included in Tables 3 and 6.

Fig. 12. (left) Tower + Pendulum at 21 oz. + 2 qtr. /ac, respectively, on *Azalea* 'Bloom-a-thon Pink Double' (right) vs. control (left) at Spring Meadow Nursery at 2 WAT.

Fig. 13. (left) Tower + Pendulum damage (left) compared to untreated (right) *Viburnum* x 'Red Balloon' at 21 oz. + 2 qtr. respectively at 2 WAT at Spring Meadow Nursery.

Table 3. Phytotoxicity from various herbicides on several ornamental species located at three nurseries near Grand Haven, MI

Sambucus 'Blacklace'

Treatment	Rate/ac	Location	1 WAT[z]		2 WAT		4 WAT	1 WA2T		2 WA2T		4 WA2T
FreeHand	150 lb.	BFN	0.0		0.0		0.0	0.0		2.2	**	0.0
FreeHand	300 lb.	BFN	0.3		0.2		0.0	1.8	**	2.6	**	0.0
FreeHand	600 lb.	BFN	0.3		0.2		0.5	0.0		0.4		0.0
Untreated	--	BFN	0.2		0.3		0.0	0.0		0.0		0.0

Berberis 'Crimson pygmy'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT	1 WA2T		2 WA2T		4 WA2T
F6875	0.375 lb. ai	BFN	1.9	**	1.1	**	--	1.2		0.4		0.3
F6875	0.75 lb. ai	BFN	3.0	**	2.5	**	--	1.6	**	1.0	**	0.3
F6875	1.5 lb. ai	BFN	3.7	**	3.5	**	--	2.8	**	2.4	**	0.6
Untreated	--	BFN	0.0		0.0		--	0.5		0.2		0.2

Echinacea 'Purple Magnus'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT	1 WA2T		2 WA2T		4 WA2T	
Biathlon	100 lb.	BFN	1.4		2.0	**	1.0	1.8		2.5	**	2.9	**
FreeHand	150 lb.	BFN	0.8		0.7		0.2	1.1		1.1		3.1	**
FreeHand	300 lb.	BFN	0.4		0.2		0.6	1.2		2.3	**	2.0	
FreeHand	600 lb.	BFN	1.3	*	0.5		0.5	3.3	**	3.3	**	3.2	**
Untreated	--	BFN	0.5		0.4		0.8	1.5		0.8		0.9	

Euonymus 'Emerald and Gold'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT	1 WA2T		2 WA2T		4 WA2T	
Gallery + Barricade	1 lb. ai + 0.66 lb. ai	BFN	0.0		0.0		1.0	0.0		0.2		3.0	**
F6875	0.375 lb. ai	BFN	0.2		0.3		0.2	0.6	**	0.8		0.0	
F6875	0.75 lb. ai	BFN	0.0		0.2		0.6	0.2		0.3		0.0	
F6875	1.5 lb. ai	BFN	0.4		0.1		0.5	1.5	**	1.6	**	0.3	
Untreated	--	BFN	0.2		0.1		0.8	0.0		0.0		0.1	

Hemerocallis 'Stella d'Oro'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
Biathlon	100 lb.	BFN	1.9	**	3.9	**	3.8	**	0.5		0.8	**	1.9	**
Tower + Pendulum	21 fl. oz. + 2 qtr.	BFN	5.4	**	5.0	**	3.9	**	0.5		1.5	**	0.3	
Gallery + Barricade	1 lb. ai + 0.66 lb. ai	BFN	0.6		0.3		0.0		0.0		0.2		0.4	
Indaziflam	200 lb.	BFN	0.8		3.3	**	3.1	**	0.0		0.1		1.5	**
Indaziflam	400 lb.	BFN	1.5	**	3.7	**	3.3	**	1.8	**	2.3	**	3.5	**
Indaziflam	800 lb.	BFN	1.5	**	3.7	**	3.8	**	3.0	**	3.7	**	4.0	**
F6875	0.375 lb. ai	BFN	5.5	**	4.9	**	3.8	**	1.4	**	1.7	**	2.5	**

F6875	0.75 lb. ai	BFN	5.9	**	5.2	**	3.7	**	2.6	**	2.9	**	2.9	**			
F6875	1.5 lb. ai	BFN	7.1	**	5.6	**	5.3	**	3.9	**	5.1	**	5.7	**			
Untreated	--	BFN	0.4		0.0		0.0		0.0		0.0		0.5				

Sambucus 'Blacklace'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T				
FreeHand	150 lb.	Northland Farms	0.0		0.3		0.2		0.3		0.0		0.7				
FreeHand	300 lb.	Northland Farms	0.0		0.1		0.3		0.7		2.8	**	0.4				
FreeHand	600 lb.	Northland Farms	0.0		0.1		1.3	**	2.0	**	2.3	**	2.3	**			
Gallery + Barricade	1 lb. ai + 0.66 lb. ai	Northland Farms	0.0		0.8	**	1.1	*	0.0		3.0	**	0.9				
Untreated	--	Northland Farms	0.0		0.1		0.0		0.0		0.0		0.0				

Echinacea 'Purple Magnus'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T				
Gallery + Barricade	1 lb. ai + 0.66 lb. ai	Northland Farms	4.4	**	4.4	**	3.5	**	6.8	**	7.7	**	4.2	**			
FreeHand	150 lb.	Northland Farms	0.5		0.5		1.0		1.2		2.3	**	2.0	**			
FreeHand	300 lb.	Northland Farms	0.8	**	1.0		2.3	**	1.8	**	4.6	**	2.3	**			
FreeHand	600 lb.	Northland Farms	0.3		1.0		2.4	**	1.6	**	2.4	**	3.2	**			
Untreated	--	Northland Farms	0.0		0.2		0.1		0.1		0.0		0.0				

Euonymus 'Emerald and Gold'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T				
F6875	0.375 lb. ai	Northland Farms	0.4		0.3		0.3		0.0		0.0		0.0				
F6875	0.75 lb. ai	Northland Farms	0.4		0.5		0.6		0.3		0.0		0.0				
F6875	1.5 lb. ai	Northland Farms	1.1	**	1.6	**	1.3	**	1.5	**	0.0		0.0				
Gallery + Barricade	1 lb. ai + 0.66 lb. ai	Northland Farms	0.2		0.2		0.5		0.2		0.0		0.0				
Untreated	--	Northland Farms	0.2		0.2		0.1		0.0		0.0		0.0				

Hemerocallis 'Stella d'Oro'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T				
Indaziflam	200 lb.	Northland Farms	0.2		3.2	**	2.7	**	1.6		1.0		1.4				
Indaziflam	400 lb.	Northland Farms	0.0		3.4	**	2.2	**	2.5	**	2.7	**	2.8	**			
Indaziflam	800 lb.	Northland Farms	0.5		4.3	**	2.8	**	3.7	**	4.4	**	5.0	**			

Gallery + Barricade	1 lb. ai + 0.66 lb. ai	Northland Farms	0.5		1.1		0.2		0.4		0.8		0.0	
Untreated	--	Northland Farms	0.4		0.3		0.2		0.3		0.0		0.0	

Berberis thunbergii SUNJOY Gold Beret ('Talago')

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
FreeHand	150 lb.	Spring Meadow	0.0		0.8		1.3		0.7		1.3		2.8	**
Untreated	--	Spring Meadow	0.0		1.5		1.9		1.0		0.8		0.0	

Rosa x HOME RUN RED ('WEKcisbako')

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
Indaziflam	200 lb.	Spring Meadow	0.7		3.1		2.4		0.9		0.0		0.2	
Untreated	--	Spring Meadow	0.3		3.4		2.5		0.4		0.0		0.2	

Viburnum x RED BALLOON ('Redell')

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
Biathlon	100 lb.	Spring Meadow	0.0		0.3		0.0		0.0		0.0		0.0	
Tower + Pendulum	21 fl. oz. + 2 qtr.	Spring Meadow	2.8	**	3.7	**	3.7	**	3.6	**	3.8	**	2.9	**
FreeHand	150 lb.	Spring Meadow	0.3		0.0		0.0		0.2		0.0		0.0	
Untreated	--	Spring Meadow	0.0		0.2		0.0		0.4		0.0		0.5	

Azalea 'BLOOM-A-THON Pink Double'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT		1 WA2T		2 WA2T		4 WA2T	
Biathlon	100 lb.	Spring Meadow	0.1		0.0		0.0		0.0		0.0		0.0	
Tower + Pendulum	21 fl. oz. + 2 qtr.	Spring Meadow	0.0		3.7	**	3.9	**	4.1	**	4.1	**	4.9	**
FreeHand	150 lb.	Spring Meadow	0.0		0.3		0.0		0.1		0.0		0.0	
Untreated	--	Spring Meadow	0.3		0.0		0.0		0.0		0.0		0.0	

z = WAT: weeks after first treatment; WA2T: weeks after second treatment
y = Phytotoxicity visual ratings based on a 0-10 scale with 0 being no phytotoxicity and 10 death with ≤3 commercially acceptable
x = Treatment means followed by *,** are significantly different from the control, based on Dunnett's t-test (α = 0.10 and 0.05, respectively)

Field trials. Due to frost events and cool, wet weather in the early part of the season, we were unable to start the filed evaluations until May, 2013. Due to the late start we were only able to evaluate the field trials until 4 WAT. No second applications were performed. Even with the short evaluation time, commercially acceptable weed control

was only evident with two products 4WAT, Tower + Pendulum and SureGuard + Surflan (Table 4). The similar control of Tower + Pendulum to SureGuard + Surflan is indicates its utility as a replacement product to this industry standard, SureGuard.

Table 4. Treatment efficacy (weed control) in the field at BFN nursery in Michigan, May – July, 2013.

Treatment	Rate/ac	Location	1 WAT[z]		2 WAT		4 WAT	
Biathlon	100 lb.	BFN	7.8[y]	ab	8.4	bc	5.9	c
Tower + Pendulum	21 fl. oz. + 2 qtr.	BFN	9.5	a	9.7	ab	8.2	ab
Indaziflam	200 lb.	BFN	6.8	bc	8.3	c	5.6	c
Indaziflam	400 lb.	BFN	8.0	a	9.0	abc	6.8	abc
Indaziflam	800 lb.	BFN	6.8	bc	8.3	c	6.9	abc
SureGuard + Surflan	12 oz. + 2 qtr.	BFN	9.8	a	9.8	a	8.7	a
F6875	0.375 lb. ai	BFN	8.0	a	8.2	c	6.1	bc
Untreated	--	BFN	5.8	c	6.0	d	3.4	d

z = WAT: weeks after first treatment

y = Efficacy visual ratings based on a 0-10 scale with 10 being complete control, 0 no control and ≤7 commercially acceptable.

Treatment means followed by similar letters mean they are not significantly different from each other, based on lsmeans (α = 0.05)

Due to frost events early in spring, above commercially acceptable injury persisted on the *Syringa* 'Common purple' for the duration of the trial as evidenced by the control (Table 5) in BFN fields. However, the *Euonymus* 'Compacta' did not have above commercially acceptable injury from frosts (Table 5). Usually products that have high efficacy also have high phytotoxicity. The *Syringa* in this trial supports this generality (Table 5). Even with the high phytotoxicity in the controls the damage caused to the BFN *Syringa* from over-the-top sprays of Tower + Pendulum and SureGuard + Surflan stand out as above commercially acceptable injury (Table 5). On the *Euonymus* the SureGuard + Surflan also caused very high phytotoxicity (7.4) (Table 5) (Fig. 13). Fig. 13 shows almost total kill from the application of SureGuard + Surflan on some *Euonymus* compared to a 4X rate of Indaziflam. The F6875 also caused above commercially acceptable injury 4WAT (3.5) on *Euonymus* (Table 5). F6875 also caused injury on *Syringa* in the field; however, taking into account the high phytotoxicity of the control, we could not confirm the level of injury from the F6875 to *Syringa*. There was no injury from Tower + Pendulum on *Euonymus.* In past SCBGs applications of Tower + Pendulum have caused no injury to *Syringa,* and it may have been possible that the existing injury to the *Syringa* was a causal factor the injury we found in this SCGB. Treatments that caused no injury in field trials are listed in Tables 5 and 6.

Fig. 13. Indaziflam at 800 lbs./ac (foreground) (1st stake- three plants following) , causing no phytotoxicity compared to SureGuard + Surflan at 12 oz. + 2 qtr./ac, respectively (background) (2nd stake – three plants following) on *Euonymus alatus* 'Compacta' at BFN Nursery, Grand Haven, MI, Spring 2013. Picture by: Luke Case.

Table 5. Phytotoxicity from various herbicides on several ornamental species located at Berry Family Nursery, Grand Haven, MI.

Syringa 'Common purple'

Treatment	Rate/ac	Location	1 WAT[z]		2 WAT		4 WAT	
Tower + Pendulum	21 fl. oz. + 2 qtr.	BFN	4.3[y]		4.8		7.5	**
Indaziflam	200 lb.	BFN	3.5		3.4		6.1	
Indaziflam	400 lb.	BFN	3.8		3.2		5.4	
Indaziflam	800 lb.	BFN	4.1		4.3		5.0	
SureGuard + Surflan	12 oz. + 2 qtr.	BFN	9.7	**	8.7	**	8.4	**
F6875	0.375 lb. ai	BFN	6.5	**	4.7	**	5.0	
Untreated	--	BFN	3.3		2.9		4.6	

Euonymus alatus 'Compacta'

Treatment	Rate/ac	Location	1 WAT		2 WAT		4 WAT	
Biathlon	100 lb.	BFN	1.2		0.3		1.8	
Tower + Pendulum	21 fl. oz. + 2 qtr.	BFN	1.5		1.5		1.7	
Indaziflam	200 lb.	BFN	0.9		1.2		2.5	
Indaziflam	400 lb.	BFN	1.7		0.9		2.3	
Indaziflam	800 lb.	BFN	1.9		1.7		2.6	
SureGuard + Surflan	12 oz. + 2 qtr.	BFN	9.5	**	9.3	**	7.4	**
F6875	0.375 lb. ai	BFN	2.7		2.2	*	3.5	**
Untreated	--	BFN	1.2		0.3		1.5	

z = WAT: weeks after first treatment

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

Treatment means followed by *,** are significantly different from the control, based on Dunnett's t-test (α = 0.10 and 0.05, respectively)

Table 6. Summary of all herbicides and crops that experienced **no phytotoxicity** at the three MI sites in 2012.

Herbicide	No phytotoxicity	Comments
Indaziflam	*Rosa* 'Home Run Red'	
	Euonymus 'Compacta'	Field
Biathlon	*Viburnum 'Red Balloon'*	1X
	Euonymus 'Compacta'	1X field
	Azalea 'Pink Double'	1X
	Hemerocallis 'Stella d oro'	1 application
FreeHand	*Viburnum 'Red Balloon'*	1X
	Sambucus 'Black Lace'	(Caution: Make sure it does not hang up at base)
	Azalea 'Pink Double'	1X
	Berberis Sunjoy	1X
Tower + pendulum	*Euonymus* 'Compacta'	Field
Gallery + Barricade	*Hemerocallis* 'Stella d oro'	
	Sambucus 'Black Lace'	
	Euonymus 'Emerald & Gold'	
F6875SC	*Euonymus 'Emerald & Gold'*	

Accomplishing Objectives 3: Further preliminary studies were conducted regarding objective 3 to identify specific weed control approaches for highly specific weed issues in MI nurseries such as mugwort (Artemisia vulgaris L) and Yellow nutsedge (Cyperus esculentus):

Preliminary Field Trial Results. At Northland Farm in a yellow nutsedge trial, Tower + Pendulum provided the best control in the field with an above commercially acceptable control rating 4WAT (Table 7).

Table 7. *Northland Farms, Yellow nutsedge trial.*

Treatment	Rate/ac	Taxus		Sedge Control	
Biathlon		0.2[Z]		3.0[X]	bc
Tower + Pendulum		0.9	**	7.3	a
FreeHand		0.0		5.3	ab
Indaziflam		0.0		4.0	abc
Untreated		0.0		0.0	c

z = Ratings are based on a 0-10 scale with 0 being no phytotoxicity and 10 death, with ≤3 commercially acceptable. Ratings are averaged over 3 dates of evaluation.

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

x = Efficacy ratings are based on a 0-10 scale with 0 being no weed control and 10 perfect weed control with ≥7 commercially acceptable. Ratings are averaged over all evaluations.

Efficacy ratings in the same column followed by the same letter are not significantly different based on lsmeans (α = 0.05)

At BFN a preliminary postemergence trial in a heavy infestation of *mugwort (Artemisia vulgaris L)* (Fig. 14) four products showed promise for continued trials in 2013, Lontrel® (Clorpyralid) (Fig. 15E), Certainty (Sulfosulfluron, Monsanto Corp.) (Fig. 15B), Riverdale® Corsair™(Chlorsulfuron, NuFarms America Inc., IL) (Fig. 15C) and SedgeHammer (Halosulfuron-methyl, Gowan Co., AZ) (Fig. 15D) versus the control (Fig. 15 A) (Table 8). These four products also provided minimal phytotoxicity (Table 8) at 4 WAT.

Fig. 14. Mugwort or false chrysanthemum (*Artemisia vulgaris*.) is a non-native perennial aster. Mugwort foliage appears similar to common ragweed (*Ambrosia artemisiifolia*) and ornamental chrysanthemums (*Chrysanthemum* spp.). Unlike those weeds, the lower surfaces of mugwort leaves are covered with a dense, silver-white pubescence. Mature *A. vulgaris* stems, which can grow 2 m (6 ft.) tall, yield rankly aromatic flower heads. It disperses in nurseries and landscape plantings primarily by rhizomes transported on contaminated cultivation equipment and nursery crops. Once established, mugwort rhizomes gradually expand outward, excluding other plants and forming a dense, monotypic stand. It has named one of the 10 most problematic weeds in nurseries of the eastern U.S.

Table 8. Berry Family Nurseries, Mugwort trial.

Treatment	Rate/ac	Buxus		Efficacy	
Basagran	2 pt.	0.1[z]		1.5[x]	cd
V-10233		3.8	**	5.3	b
Pennant Magnum	2 pt.	0.3		0.8	d
Lontrel	1 pt.	1.9	**	8.0	a
Certainty	0.06 lb. ai	2.3	**	7.5	a
F6875	0.375 lb. ai	2.9	**	3.8	bc
Corsair	5.5 oz.	1.8	**	8.3	a
SedgeHammer	0.125 lb. ai	1.2	*	7.8	a
Untreated	--	0.0		0.0	d

z = Ratings are based on a 0-10 scale with 0 being no phytotoxicity and 10 death, with ≤3 commercially acceptable. Ratings are averaged over 3 dates of evaluation.

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

x = Efficacy ratings are based on a 0-10 scale with 0 being no weed control and 10 perfect weed control with ≥7 commercially acceptable. Ratings are averaged over all evaluations.
Efficacy ratings in the same column followed by the same letter are not significantly different based on lsmeans (α = 0.05).

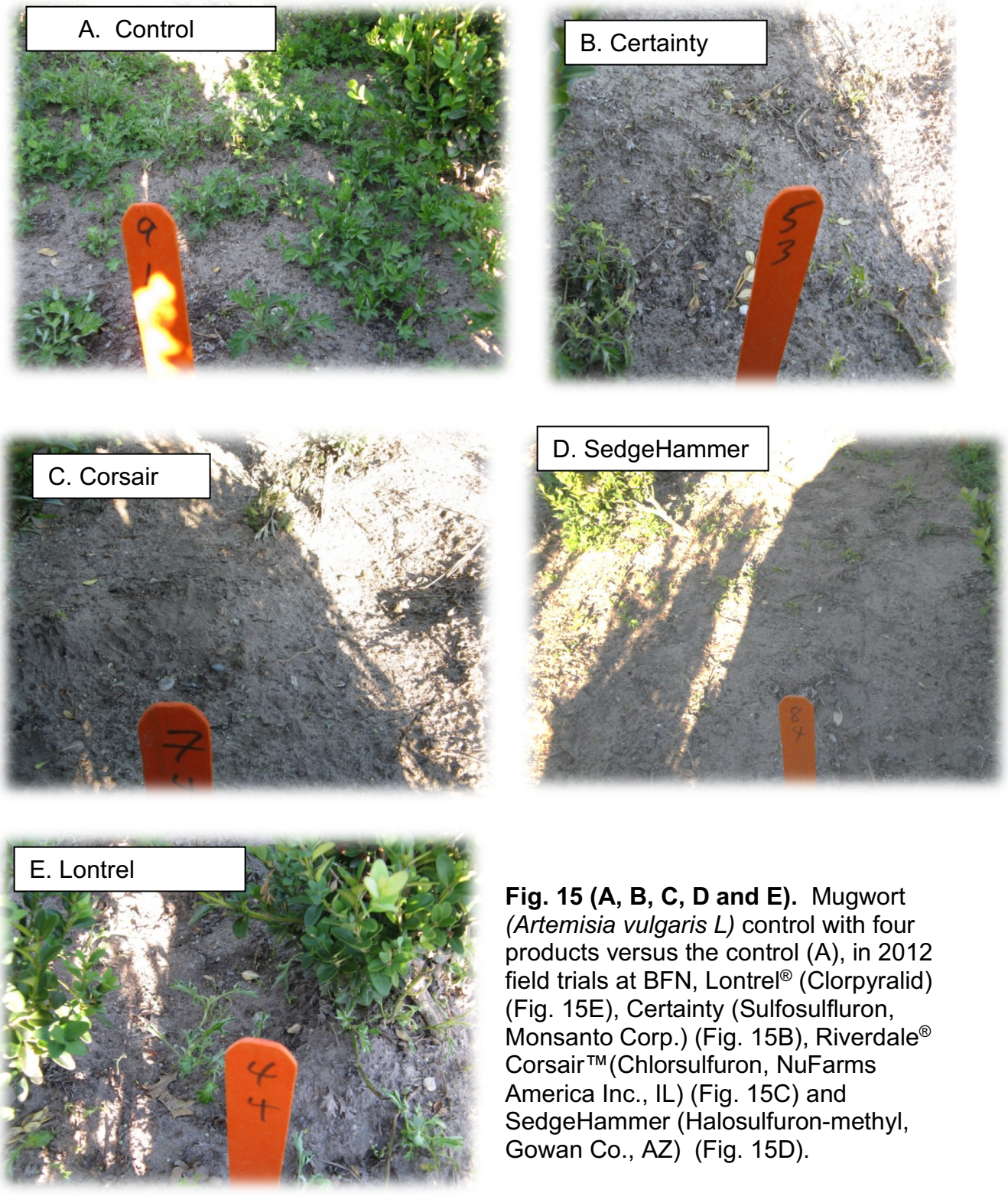

Fig. 15 (A, B, C, D and E). Mugwort *(Artemisia vulgaris L)* control with four products versus the control (A), in 2012 field trials at BFN, Lontrel® (Clorpyralid) (Fig. 15E), Certainty (Sulfosulfluron, Monsanto Corp.) (Fig. 15B), Riverdale® Corsair™(Chlorsulfuron, NuFarms America Inc., IL) (Fig. 15C) and SedgeHammer (Halosulfuron-methyl, Gowan Co., AZ) (Fig. 15D).

Beneficiaries. Beneficiaries from these trials were obviously the nursery managers and staff that were involved in the trials at the three sites in MI. However, in 2012, 16 extension/ research presentations were also given with results from these trails. Seven of these were out-of-Ohio and benefited 504 attendees in MI and IN. Nine were in-Ohio presentations and benefited 2069 attendees from landscape, lawn care, nursery, arboriculture and garden center backgrounds. All of the out-of-state presentations were invited and were for industry organized events. This indicates the value and demand for this information to industry members. All of the in-state presentations were also invited with 65% organized by university, extension or government agencies indicated the high demand for the information from agencies that promote current information to their audiences. One technical report and four contributed articles to technical reports were completed in association with this project. Three papers in proceeding and 9 trade articles were published using information obtained from this project. It is estimated that between the 16 presentations that were given and the 9 trade articles published we reached over 5000 people in the MI ornamental industry.

Lessons Learned. We started the trials very early in the spring to be representative of normal industry preemergence herbicide timing; however, we encountered numerous frost events with somewhat impeded our ability to diagnosis injury at some sites. In the future we will start the trials later in the spring to ensure frost events have past.