Specialty Crop Block Grant Program-Farm Bill (FY15)

Final Performance Report

Grant Title: Development of Innovative Weed Control Programs for Michigan Nurseries

Grant #: 791N6600144

Grantee: Michigan Nursery & Landscape Association

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Partner Organization: Michigan Nursery & Landscape Association
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PROJECT SUMMARY

The tremendous efficacy and duration of efficacy that we received with just one *dormant* application, allowed us to change the original protocol of applying two subsequent herbicides, to only one, additional application on July 19, 2016 at Northland Farms (NF) and Gardens Alive (GA). No additional applications were conducted at Lincoln Nursery, as some treatments were still commercially viable at 9 months after application (MAT). Although, we changed from the original protocol, our outcomes targets and performance measures were all exceeded and in only one case did we fall short by 19%. In this one case we achieved a 56% reduction in weed growth, when shooting for a 75% reduction, over the entire year- long program. However, few growers would be unhappy with a 56% reduction!! We attribute the majority of our success to the novel application timing or Dec. 14, 2015 and the use of Marengo 15 oz in this period followed as a 2nd application with SureGuard 8 oz or SureGuard 12 oz followed by Marengo 7.5 oz or SureGuard 8 oz. Both of these herbicide performed exceptionally as mid-December applications and helped with residual control into the 2nd application.

PROJECT PURPOSE

The objectives of this trial were to evaluate over the top (OTT) use of various non-traditional pre- and post- emergence herbicides on early winter dormant ornamentals, followed by in-season advanced pre-emergence herbicides attending to mode of action (MoA) rotation, long-term efficacy and minimal phytotoxicity. Success was measured quantitatively as > 75% reduction in weed biomass, at the project's conclusion, and by less than 20% crop injury of any kind. These measures were accomplished by harvesting weed biomasses from control areas (no herbicides) versus treated areas and calculating change in growth index values (initiation of trials – project completion) for the various crop. This project addressed the discrepancy between how herbicides are usually studied and what a MI nursery growers requires. Herbicides are studied as points in time applications; however, nursery growers apply consecutive applications in a season-long herbicide program. The issues of what impact sequential applications, over a cropping cycle, have on the crop, and weed control based on the timing of the application were addressed. Also, due to the severity of weed infestations, following years of economic downturn, this project was timely and of great importance in restoration and recovery of high-value crops that were neglected in the downturn and now are of high- and augmented-value. This study was the culmination of the years of research and of previous SCBGs including: 791N1300090 - *Addressing Foremost Weed Control Issues for MI Nursery & Landscape Industries;* 791N2200136 – *Major Weed Control Issues in MI Nurseries;* and, 12-25-B-1468 – *Weed Control in Specialized and Traditional MI Nursery Crops.* These previous projects were the basis for propose ten season long programs for MI nursery crops and weed issues.

PROJECT ACTIVITIES

During the course of this project we conducted two herbicide applications to eight crops at three nurseries (one dormant and one mid-season); we conducted 8 evaluations; performed two measures of growth (one with full weed biomass collections, including timings of weeding, and both including measures of stock to calculate volume of growth increases), volume is a preferred way to evaluate quality and not just growth increases.) In total ten technical presentations were given re the successes of this project, four trade articles were published and one PowerPoint was downloaded to our website for an estimated outreach to 35,210 program beneficiaries. The outreach of this project has been beyond the reach of MI nursery growers and has assisted specialty crop growers in other states in the Midwest. Of course, enhancing the specialty crop industry in the region only benefits the specific state, for as the region's economy goes, so goes the state.

GOALS AND OUTCOMES ACHIEVED

Bench Mark, Target #1 and Performance Measure #1 and 2: Meet - Surveys were conducted at each participating nursery in Nov. 2015 providing us with their current weed control programs. The control programs were designated into four categories: *non-existent or nil* (Lincoln Nurseries); *non-aggressive* (Northland Farm); *mildly aggressive* (Zelenka); and, *aggressive* (Bay Landscaping). Random sampling on fields for weed biomass calculations were collected in Dec., 2015 before any applications and initial growth measures. Starting heights and calipers were collected for the B&B operations (Lincoln and Bay Landscaping), and growth index values were collected and calculated by field and site at liner operations (Lincoln and Zelenka). One MNLA magazine trade article re current practices and problematic weeds was published in March. 2016 for the May/June magazine issue (see Appendix A – in Additional Information).

Bench Mark #2: Exceeded – Due to the success of the dormant applications a second application in March 2016 was not required; therefore, activities were performed in Bench Mark #3. In the spring up to June 30, 2016 three evaluations were conducted and averaged.

Bench Mark #3, Target #2 and 3 and Performance Measure #2 and 3: Exceeded - Before the second (July 19, 2016) application random sampling of field sections for weed biomass calculations in control and treated plots were performed. Growth index (GI) (which is a measure of plant volume) values were collected and calculated by field and site at liner operations [Northland Farms (Table1) and Zelenka (Table 3)]. Heights and calipers were not collected for the B&B operations at Lincoln (Table 2) as dormant applications were still providing above commercial control. Bay Landscaping at Bay City, MI had been discontinued due to expenses after three weeks following application and is not included in this report. The GI calculations, plus the four evaluations conducted after the 2nd application, indicate targets 2 and 3 had been exceeded after one application. Greater than 80% and 70% reductions in weed biomass at Northland Farm in *Thuja* and *Euonymus,* respectively (Table1) and >80% reductions in weed biomass at Zelenka in *Buxus* (Table 3). To meet performance measures 2 and 3, we wanted a total increase in crop growth of 20% before the second application. Again, we surpassed our performance measures with crop growth increases of 56.7%, 124.5% corresponding to the 80% and 70% reductions in weed biomass at Northland Farm in *Thuja* and *Euonymus,* respectively (Table 1). The *Buxus* at Zelenka increased in growth volume by 103.8% corresponding to the 86.8% reduction in weed biomass with the Barricade + Gallery SC application (Table 3).

The *Syringa* and *Euonymus* at Zelenka increased in volume by 24.8% and 37.7%, respectively (Table 3). Unfortunately, both crops were hand-weeded due Zelenka's change of ownership that was occurring in this period. These hand weeding events prevented the calculation of corresponding weed biomass reductions with the increases in growth.

No growth or weed biomass calculations were done for Lincoln as after 33 weeks or 8 months following dormant applications (Table 2). At 8 months after treatment no, two and one treatment in the Kentucky Coffeetree, 'Autumn Blaze' Maple and 'Red Jewel' Crabapple, respectively, were still providing commercially acceptable weed control. Leaving these treatments to run their course at Lincoln, helped later with us understanding some of the interactions of 2nd applications with the 1st at other sites.

In summary, of eight remaining crops, after only one application of herbicide, at the three nurseries, six crops shared a top treatment for reducing weed growth and correspondingly increasing crop growth. This top performing crop in 6 of 8 crops was Lontrel + Marengo SC applied dormant in Dec. 2016 (Table 1, 2 and 3). The only two exception crops were the *Buxus* and *Euonymus* at Zelenka (Table 3). In these two crops the best performing treatment was Tower + Barricade (Table 3). We attribute this divergence to the predominant weed species in these two Zelenka fields of Mugwort or *Artemisia vulgaris*. The Tower (as a shoot inhibitor) seemed have some superior efficacy with this weed. This finding will be built upon in our 2016 SCBG studies. In addition, we out-performed, performance measure #1, with one extra MNLA magazine article being published in their July/August issue. Furthermore, four presentations were given to national representatives of the specialty crop sector at trade and scientific conferences including, Cultivate 2016, ASHS and ISHS in this period (see Appendix A - in Additional Information).

Bench Mark #4, Target #4 and Performance Measure #4: In terms of performance measure #4, two additional MNLA magazine articles published in the Sept/Oct and Nov/Dec. 2016 issues. This exceeded the performance measure #4 since no article publications were required in this period. Moreover, two presentations were given to state representatives of the specialty crop sector at the Michigan Nursery and Landscape Association, GLTE conference, in this period (see appendix A – in Additional Information).

We had targeted to cut weed biomass after the second application compared to the control by another 30% for a total weed biomass cut of 75% over the year-long program. Again, we had reached this 75% target with the *Thuja* and *Euonymus* at Northland Farms (NF) with reduction in weed biomass before the second application of 82 – 96% and 72 to 31%, respectively, after the first dormant application only(Table 1). However, using the rating scores for efficacy we did achieve additional cuts in weed biomass of another 10 to 30% compared to the control (Table 1) after the 2nd application. We also achieved our 4th performance measure(s), of an additional 10% crop growth increase and weed control cost reduction by 10%, versus hand-weeding (Table 1). Unfortunately, only the *Euonymus* at Northland could be used to calculate these gains do to hand weeding issues with the one other remaining Northland crop. However, two treatments the SureGuard (8 oz/ac) following the Casoron CS(3 gal ai/ac) dormant application and the Marengo SC (7.5 oz/ac) following the Basagran + Gallery dormant application (each at 1 lb ai/ac) yielded 19.7 and 25.6% growth gains, respectively at NF.

Hand weeding timings conducted before the 2nd application, determined that averaged across fields and crops, 142.2 grams of weed fresh weight could be hand weeded/ minute. By calculating at $15.00/h for labor, and converting our 6 ft^2 plots to represent 43,560 ft^2 (or one acre plots), we estimated savings in the *Euonymus* SureGuard (8 oz/ac) following the Casoron CS(3 gal ai/ac) dormant application at $435.75/ac versus the controls. We also liberally allocated only 20% of the total field was infested in our $435.75/ac savings. This 20% or 80% reduction was liberal as it considered Zelenka's current program as delivering this amount of weed control (although it was not). The $436 saving more than paid for the SureGuard at 12 oz (~ $150.00/ac) that reaped this saving in hand weeding versus their current program Tower+ Pendulum Aqua Cap which is ~100.00/ac. In summary we exceeded our 10% cut in cost with a 44% cut in weed control program costs, calculated as:

$436.00 (hand weeding) + $100.00 (chemical program) minus 2 applications of SureGuard at 12 oz/ac (dormant) and 8 oz/ac (in-season) (=$300.00):

Therefore at $536.00 - $300.00/536 X 100 = 44%/ ac saving are provided.

In addition, this cost saving relies upon the use of a dormant application in Dec. which is a down-time in the industry, thus additional labor efficacy gains could be estimated.

Again, we far exceeded our 75% target at Lincoln Nursery with reduction in weed growth with only one application, with treatments at 9 MAT providing 80% control (Marengo SC) (Table 2) in the *Acer* and one at 80% in the *Malus* (Marengo SC) (Table 2). These gains are incredible as Lincoln had no field weed control program at the initiation of this study in 2015. Lincoln staff were so amazed by the results that they have whole-hearted embraced Marengo in their fields. Taking fields that were infested with weeds to productive, yielding B&B production. We believe, this projects may have saved the field tree growing program at Lincoln. At trial initiation, Lincoln was in a staff void for the field tree nursery program. Due to staff changes, not even mowing in the rows was occurring. We had to expend significant time hoeing plots around each treatment, species, and replication, in order to see the ground and sometimes the trees, and apply the treatments. At the trial, during the March 3 final measures, clean areas, as we had left them in Dec. 2015, after hoeing and spraying. The savings in meeting a 10% reduction in the weed program at Lincoln, is not the proper performance measure. The real performance measure should have been saving an entire portion of the business i.e. B&B production. Therefore, the cost saving at this site is worth far more than ½ a million, and far surpasses any 10% reduction in weeding costs. One treatment (Lontrel +Marengo) that had been most effective up to July, 2016 and even to 9 MAT in the *Malus* proved in the final measures in 03/03/2017 or 63 WAT to assert a cost in growth to the trees (Table 2). This was also seen in the *Acer.* For this reason the best treatment in terms of weed control and corresponding increase in growth versus the control was Marengo SC in all three species at 15 oz/ac. We saw a non-significant change in height at Lincoln with *Gymnocladus* (Table 2), a 10% increase in height with *Acer*, and 8.3% increase in caliper with *Malus* with the use of Marengo (Table 2). This site alone made the project a success – it was like a 1 in 50 year test!

Furthermore, we were only short 19% in meeting our overall 75% target at Gardens Alive, despite going through many set-backs and changes and hindrances. One crop provided full growth measures before the 2nd application, and one crop had a full set of final measures on 03/03/2017, the *Syringa* (Table 3). Therefore, the *Syringa* is the only crop we can discuss, at this location, in terms of targets and performance measure #4. We achieved at trial end a 56% increase in plant volume with the SureGuard 8 oz/ac following the Lontrel + Marengo SC (7.5

oz/ac), a 52% increase with SureGuard (8 oz/ac) following the Casoron CS (3 gal ai/ac) dormant application, a 55% increase in growth with SureGuard 8 oz following SureGuard 12 oz applied dormant (each at 1 lb ai/ac) at Gardens Alive (Table 3). Associated with these reductions in weed growth we had corresponding tremendous increases in growth that far exceeded any performance measure set of 112.6% with the SureGuard 8 oz/ac following the Lontrel + Marengo SC (7.5 oz/ac) and 110.5% with the SureGuard (8 oz/ac) following the Casoron CS (3 gal ai/ac) dormant application (Table 3).

Table 1. Northland Farms, L.L.C., West Olive, MI, *Development of Innovative Weed Control Programs for Michigan Nurseries* efficacy means, weed fresh weights, phytotoxicity means, growth index (GI), change in GI from start to second applications, and second application to end of study. Percent cut in weed biomass versus control and percent increase in growth of crop are calculated to meet the projects outcomes, targets and performance measures. The trial was initiated on December 14, 2015. 29 WAT represents 29 weeks after treatment. Unfortunately, the Hicks yews (*Taxus Xmedia* 'Hicksii') were removed by Northland Farms at 21 WAT. No growth index (GI) values could be calculated for this crop. GI was calculated as GI=Pi (Ht)(r^2), where Ht. was final height, r was half of the average of W1+W2 (two perpendicular measurements taken of plant diameter or width) and Pi was "π". 'Green Giant' arborvitae *(Thuja* (*standishii x plicata*) 'Green Giant' were planted spring 2015 as three year old liners from Northland Farms. The average GI for 'Green Giant' on 12/14/2015 was 553.3 in^3. Unfortunately, final measures of growth could not be performed on the Arborvitae as they had been hand weeded by Northland Farm staff after the 17WA2T evaluations and data was felt to be corrupted as a result. Dwarf burning bushes (*Euonymus alatus 'Compacta')* were also planted spring 2015 as three year old liners and had an average GI on 12/14/2015 of 64.5 in^3. Bolded fresh weed weights indicate treatments with above commercially acceptable weed control. Bolded percentages in the reduction of weed biomass or increase in crop growth indicate treatments that far surpassed our targets of 30% cut in weed biomass or 10% increase in growth. Negative values in % reduction indicate weed biomass was reduced and positive values indicate weed biomass was increased by the treatment compared to the control. Positive values in the % increase in growth indicate growth was increased and negative values indicate growth was reduced by the treatment compared to the control. Final GI's were calculated for *Euonymus* and indicated two treatment exceeded the target and performance measures of an additional 10% crop growth gain after the second application. However, several treatments showed an adverse effects on growth following the summer applications. In the Arborvitae and Euonymus tables Lontrel was abbreviated to L and Marengo SC to M, in combination treatments because of space. Also Casoron CS was abbreviated to Cas., in these same two tables, again for space.

Hicks Yew *(Taxus Xmedia* 'Hicksii') (6 yr. old)

Treatment	Rate/ac	4 WAT	8 WAT	12 WAT	17 WAT	20 WAT	Average
Control	--	snow cover	snow cover	10.0a[ZX]	10.0a	10.0a	10.0a
Tower® + Barricade®	21 oz + 1 lb	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a
Lontrel™	16 oz/ac	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a
Certainty®	7.5 fl oz	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a
Marengo® SC	15 oz	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a
Lontrel™ + Marengo® SC	16 oz + 7.5 oz	snow cover	snow cover	10.0a	9.8a	9.0a	9.6a
Casoron® CS	3 gal ai	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a

Barricade® + Gallery® SC	1 lb + 1 lb ai	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a
SureGuard®	12 oz	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a
V-10223	15 oz	snow cover	snow cover	10.0a	10.0a	10.0a	10.0a

***Arborvitae* 'Green Giant'**

1st Round Treatment (lb or oz/ac)	4 – 29 WAT Eff Av.	29 WAT Fresh weed wt. (g)	4 – 29 WAT Phyto. Av.	Calc. GI (in^3)	Delta GI (12/14/15 to 7/7/16) (in^3)	% Reduced weed biomass vs control by wt. (g) 1st app.	% Increase in growth vs control by calc. GI 1st app.	2nd Round Treatments (lb or oz/ac)	2-17 WA2T Eff. Av.	2-17 WA2T Phyto. Av.	32 WA2T Calc. GI (in^3)	GI (7/7/16 to 3/3/17) (in^3)	% Increase in growth vs control by calc. GI 2nd app.
Control	**7.5b**	65.3b	0.0a	1351.0d	797.7	0b	0d	Control	**7.0b**	0.0a	N/A	N/A	N/A
T+B (21 oz + 1 lb)	**9.2a**	63.0b	0.0a	1394.9d	576.2	-3.5b	+3.2d	Marengo 7.5 oz	**8.4b**	0.0a	N/A	N/A	N/A
Lontrel 16 oz	**8.2**	69.3b	0.0a	1753.1b	1199.7	+6.1c	+28.8b	Gallery 1 lb a.i.	**7.8b**	0.0a	N/A	N/A	N/A
Certainty 7.5 oz.	**7.7**	56.8b	0.0a	2007.0a	1453.7	-13.0b	**+37.4b**	Marengo 7.5 oz	**8.5ab**	0.0a	N/A	N/A	N/A
Marengo 15 oz.	**9.5**	8.0a	0.0a	1349.4d	725.5	**-87.7a**	-0.1e	Marengo 7.5 oz	**10.0a**	0.0a	N/A	N/A	N/A
L+M (16+7.5oz)	**9.4**	11.3a	0.0a	2115.9a	1562.6	**-82.7a**	**+56.7a**	SureGuard 8 oz	**8.8ab**	0.0a	N/A	N/A	N/A
Cas CS 3 gal ai.	**9.7**	2.5a	0.0a	2472.8a	1919.5	**-96.2a**	**+53.0a**	SureGuard 8 oz	**9.0a**	0.0a	N/A	N/A	N/A
B + G (1+1 lb ai)	**9.4**	11.8a	0.0a	1744.5b	1392.2	**-81.9a**	+15.9c	Marengo 7.5 oz	**9.5a**	0.0a	N/A	N/A	N/A
SureGuard 12oz	**9.6**	0.5a	0.0a	1422.7d	869.4	**-99.2a**	+4.1d	SureGuard 8oz	**9.0a**	0.0a	N/A	N/A	N/A
V-10223 15 oz	**9.7**	0.25a	0.0a	1565.4c	1012.1	**-99.6a**	+15.1c	Marengo 7.5 oz	**9.5a**	0.0a	N/A	N/A	N/A

***Euonymous alatus* 'Compactus'**

1st Round Treatment (lb or oz/ac)	4 – 29 WAT Eff Av.	29 WAT Fresh weed wt. (g)	4 – 29 WAT Phyto. Av.	Calc. GI (in^3)	Delta GI (12/14/15 to 7/7/16) (in^3)	% Reduced weed biomass vs control by wt. (g)	% Increase in growth vs control by calc. GI	2nd Round Treatments (lb or oz/ac)	2-17 WA2T Eff. Av.	2-17 WA2T Phyto. Av.	32 WA2T Calc. GI (in^3)	GI (7/7/16 to 3/3/17) (in^3)	% Increase in growth vs control by calc. GI
Control	3.2a	981.7e	0.0a	189.2b	127.0	0c	0c	Control	**7.0a**	0.0a	2134.7c	1945.5	0c
T+B (21 oz + 1 lb)	4.6ab	560.7c	0.5a	197.8c	144.9	**-42.9b**	+4.5c	Marengo 7.5 oz	**8.4a**	1.5ab	1548.5b	1350.7	-30.61b
Lontrel 16 oz	3.2a	1133.3e	0.0a	170.8b	106.3	+15.4d	-9.3d	Gallery 1 lb a.i.	**7.8a**	0.0a	2156.8c	1986.0	2.1d
Certainty 7.5 oz.	3.9ab	1017.3e	0.0a	204.5c	140.0	+3.6d	+9.0c	Marengo 7.5 oz	**8.5ab**	3.5b	1044.8a	840.3	-56.8a
Marengo 15 oz.	4.6ab	417.7b	0.8a	108.5a	44.0	**-57.5ab**	-39.5e	Marengo 7.5 oz	**10.0c**	0.0a	1500.3a	1391.8	-28.5b
L+M (16+7.5oz)	6.8c	300.0a	0.0a	324.3e	243.1	**-69.4a**	**+124.5a**	SureGuard 8 oz	**8.8bc**	**3.0b**	1121.7a	797.4	-59.0a
Cas CS 3 gal ai.	5.0b	672.3d	0.0a	200.3c	135.8	**-31.5b**	+3.4c	SureGuard 8 oz	**9.5bc**	0.0a	2528.6d	**2328.3**	**19.7e**
B + G (1+1 lb ai)	5.5b	484.5b	0.5a	256.2d	191.7	**-50.6ab**	**+33.4b**	Marengo 7.5 oz	**9.5bc**	0.0a	2700.0d	**2443.8**	**25.6e**
SureGuard 12oz	**8.2c**	271.0a	2.8b	124.8a	51.7	**-72.4a**	-25.1e	SureGuard 8oz	**9.0bc**	0.0a	2270.1d	1999.0	2.8d
V-10223 15 oz	**7.4c**	329.8a	0.0a	201.6c	44.0	**-66.4a**	+9.9c	Marengo 7.5 oz	**9.5bc**	1.0a	1772.8bc	1443.8	-25.8b

Z = Efficacy (Eff.) ratings are based on a 0-10 scale with 10 being complete control, 0 no weed control, and ≥7 commercially acceptable control. Phytotoxicity (Phyto.) ratings are based on a 0-10 scale with 10 being dead, 0 no injury, and ≤3 commercially acceptable injury. Ratings are averaged (Av.) over four replications per species field, per site. X = Treatments with different letters signify efficacy was statistically different at p=0.05 using LS means.

Table 2. Lincoln Nurseries, Inc., Grand Rapids, MI, *Development of Innovative Weed Control Programs for Michigan Nurseries* efficacy means, phytotoxicity means, final heights and calipers, change (▲ in height and caliper) from start to end of study. Percent increase in growth of crop are calculated to meet the projects outcomes, targets and performance measures. Efficacy means will be used to indicate percent decrease in weed cover. Trial initiated on December 14, 2015. 4 WAT represents four weeks after treatment, 8, 12… 37, 42, 63. Kentucky coffeetrees (*Gymnocladus dioicus*) were planted spring 2015 as five ft. liners from Oregon. The average height and diameter at trial initiation was 67.3 in. or 5.6 ft., and 1 in., respectively. Autumn Blaze® maples (*Acer X freemanii* 'Jeffersred') were planted spring 2015 as six ft. liners from Oregon. Average heights and diameter at initiation for Autumn Blaze® was 88.3 in. or 7.3 ft., and 1", respectively. 'Red Jewel' crabapples (*Malus x* 'Red Jewel') were also planted in spring 2015 as six ft. west coast liners. Average height and diameter for the 'Red Jewel' were 76 in. or 6.3 ft., and 0.7 in, respectively. Unfortunately, our caliper equipment quit working due to cold temperatures before we could measure the *Acer* 'Autumn Blaze. In tree nursery fields, such as this nursery site, stock is sold by caliper; therefore, % increase in caliper is more important to the grower versus height increases. However, in the absence of caliper readings for *Acer*, we are required to use the heights for this species only, to access meeting project expectations. No weed weights were conducted at Lincoln as we did not conduct any second applications at this site. However, the efficacy ratings at 42 WAT (10/05/2016) serve as a measure of weed cover as a % of the plot. Delta (or change) in height and caliper, were calculated by taking the mean of the replicates by treatment measured on 03/03/17 versus the starting height and caliper measures from 12/14/2015. Percent increase or decrease in height and caliper were calculated by dividing the change in the treatment, from initiation to final measure, from the control treatment mean times 100 for percent; therefore the control percent change is always 0. **Bolded** efficacy scores at evaluation dates indicate treatments with above commercially acceptable weed control ($\geq$ 7) and significant % increase in growth in keeping with meeting outcome, target and performance measure #4.

Table 2 (a, b and c).

a. Kentucky Coffeetree (*Gymnocladus dioicus*)

Treatment	Rate/ac	Eff. 4-23 WAT Av.	Eff 33-37 WAT Av.	Phyto. 33-37 WAT Av.	Eff 42 WAT Av.	Phyto. 42 WAT Av.	Height (ft) Av. 63 WAT	Caliper (mm) Av. 63 WAT	Delta Height (ft) (12/14/15 to 3/3/17)	Delta Caliper (mm) (1214/15 to 3/3/17)	% Increase in Height (ft) vs control	% Increase in caliper (mm) vs control
Control	--	2.3a	0.0a	3.0b	0a	2.5b	6.5b	22.8c	0.9	-2.6	0b	0c
Tower® + Barricade®	21 oz + 1 lb	4.7bc	1.2a	0.3a	0a	0a	6.0a	23.0c	0.4	-2.4	-7.7f	0.9c
Lontrel™	16 oz/ac	4.5bc	0.75a	0.0a	0a	0a	6.4a	22.3c	0.8	-3.1	-1.5b	-2.2d

Certainty®	7.5 fl oz	5.8cd	1.2a	0.4a	0a	0a	6.1a	26.4e	0.5	1	-6.2e	**16.1a**
Marengo® SC	15 oz	**8.9ef**	4.9c	0.5a	1.5b	0a	6.3a	19.6bc	0.7	-5.8	-3.1c	-12.1f
Lontrel™ + Marengo® SC	16 oz + 7.5 oz	**8.9ef**	4.2bc	1.8b	1.0a	0a	6.3a	23.7d	0.7	-1.7	-3.1c	4.6c
Casoron® CS	3 gal ai	**9.2f**	4.0bc	0.25a	2.0b	0a	6.7b	23.6d	1.1	-1.8	**3.1a**	3.4c
Barricade® + Gallery® SC	1 lb + 1 lb ai	3.8b	0.9a	0.0a	3.0b	0a	6.7b	24.5d	1.1	-0.9	**3.1a**	**7.2b**
SureGuard®	12 oz	**7.5e**	2.8b	0.5a	0.5a	0a	6.2a	21.7c	0.6	-3.7	-4.6d	-4.5e
V-10223	15 oz	6.1d	4.1	0.5a	0.0a	0a	6.0a	15.4a	0.4	-10	-7.7f	-34.1g

b. Autumn Blaze® Maple (*Acer X freemanii* 'Jeffersred')

Treatment	**Rate/ac**	**Eff. 4-23 WAT Av.**	**Eff 33-37 WAT Av.**	**Phyto. 33-37 WAT Av.**	**Eff 42 WAT Av.**	**Phyto. 42 WAT Av.**	**Height (ft) Av. 63 WAT**	**Caliper (mm) Av. 63 WAT**	**Delta Height (ft) (12/14/15 to 3/3/17)**	**Delta Caliper (mm) (1214/15 to 3/3/17)**	**% Increase in Height (ft) vs control**	**% Increase in caliper (mm) vs control**
Control	--	2.7a	0a	0.0a	0.0a	0.0a	7.9ab	N/A	0.6bc	N/A	0	N/A
Tower® + Barricade®	21 oz + 1 lb	3.6a	0.3a	0.0a	0.0a	0a	8.1bc	N/A	0.8c	N/A	2.5	N/A
Lontrel™	16 oz/ac	4.5b	0a	0.0a	0.0a	0a	7.9ab	N/A	0.6bc	N/A	0.0	N/A
Certainty®	7.5 fl oz	6.0c	0.2a	0.0a	0.0a	0a	7.7a	N/A	0.4b	N/A	-2.5	N/A
Marengo® SC	15 oz	**9.3de**	**7.9d**	0.0a	6.8d	0a	8.7d	N/A	1.4d	N/A	10.1	N/A
Lontrel™ + Marengo® SC	16 oz + 7.5 oz	**9.1de**	6.3c	0.0a	4.8c	0a	7.5a	N/A	0.2a	N/A	-5.1	N/A
Casoron® CS	3 gal ai	**9.9e**	**6.9cd**	0.0a	5.0c	0a	8.5cd	N/A	1.2d	N/A	7.6	N/A
Barricade® + Gallery® SC	1 lb + 1 lb ai	6.6c	1.3a	0.0a	0.0a	0a	8.5cd	N/A	1.2d	N/A	7.6	N/A
SureGuard®	12 oz	**8.1c**	2.9b	0.0a	1.8b	0a	8.0b	N/A	0.7bc	N/A	1.3	N/A
V-10223	15 oz	**8.2c**	3.7b	0.0a	2.0b	0a	8.2bc	N/A	0.9cd	N/A	3.8	N/A

c. 'Red Jewel' Crabapple (*Malus* 'Red Jewel')

Treatment	Rate/ac	Eff. 4-23 WAT Av.	Eff 33-37 WAT Av.	Phyto. 33-37 WAT Av.	Eff 42 WAT Av.	Phyto. 42 WAT Av.	Height (ft) Av. 63 WAT	Caliper (mm) Av. 63 WAT	Delta Height (ft) (12/14/15 to 3/3/17)	Delta Caliper (mm) (1214/15 to 3/3/17)	% Increase in Height (ft) vs control	% Increase in caliper (mm) vs control
Control	--	3.9a	0.2	0.0a	0.0a	0.0a	6.8b	30.0b	0.5	12.2	0c	0c
Tower® + Barricade®	21 oz + 1 lb	6.0b	1.3	0.0a	0.3a	0.0a	6.4a	30.4b	0.1	12.6	-5.9a	1.3b
Lontrel™	16 oz/ac	7.8cd	1.0	0.0a	0.0a	0.0a	6.8b	35.3c	0.5	17.5	0.0c	**17.7f**
Certainty®	7.5 fl oz	6.5bc	1.2	0.0a	0.3a	0.0a	6.7ab	29.3ab	0.4	11.5	-1.5b	-2.3b
Marengo® SC	15 oz	**9.3d**	8.1	0.0a	**6.8c**	0.0a	7.3c	32.5ab	1.0	14.7	**7.4d**	**8.3d**
Lontrel™ + Marengo®SC	16 + 7.5 oz	**9.2d**	**7.8**	0.0a	**7.0c**	0.0a	6.8b	27.0a	0.5	9.2	0.0c	-10.0a
Casoron® CS	3 gal ai	**9.2d**	3.2	0.0a	1.5b	0.0a	7.8c	34.4c	1.5	16.6	**14.7e**	**14.7e**
Barricade® + Gallery®SC	1 lb + 1 lb ai	5.7b	1.8	0.0a	0.5a	0.0a	6.8b	27.5a	0.5	9.7	0.0c	-8.3a
SureGuard®	12 oz	**7.9cd**	3.5	0.0a	1.0a	0.0a	6.8b	33.6c	0.5	15.8	0.0c	**12.0e**
V-10223	15 oz	**7.5c**	1.9	0.0a	0.8a	0.0a	6.4a	27.2a	0.1	9.4	-5.9a	-9.3a

Z = Efficacy (Eff.) ratings are based on a 0-10 scale with 10 being complete control, 0 no weed control, and $\geq$7 commercially acceptable control. Phytotoxicity (Phyto.) ratings are based on a 0-10 scale with 10 being dead, 0 no injury, and $\leq$3 commercially acceptable injury. Ratings are averaged (Av.) over four replications per species field, per site. X = Treatments with different letters signify efficacy was statistically different at p=0.05 using LS means.

Table 3. Zelenka Farms, Inc., Grand Haven, MI, now called Gardens Alive Farms (GAF) - Michigan, *Development of Innovative Weed Control Programs for Michigan Nurseries* efficacy means, weed fresh weights, phytotoxicity means, growth index (GI), change in GI from start to second applications. Percent cut in weed biomass versus control and percent increase in growth of crop are calculated to meet the projects outcomes, targets and performance measures. The trial was initiated on December 14, 2015. 29 WAT represents 29 weeks after treatment. Unfortunately, the *Euonymus* were lifted and sold before final measures could be done. No final growth index (GI) values could be calculated for this crop. GI was calculated as GI=Pi (Ht)(r^2), where Ht. was final height, r was half of the average of W1+W2 (two perpendicular measurements taken of plant diameter or width) and Pi was "π". The trial was initiated on December 14, 2015. 29 WAT represents 29 weeks after treatment. In the change of ownership between Zelenka nursery to GAF, unfortunately, the *Syringa vulgaris* 'Common Purple' and *Euonymus alatus* 'Compacta' were hand weeded before the July 29 evaluation as part of a clean-up for new owner viewing. Thus no fresh weed weights or scores of efficacy could be taken for these two species. Heights and widths however, were still taken to calculate growth index (GI) values and these were compared to the

control for % growth increase. Negative values in % reduction, in the *Buxus sinica* var. *insularis* 'Winter Gem', indicate weed biomass was reduced and positive values indicate weed biomass was increased by the treatment compared to the control by the 2nd application. Positive values in the % increase in growth indicate, in all three species listed below, that growth was increased and negative values indicate growth was reduced by the treatment compared to the control. 'Winter Gem' Boxwood (*Buxus sinica* var. *insularis* 'Winter Gem') were planted in spring 2015 as rooted cuttings grown at Zelenka Farms. Measures were collected for the final GI the *Buxus*, however, they were misplaced and are N/A. 'Common purple' Lilac (*Syringa vulgaris* 'Common Purple') were planted spring 2015 as 2-0 plants from a bareroot nursery in MI. Regrettably, as the Syringa field was locked no final GI or measures could be taken on 03/03/2017. Dwarf Burning Bush (*Euonymus alatus* 'Compacta') were also planted spring 2015 as one year old rooted cuttings grown at Zelenka. Bolded efficacy scores at evaluation dates indicate treatments with above commercially acceptable weed control ≥ 7. **Bolded** efficacy scores at evaluation dates indicate treatments with above commercially acceptable weed control (≥ 7) and significant % increase in growth in keeping with meeting outcome, target and performance measure #4.

Table 3 a, b and c.

a. 'Winter Gem' Boxwood (*Buxus sinica* var. *insularis* 'Winter Gem') (2 yr. old)

1st Round Treatment (lb or oz/ac)	4 – 29 WAT Eff Av.	29 WAT Fresh weed wt. (g)	4 – 29 WAT Phyto. Av.	Calc. GI (in^3)	% Reduced weed biomass vs control by wt. (g) 1st app.	% Increase in growth vs control by calc. GI 1st app.	2nd Round Treatments (lb or oz/ac)	2-11 WA2T Eff. Av.	2-11 WA2T Phyto. Av.	32 WA2T Eff. Av.	32 WA2T Phyto. Av	32 WA2T Calc. GI (in^3)	% reduced weed cover after 2nd app. Vs control
Control	5.0	826.0f	0.0a	504.4b	0	0	Control	**5.3**	0.3	4.5	0.0	N/A	0
T+B (21 oz + 1 lb)	**7.7**	208.0a	0.0a	1106.3e	**-74.8c**	**+119.3d**	Marengo 7.5 oz	**8.6**	0.2	8.5	0.3	N/A	47%
Lontrel 16 oz	5.1	428.0c	0.0a	526.0b	**-48.2b**	+4.3b	Gallery 1 lb a.i.	**5.0**	0.3	4.0	0.0	N/A	0
Certainty 7.5 oz.	**7.6**	304.0b	1.0a	811.1c	**-63.2c**	**+60.8c**	Marengo 7.5 oz	**7.8**	0.8	7.0	2.0	N/A	35%
Marengo 15 oz.	**8.4**	447.5c	1.3a	989.5d	**-45.8b**	**+96.2**	Marengo 7.5 oz	**8.4**	1.8	7.5	1.8	N/A	40%
L+M (16+7.5oz)	**8.4**	575.5d	1.0a	454.4ab	**-30.3b**	-9.9a	SureGuard 8 oz	**8.5**	1.3	8.3	1.3	N/A	46%
Cas CS 3 gal ai.	**7.2**	753.0e	0.0a	395.7a	-8.8a	-21.6a	SureGuard 8 oz	**8.0**	0.4	6.5	0.0	N/A	31%
B + G (1+1 lb ai)	**9.1**	109.0a	0.0a	1027.9	**-86.8c**	**+103.8d**	Marengo 7.5 oz	**9.3**	0.2	8.5	0.0	N/A	47%
SureGuard 12oz	**8.1**	430.3c	0.0a	990.7d	**-47.9b**	**+96.4d**	SureGuard 8oz	**8.4**	0.3	7.5	0.0	N/A	40%
V-10223 15 oz	**7.4**	569.7d	0.0a	1286.4f	**-31.0b**	**+155.0e**	Marengo 7.5 oz	**8.1**	0.7	7.3	1.3	N/A	22%

b. 'Common purple' Lilac (*Syringa vulgaris* 'Common Purple') (3 yr. old)

1st Round	4 –	29 WAT	29 WAT	Calc.	% Reduced	%	2nd Round	2-6	2-6	32	32	32	GI	%	%

Treatment (lb or oz/ac)	23 WAT Eff Av.	Fresh weed wt. (g)	Phyto. Av.	GI (in^3)	weed biomass vs control by wt. (g) 1st app.	Increase in growth vs control by calc. GI 1st app.	Treatments (lb or oz/ac)	WA2T Eff. Av.	WA2T Phyto. Av.	WA2T Eff. Av.	WA2T Phyto. Av	WA2T Calc. GI (in^3)	(7/7/16 to 3/3/17) (in^3)	Increase in growth vs control by calc. GI	reduced weed cover after 2nd app. Vs control
Control	5.5a	Weeded	Diseased	687.3c			Control	**9.5a**	0.3a	4.3	0.0a	4493.1	3805.8	-64.8	0
T+B (21 oz + 1 lb)	7.7b	Weeded	Diseased	562.6b	N/A	-18.1a	Marengo 7.5 oz	**10.0a**	1.3a	6.0	0.0a	1902.6	1340	-96.7	38%
Lontrel 16 oz	7.8b	Weeded	Diseased	421.7a	N/A	-38.6a	Gallery 1 lb a.i.	**9.9a**	1.8a	7.3	0.0a	545.9	124.2	**107.7**	41%
Certainty 7.5 oz.	6.5ab	Weeded	Diseased	500.6b	N/A	-27.2a	Marengo 7.5 oz	**10.0a**	0.8a	6.0	0.0a	8405.5	7904.9	**30.6**	38%
Marengo 15 oz.	9.5c	Weeded	Diseased	704.3c	N/A	+2.5b	Marengo 7.5 oz	**9.8a**	1.2a	8.0	0.0a	5673.3	4969	**105.5**	46%
L+M (16+7.5oz)	8.7bc	Weeded	Diseased	857.9d	N/A	**+24.8c**	SureGuard 8 oz	**10.0a**	2.8b	9.8	0.0a	8677.5	7819.6	**112.6**	**56%**
Cas CS 3 gal ai.	9.0bc	Weeded	Diseased	789.4c	N/A	**+14.9c**	SureGuard 8 oz	**10.0a**	**3.3b**	9.0	0.0a	8878.7	8089.3	**110.5**	**52%**
B + G (1+1 lb ai)	7.6b	Weeded	Diseased	502.8b	N/A	-26.8a	Marengo 7.5 oz	**9.3a**	1.4a	5.3	0.0a	8513.2	8010.4	**217.3**	19%
SureGuard 12oz	8.6bc	Weeded	Diseased	424.6a	N/A	-38.2a	SureGuard 8oz	**10.0a**	2.3b	9.5	0.0a	12,501.2	12076.6	0.3	**55%**
V-10223 15 oz	8.9bc	Weeded	Diseased	515.1b	N/A	-25.1a	Marengo 7.5 oz	**10.0a**	1.4a	6.3	0.0a	4331.8	3816.7	-64.8	32%

c. Dwarf Burning Bush (*Euonymus alatus* 'Compacta') (2 yr. old)

1st Round Treatment (lb or oz/ac)	4 – 23 WAT Eff Av.	29 WAT Fresh weed wt. (g)	29 WAT Phyto. Av.	Calc. GI (in^3)	% Reduced weed biomass vs control by wt. (g) 1st app.	% Increase in growth vs control by calc. GI 1st app.	2nd Round Treatments (lb or oz/ac)	2-11 WA2T Eff. Av.	2-6 WA2T Phyto. Av.	32 WA2T Eff. Av.	32 WA2T Phyto. Av	32 WA2T Calc. GI (in^3)	% reduced weed cover after 2nd app. Vs control
Control	9.8b	Weeded	0.0a	1754.4			Control	6.4	0.3a	Lifted	Lifted	Lifted	Lifted
T+B (21 oz + 1 lb)	9.1b	Weeded	0.0a	2415.3	N/A	**+37.7c**	Marengo 7.5 oz	9.5	1.3a	Lifted	Lifted	Lifted	Lifted
Lontrel 16 oz	9.7b	Weeded	0.0a	2168.4	N/A	**+23.6b**	Gallery 1 lb a.i.	8.3	1.8a	Lifted	Lifted	Lifted	Lifted
Certainty 7.5 oz.	7.6a	Weeded	0.0a	1563.1	N/A	-10.9a	Marengo 7.5 oz	9.1	0.8a	Lifted	Lifted	Lifted	Lifted
Marengo 15 oz.	8.7ab	Weeded	0.0a	1668.7	N/A	-4.9a	Marengo 7.5 oz	9.2	1.2a	Lifted	Lifted	Lifted	Lifted
L+M (16+7.5oz)	8.7ab	Weeded	0.0a	2080.4	N/A	**+18.6b**	SureGuard 8 oz	9.6	2.8b	Lifted	Lifted	Lifted	Lifted
Cas CS 3 gal ai.	9.1b	Weeded	0.0a	1314.4	N/A	-25.1a	SureGuard 8 oz	8.4	**3.3b**	Lifted	Lifted	Lifted	Lifted
B + G (1+1 lb ai)	8.3ab	Weeded	0.0a	1965.3	N/A	**+12.0b**	Marengo 7.5 oz	7.7	1.4a	Lifted	Lifted	Lifted	Lifted
SureGuard 12oz	9.4b	Weeded	0.0a	1083.3	N/A	-38.3a	SureGuard 8oz	8.7	2.3b	Lifted	Lifted	Lifted	Lifted
V-10223 15 oz	9.6b	Weeded	0.0a	1410.5	N/A	-19.6a	Marengo 7.5 oz	9.9	1.4a	Lifted	Lifted	Lifted	Lifted

Z = Efficacy (Eff.) ratings are based on a 0-10 scale with 10 being complete control, 0 no weed control, and ≥7 commercially acceptable control. Phytotoxicity (Phyto.) ratings are based on a 0-10 scale with 10 being dead, 0 no injury, and ≤3 commercially acceptable injury. Ratings are averaged (Av.) over four replications per species field, per site. X = Treatments with different letters signify efficacy was statistically different at p=0.05 using LS means.

BENEFICIARIES

The primary beneficiaries of this research were the MI nursery growers in the Grand Rapids, Grand Haven, West Olive and Holland regions of MI. However, the over 48,000 full and part-time MI green-industry employees throughout the state (Hodges et al., 2011) benefited in terms of developing targeted weed control strategies for MI weeds and information extension state- and nation-wide. The results were presented at the MNLA Great Lakes Trade Exposition (GTLE) in January to over 500 attendees in two presentations on January 23, 2017 from the nursery/ landscape and retail section of the ornamental specialty crop sector. In addition a MNLA sponsored *Pesticide Recertification Weed Workshop* on March 2, 2017 at the Macomb County, MSU Extension Building. This was a 4 hour workshop with hands-on weed identification and three other 50 minute presentations by Dr. Hannah Mathers. 70 people attend all four session of the workshop for 280 contact hours for landscapers and nursery growers primarily in the Detroit/ Port Huron region of the state. Surveys were conducted at this event to measure the program impact and are discussed in this section below. With all ten presentations given as part of this project and the four MNLA magazine article with a circulation of 8200, we calculate **35,210 beneficiaries** of this project. In our survey, that had an 84% response rate, we learned 66% of beneficiaries learned at least one new idea from the project as a weed control approach, new herbicide idea, new timing for application or new identification to implement at a saving of $2,000.00 to their company. 50% learned more than one new "know-how," with 38% learning more than 3. At a value of $2,000 for each, to their businesses and their opinion. Therefore, we estimate the impact of this SCBG to be over $75.7 Million (Mn). However, this is a conservative estimate, as we estimate the program savings learned by Lincoln Nursery alone, long-term, in participating in this project is worth over ½ million to their business. The impacts of this research will be long lasting for those participants and those attending the program re the research. Because weed control is a major cost in traditional and specialized nurseries and because the impact of sequential herbicide applications (season-long) have never been evaluated, this project will help the green industry become more environmental and economically sustainability.

- How beneficiaries benefited from the project are listed below.
  1. Discovered new - more environmental sustainable herbicides: 43%, 46% and 51% increase in knowledge of Marengo, FreeHand and Biathlon, respectively.
  2. Use of discovered new products – 33% Yes - affirmative.
  3. Learned to identify new weeds: 25% of project beneficiaries, on average learned two new weeds.
  4. Herbicide rotation: 28% of beneficiaries realized herbicides need to be rotated.
  5. Importance of weed control: 50% of beneficiaries indicated spraying, hoeing, hand weeding were essential parts of their business taking on average 38% of staff time.
  6. Learned new practice(s), herbicide(s), method(s), timing(s), etc.: 47% learned one new thing as a result of this project and 38% of those learned more. The highest response rate for new "know-how" was 3-5 new capabilities with the majority of those beneficiaries expressing each new "know-how" was worth an average of $2,000.00 to their business.

LESSONS LEARNED

Zelenka went through a change in ownership in the early summer of 2016, being purchased by Gardens Alive (GA) and becoming their largest farm location at 1745 acres. With such a large acquisition, it appeared there were a lot of changes in staff responsibility including in field care and security. Two fields were hand-weeded before we could collect the weed weights in July (*Syringa* and *Euonymus*) and two fields had locked fences when we were conducting our November evaluations (*Buxus* and *Syringa*). Furthermore the *Buxus* field was locked again when we were conducting our final measures on March 3, 2017. No staff could be reached to have these fences opened on either date. In addition, one field (*Euonymus*) was lifted before our November 2016 evaluations. Therefore, there was a total loss of final data from the GA *Euonymus* and *Buxus* fields at GA. Only the *Syringa* field yielded final data for calculating outcome, target and performance measure #4 at this nursery. In addition Northland Farms removed the *Taxus* crop before our 29 WAT evaluations. From these set-backs that prevented outcome and final measures from being performed we learned that staking the trial areas with six foot posts strung with highly visible flagging tap from side to side are essential to keeping normal activities like weeding and lifting from occurring when staff changes are occurring at a site. Also, establishing clear guidelines with site participants at the trial initiation of the trial is critical.

Due to the unexpected yet tremendous efficacy and duration of efficacy that we received with one dormant application, the original protocol of applying two subsequent applications was changed to one additional application on July 19, 2016 at Northland Farms (NF) and Gardens Alive (GA). No additional applications were conducted at Lincoln Nursery. This protocol change, however, did not result in any outcomes, targets or performance measures from not being achieved. The success of the dormant applications were so great that all goals, outcomes and measures were met with just this one (vs) the original three applications. This positive experience taught us that if you have a great success and all goals are achieved in one event, the project efficiency is greatly improved by switching resources in the outreaching this success. In addition, the savings that will be realized with this success far surpass any original goal for reducing the cost of weed control for the grower, going forward.

The one site that was added in April, needed to be dropped in this reporting period due to lack of time and travel budget to conduct the required work at this site. The lack of time and travel budget was due to this site (Bay City Landscaping, Essex, MI) not being part of the original grant. From this negative experience we learned that although adding sites in the early part of the project may seem to be a good steward-like thing to do, later when the work load and travel requirements that were budgeted are already being maximized, any addition such as another test site is unmanageable. In other words, we learned if it wasn't originally scheduled, do not add it after the fact, as it will drag down the whole project if not jettisoned.

ADDITIONAL INFORMATION

- A list of publications, websites, and published articles is provided in appendix A – below. Additionally, pdf's of various trade articles are attached with this report. Furthermore, summary tables for the entire grant period and photos are provided that are referenced in sections above.

Appendix A

Additional Information for MDARD SCBG Number: 791N6600144

Development of Innovative Weed Control Programs for Michigan Nurseries

Invited Presentations

State

1. Mathers, H. M. 2017. The War against Weeds: Weed identification Overview and Terms. MNLA Pesticide Winter Series, Macomb County MSU Extension Building. 70 industry members attending. March 2, 2017.
2. Mathers, H. M. 2017. The War against Weeds: Chemical Controls. MNLA Pesticide Winter Series, Macomb County MSU Extension Building. 70 industry members attending. March 2, 2017.
3. Mathers, H. M. 2017. The War against Weeds: Weed Identification Hands-On. MNLA Pesticide Winter Series, Macomb County MSU Extension Building. 75 industry members attending. March 2, 2017.
4. Mathers, H. M. 2017. The War against Weeds: What Causes Weeds and Improving Control. MNLA Pesticide Winter Series, Macomb County MSU Extension Building. 75 industry members attending. March 2, 2017.

Regional

1. Mathers, H.M. 2017. Diagnosing Long and Short Term Effects of Herbicides on Landscape Plants. Presented at Great Lakes Trade Exposition (GLTE) by the Michigan Nursery and Landscape Association to 125 industry members. Lansing, MI. (January 23).
2. Mathers, H.M. 2017. Dormant Applications. Presented at Great Lakes Trade Exposition (GLTE) by the Michigan Nursery and Landscape Association to 125 industry members. Lansing, MI. (January 23).

National

1. Mathers, H.M. 2016. Evaluation of nursery season-long program. International Society of Horticulture Science. 3rd International Symposium of Woody Plants for the Temperate Zone. 50 participants. Minneapolis, MN. (August 3).
2. Mathers, H.M. 2016. Diagnosing Drift and Carry-over injury in nursery/landscape plants. Herbicide drift and carry-over to Horticultural Crops. Pest Management Working Group Workshop. Invited workshop speaker. American Society for

Horticultural Science. 20 professional society members. Atlanta, GA. (August 11) HortScience 51(9): 93-94.

3. Mathers, H.M. 2016. Maximizing weed control through herbicides and MoA rotations. Panelist. Cultivate 2016. AmericanHort. 65 industry members. Columbus, OH. (July 10).
4. Mathers, H.M. 2016. Herbicide rotation programs that work. Cultivate 2016. AmericanHort. 25 industry members. Columbus, OH. (July 11).

Invited Trade Articles

1. Mathers, H.M., E.J. Beaver. 2016. The five most unwanted Midwest nursery weeds. Part 4. Red stem filaree (Erodium cicutarium) The Michigan Landscape. 59(6):44-47. Nov/Dec.
2. Mathers, H.M. 2016. The five most unwanted Midwest nursery weeds – Part 3: Yellow nutsedge. The Michigan Landscape. 59(5): 32-34. Sept/Oct.
3. Mathers, H.M. 2016. The five most unwanted Midwest nursery weeds – Part 2: Mugwort. The Michigan Landscape. 59(4): 40-42. July/Aug.
4. Mathers, H.M. 2016. The five most unwanted Midwest nursery weeds – Part 1: Creeping yellow cress. The Michigan Landscape. 59(3): 42-45. May/June.

Website

One of the regional presentations cited above was uploaded to the Mathers Environmental website. *Diagnosing Long and Short Term Effects of Herbicides on Landscape Plants.* This PowerPoint was presented at Great Lakes Trade Exposition (GLTE) by the Michigan Nursery and Landscape Association. Lansing, MI. (January 23, 2017). The web address is: **http://www.mathersenvironmental.com/wp-content/uploads/2016/01/ShortLongInjury2016-with-security.pdf**

Total: 10 Presentations, 4 Trade Articles, one PowerPoint on website **– 35,210 Beneficiaries**