FINAL PROJECT REPORT TEMPLATE

Final Performance Reports must illustrate the completion of each project within the grant agreement. Each project shall be outlined as separate project profiles. You will report on projects in the same order they were submitted in the approved application and subsequent amendments.

PROJECT INFORMATION

Project Title	The Sagacious and Shrewd Weed Control Imperative for Herbaceous Perennials—SCBG #791AgDS8109			
Recipient Organization Name:	Michigan Nursery & Landscape Association			
Period of Performance:	**Start Date:**	11/22/2019	**End Date:**	9/30/2021

PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Provide enough information for the reader to understand the importance or context of the project. This section may draw from the background and justification contained in the approved project proposal.

The MI herbaceous perennial (HP) nursery sector has the largest capacity for growth in the industry. The expense of using the wrong herbicide and the resulting crop injury is of major concern in high value HP crops and prevents many HP growers from using herbicides. Liquid formulations are considerably more injurious than granular herbicide applications and yet liquids require less calibration, are significantly cheaper, concur with the available industry application equipment, and provide better weed control. For these reasons, HP growers prefer to apply liquids. The issue, however, has been the lack of liquid herbicide control programs to improve the efficiency and profitability of this sector through improved weed control. To this end we followed on the success of previous SCBG's that were primarily focused on granular herbicides, to develop new liquid herbicide programs in this SCBG. We have tested a new program on 25 species and found low injury and great efficacy on 22 in order to offer of Tower EC + Dimension 2EW as a new standard liquid that growers can use. We have also been able to determine three other alternative liquid programs.

ACTIVITIES PERFORMED

1. Research activities:
   a. Table 1 (Summary of tables: 2 to 12)
   b. Fig. 1, 2, 3, 4 and 5.

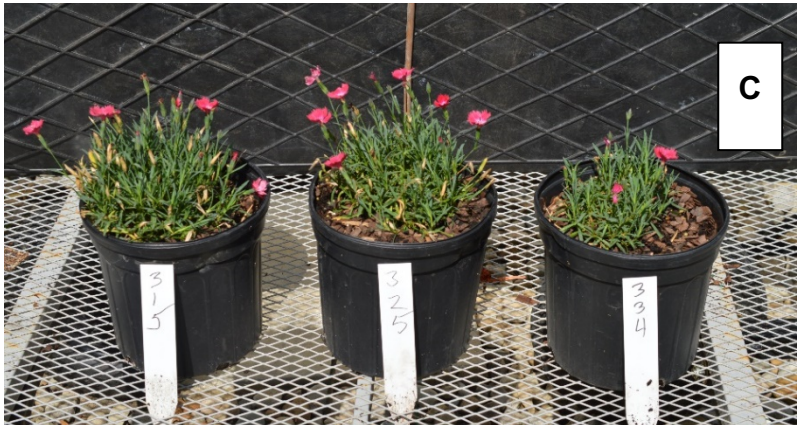
Table 1. Summary of results for 1X Tower EC + ½ Dimension 2EW a new standard liquid treatment from Tables 2-12 (p. 2-5, below) are presented. Evaluation year, 2020-2021; trial type phytotoxicity (P) and/or efficacy (E); species and growth measures are indicated. The number of other treatments with the new standard are also indicated.

Table No.	Item#	Species	Treatments Evaluated & Year	Trial Type (P) or (E) or (P&E)	New Standard Herbicide Combo	Av. Phyto Score/ Eff. Score	Δ^{w}HT (P) Weight (E)	ΔGI (P)
2	**i** **ii**	**Hemerocallis 'Stella D Oro'** **Hemerocallis 'Happy Returns'**	7 (Spring 2020)	P&E	1X Tower EC + ½ Dimension 2EW	0.0/ 8.2 (over 24 weeks) 1.1/9.7 (over 12 weeks)	--	--
3	**i**	**Allium 'Millennium'**	7 (Spring 2020)	P&E	1X Tower EC + ½ Dimension 2EW	0.7/9.6 (over 24 weeks)	--	--
4	**i** **ii**	**Hosta 'Francee'** **Hosta 'Gold Standard'**	7 (Spring 2020)	P&E	1X Tower EC + ½ Dimension 2EW	0.0/7.5 (over 12 weeks) 1.0/8.1 (over 12 weeks)	--	--
5	**New herb.**	**Large Crabgrass (*Digitaria sanguinalis*)**	6 (Spring 2020)	E	1X Tower EC + ½ Dimension 2EW	Eff =1.8 weeds (over 10 weeks)	34.2 (50% v. control)	--
6	**Old herb.**	**Large Crabgrass (*Digitaria sanguinalis*)**	5 (Spring 2020)	E	Devrinol + Dimension	Eff =0 weeds (over 10 weeks)	0 v. 67.9g control	--
7	**New herb.**	**Common ragweed (*Ambrosia artemisiifolia*)**	6 (Spring 2020)	E	1X Tower EC + ½ Dimension 2EW	Eff =0.2 weeds (over 10 weeks)	0 v. 14.3 g control)	--

8	**Old herb.**	**Common ragweed (*Ambrosia artemisiifolia*)**	5 (Spring 2020)	E	Devrinol + Dimension	Eff =0.5 weeds (over 10 weeks)	0 v. 14.3 g control)	--
9	**i**	**Hosta 'Patriot**	2 (Winter 2020-Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	3.0 (over 30 weeks)	--	--
	ii	***Panicum virgatum* 'Shenandoah'**	2 (Winter 2020-Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	0 (over 30 weeks)	--	--
	iii	***Paeonia* 'Benjamin Franklin'**	2 (Winter 2020-Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	1.0 (over 30 weeks)	--	--
	iv	***Achillea* 'Terracoto'**	2 (Winter 2020-Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	0 (over 30 weeks)	--	--
	v	***Asclepias incarnata***	2 (Winter 2020-Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	0 (over 30 weeks)	--	--
	vi	***Vinca minor***	2 (Winter 2020-Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	0 (over 30 weeks)	--	--
	vii	***Hemerocallis* 'Stella D Oro'**	2 (Winter 2020-Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	1 (over 9 weeks)	--	--

10	**A**	***Phlox paniculata* 'Bright Eyes'**	3 (Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	3.8 (over 9 weeks)	+2	+370
	B	***Iris germanica 'Stepping Out'***		P	1X Tower EC + ½ Dimension 2EW	0.3 (over 9 weeks)	+6	+474
	C	***Dianthus gratianopolitanus* 'Vivid Cherry Charm'**	3 (Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	0.3 (over 9 weeks)	+2	+96
	D	***Phlox paniculata* 'Fashionably Early'**	3 (Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	0.2 (over 9 weeks)	No change	+894
	E	***Hemerocallis* 'Passionate Returns'**	2 (Summer 2021)	P	1X Tower EC + ½ Dimension 2EW	0.0 (over 9 weeks)	No change	+3983
11		**Common wood sorrel (O*xalis stricta)***	3 (Summer 2021)	**E**	1X Tower EC + ½ Dimension 2EW	10 perfect (after 13 weeks)	0 v. 55.5 g control	
12	**A**	***Hosta 'Frances William'***	3 (Summer 2021)	**P**	1X Tower EC + ½ Dimension 2EW	2.6 (over 6 weeks)	+1.5	+284
	B	***Echinacea Purpurea***	3 (Summer 2021)	**P**	1X Tower EC + ½ Dimension 2EW	3.0 (over 6 weeks)	-5.0	-2317
	C	***Geranium calliope 'Orange Splash'***	3 (Summer 2021)	**P**	1X Tower EC + ½ Dimension 2EW	2.0 (over 6 weeks)	+2.5	+550
	D	***Coleus 'Beauty of Lyon'***	3 (Summer 2021)	**P**	1X Tower EC + ½ Dimension 2EW	3.5 (over 6 weeks)	+1.1	-235

Fig. A, B., C and D. A. (left) *Phlox paniculata* 'Bright Eyes' sprayed with treatments as listed in Table 10A. With tmt 2 being 1X Tower EC + ½ Dimension 2EW (middle) and control far right at 2 WAT on July 12, 2021. There is some stunting and delay in flowering but almost a plant growth regulator (PGR) effect which makes for a sturdier plant. The third treatment which is 2 applications or treatment #3 (2nd number on tag), is considerably phytotoxic. **B. (below)** The *Phlox paniculata* 'Fashionably Early' is considerably less effected by the 1X Tower EC + ½ Dimension 2EW than the 'Bright Eyes' at this stage of growth but still showing the same PGR effect. **C. (below left)** *Dianthus gratianopolitanus* 'Vivid Cherry Charm' shows little variation between the control (far right) and the 1X Tower EC + ½ Dimension 2EW (middle) at 6 WAT or August 5, 2021. **D.** (lower right) *Hemerocallis* 'Passionate Returns' *at 6 WAT is unaffected by the* 1X Tower EC + ½ Dimension 2EW (Right) vs. Control (left).Photos by: Dr. H. Mathers.



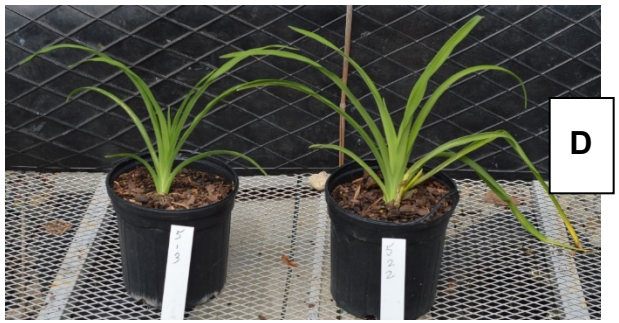


Table 2. i. and ii. Walters Gardens, Zeeland, MI old/new herbicide combos on Fall 2019 planted *Hemerocallis* with four replications of two rows per replicate, or 8 plants per replicate, for 32 daylilies per treatment. Two cultivars are evaluated **A.** 'Stella de Oro daylily (Hemerocallis 'Stella D' Oro') and **B.** 'Happy Returns' daylily (*Hemerocallis* 'Happy Returns'). At application, the temperature was 40°F and winds were 8 mph. The trial was initiated in 04/16/2020 including measures of height (Ht), width (W_1) and a second width (W_2) taken at perpendicular to the first. Phytotoxicity and efficacy ratings are explained in the footnotes and occurred at 4 weeks after treatment (4 WAT) and 7 WAT. Evaluations will continue monthly until efficacy of all treatments reaches an overall mean of 4, 6., 7, 12, 17 and 24 WAT for "Stella D' Oro'. Unfortunately, the 'Happy Returns' was harvested and sold by Walters Gardens, shortly after we completed our July 8, 2020 evaluations. Walters had an inventory shortages of this cultivar that caused this ending of the trial. Therefore, we were only able to evaluate this cultivar at 4,6,7 and 12 WAT. This study meets objective 3 and 4 for season-long environmentally sound program development using newer herbicides combined with older herbicides to provide alternatives to the current program of Gallery/Pendulum with the addition of glyphosate and a 2,4-D in the dormant period.

i. Stella D'Oro daylily (*Hemerocallis* 'Stella D'Oro')

	Treatment Applied 04/16/2020 Recently emerged daylilies	Rate/ac	Initiation (means)			1st Eff.[x] 4 WAT[z] (5/13)	2nd Eff. 6 WAT (5/27)	3rd Eff. 7 WAT (6/5)	4th Eff. 12 WAT (7/8)	5th Eff. 17 WAT (8/12)	6th Eff. 24 WAT (9/30)	1st Phyto.[y] 4 WAT (5/13)	2nd Phyto. 6 WAT (5/27)	3rd Phyto. 7 WAT (6/5)	4th Phyto. 12 WAT (7/8)	5th Phyto. 17 WAT (8/12)	6th Phyto 24 WAT (9/30)
			Ht (in)	W_1 (in)	W_2 (in)												
1	1X Tower 6EC + ½ X Dimension 2EW	21 oz + 16 oz	4	7	7	9.8a	9.0bc	9.0bc	8.6bc	7.8d	6.0b	1.0ab	0.0a	0.0a	0.5a	0.0a	0.0a
2	Tower 6EC + Pendulum Aqua Cap	24 oz + 50.4oz	4	4	5	9.0a	9.0bc	9.0bc	8.5bc	7.0cd	5.8b	1.8b	0.3a	0.3a	0.0a	0.0a	0.0a
3	½ Tower 6EC + 1X Pennant Magnum	10.5 oz + 32oz	4	4	7	9.8a	8.3b	8.3b	7.5b	6.0c	4.8b	2.3b	1.0a	1.0a	0.5a	0.0a	0.0a
4	½ Tower 6EC + ½ Pennant Magnum	10.5 + 16 oz	4	7	7	9.5a	9.3bc	9.3bc	8.5bc	6.8cd	5.0b	2.0b	1.0a	1.0a	0.5a	0.0a	0.0a
5	Devrinol DF- XL	8 lb./ac	4	6	5	9.5a	9.8c	9.8c	8.0bc	4.0b	0.0a	1.8b	0.0a	0.0a	0.0a	0.0a	0.0a
6	Dimension 2EW	32 oz	4	9	8	9.8a	9.8c	9.8c	9.3c	7.0cd	5.0b	1.0a	0.3a	0.3a	0.0a	0.0a	0.0a
7	Control	--	3	10	6	9.0a	5.5a	5.5a	4.8a	2.0a	0.0a	0.0a	0.3a	0.3a	0.5a	0.0a	0.0a

ii. 'Happy Returns' daylily (*Hemerocallis* 'Happy Returns')

	Treatment Applied 04/16/2020 Recently emerged daylilies	Rate/ac	Initiation (means)			1st Efficacy[x] 4 WAT[z] (5/13)	2nd Efficacy 6 WAT (5/27)	3rd Efficacy 7 WAT (6/5)	4th Efficacy 12 WAT (7/8)	1st Eval. Phyto.[y] 4 WAT (5/13)	2nd Eval. Phyto. 6 WAT (5/27)	3rd Phyto. 7 WAT (6/5)	4th Phyto. 12 WAT (7/8)
			Ht (in)	W_1 (in)	W_2 (in)								
1	**1X Tower 6EC + ½ X Dimension 2EW**	**21 oz + 16 oz**	5	7	7	9.8a[≠]	9.8a	9.8a	9.5b	2.9b	0.8	0.8	0.0a
2	**Tower 6EC + Pendulum Aqua Cap**	**24 oz + 50.4oz**	4	6	7	9.0a	9.0a	9.0a	8.5b	2.5b	0.0a	0.0a	0.0a
3	**½ Tower 6EC + 1X Pennant Magnum**	**10.5 oz + 32oz**	5	8	5	10.0a	9.5a	9.8a	10.0b	0.8ab	0.0a	0.0a	0.0a
4	**½ Tower 6EC + ½ Pennant Magnum**	**10.5 + 16 oz**	5	6	7	10.0a	9.5a	9.8a	10.0b	2.3b	0.8a	0.8a	0.0a
5	**Devrinol DF- XL**	**8 lb./ac**	5	6	7	10.0a	10.0a	10.0a	9.3b	2.5b	0.8a	0.8a	0.0a
6	**Dimension 2EW**	**32 oz**	5	4	6	10.0a	9.5a	9.8a	9.5b	2.5b	2.3b	2.3b	0.0a
7	**Control**	**--**	4	5	6	10.0a	9.3a	9.7a	6.5a	0.3a	0.3a	0.3a	0.0a

z = weeks after treatment

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

X = Efficacy (Eff.) ratings are based on a 0-10 scale with 10 being complete control, 0 no weed control, and >7 commercially acceptable control.

≠ = Treatments with different letters signify efficacy was statistically different at p=0.05 using LS means following ANOVA in SAS.

Table 3. i. *Allium* 'Millennium' Walters Gardens, Zeeland, MI old/new herbicide combos on Spring 2020 planted bulbs with four replications consisting of two rows per replicate, or 16 plants per replicate, for 64 allium per treatment. No prior herbicides were applied, and no winter wheat was planted. The trial was initiated in 04/15/2020, 8:30 – 9:00 pm, the temperature was 32°F, and wind speed was 2 mph. Phytotoxicity and efficacy are explained in the footnotes and occurred at 4 weeks after treatment (WAT) (5/13/20) 6, 7, 12, 17 and 24 WAT. This study meets objective 3 and 4 for season-long environmentally sound program development.

i. ***Allium* 'Millennium'**

	Treatment Applied 04/16/2020 Recently emerged daylilies	Rate/ac	Initiation (means)			1st Eff.[x] 4 WAT[z] (5/13)	2nd Eff. 6 WAT (5/27)	3rd Eff. 7 WAT (6/5)	4th Eff. 12 WAT (7/8)	5th Eff. 17 WAT (8/12)	6th Eff. 24 WAT (9/30)	1st Phyto.[y] 4 WAT (5/13)	2nd Phyto. 6 WAT (5/27)	3rd Phyto. 7 WAT (6/5)	4th Phyto. 12 WAT (7/8)	5th Phyto. 17 WAT (8/12)	6th Phyto 24 WAT (9/30)
			Ht (in)	W_1 (in)	W_2 (in)												
1	**1X Tower 6EC + ½ X Dimension**	**21 oz + 16 oz**	1.5	2.5	2	10.0a	10.0b	10.0b	9.8c	9.3e	8.5c	2.5b	0.8ab	0.8ab	0.0a	0.0a	0.0a
2	**Tower 6EC + PendulumAC**	**24 oz + 50.4oz**	1	1	1.5	1.00a	9.5ab	9.5ab	9.0bc	8.5de	8.0c	1.5b	2.0b	2.0b	0.0a	0.0a	0.0a
3	**½ Tower 6EC + 1X Pennant**	**10.5 oz + 32oz**	1.8	2	1.5	10.0a	9.8b	9.8b	8.3b	4.5b	1.0a	1.3ab	0.8ab	0.8ab	0.0a	0.0a	0.0a
4	**½ Tower 6EC + ½ Pennant**	**10.5 + 16 oz**	1	2	1	10.0a	9.8b	9.8b	9.0bc	7.0c	5.0b	0.3a	0.0a	0.0a	0.0a	0.0a	0.0a
5	**Devrinol**	**8 lb.**	1.5	1.8	1.5	10.0a	8.8a	8.8a	8.3b	7.3dc	5.0b	0.3a	0.0a	0.0a	0.0a	0.0a	0.0a
6	**Dacthal Flow + Dimension**	**8 lb. + 32 oz**	1.5	1.5	2.5	10.0a	10.0b	10.0b	9.0bc	7.5dc	6.5b	2.0b	0.3a	0.3a	0.0a	0.0a	0.0a
7	**Control**	**--**	1	2.3	1.5	9.8a	8.3a	8.3a	5.0a	2.8a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a	0.0a

z = weeks after treatment

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

X = Efficacy (Eff.) ratings are based on a 0-10 scale with 10 being complete control, 0 no weed control, and >7 commercially acceptable control.

≠ = Treatments with different letters signify efficacy was statistically different at p=0.05 using LS means following ANOVA in SAS.

Table 4. i. and ii. Walters Gardens, Zeeland, MI *Hosta* planted October 2019, 4 replications consisting of two rows per replicate, or 12 plants per replicate, for 48 plants per treatment, initiated 04/16/2020 the temperature was 40°F and winds were 12 mph. Two *Hosta* cultivars are evaluated **A.** *Hosta* 'Francee and **B.** *Hosta* 'Gold Standard' and were dormant at application. Grass had been seeded for winter protection but was dying out by the 2nd evaluation due to a dormant spray of glyphosate before *Hosta* emergence. At the 1st evaluation there was frost injury present with greater impact on the 'Gold Standard.' Due to dormancy no shoot heights or other measures were collected. Phytotoxicity and efficacy ratings are explained in the footnotes and occurred at 4 weeks after treatment (4 WAT), 6, 7 and 12 WAT. Unfortunately, none of the treatments at 12 WAT were providing commercially acceptable weed control and thus further evaluations were cancelled. The lack of poor weed control at 12 WAT was blamed on less deposition of the chemical due to higher winds than suitable for spraying. This study meets objective 3 and 4 for season-long environmentally sound program development.

i. Hosta 'Francee'

	Treatment Applied 04/16/2020 Dormant Hosta	Rate/ac	1st Eval. Efficacy[x] 4 WAT[z] (May 13)	2nd Eval. Efficacy 6 WAT (May 27)	3rd Efficacy 7 WAT (June 5)	4th Efficacy 12 WAT (July 8)	1st Eval. Phyto.[y] 4 WAT (May 13)	2nd Eval. Phyto. 6 WAT (May 27)	3rd Phyto. 7 WAT (June 5)	4th Phyto. 12 WAT (July 8)
1	**1X Tower 6EC + ½ X Dimension 2EW**	**21 oz + 16 oz**	9.3b	8.8b	8.0b	3.8cd	0.0a	0.0a	0.0a	0.0a
2	**Tower 6EC + Pendulum Aqua Cap**	**24 oz + 50.4oz**	9.3b	8.5b	7.8b	2.8bc	0.0a	0.8a	0.8a	0.0a
3	**½ Tower 6EC + 1X Pennant Magnum**	**10.5 oz + 32oz**	7.3a	7.5ab	7.5ab	6.0e	0.3ab	0.8a	0.8a	0.0a
4	**½ Tower 6EC + ½ Pennant Magnum**	**10.5 + 16 oz**	8.5ab	8.5b	8.1b	2.0ab	1.3ab	2.3b	2.3b	0.0a
5	**Dacthal Flowable**	**12.67 oz**	9.3b	8.5b	7.0b	2.5ab	0.8a	0.3a	0.3a	0.0a
6	**Devrinol DF-XL + Dimension**	**8 lb. + 32 oz**	8.0a	8.0ab	8.0ab	4.0d	1.5b	0.0a	0.0a	0.0a
7	**Control**	**--**	7.0a	7.0a	6.0a	1.0a	0.0a	0.0a	0.0a	0.0a

ii. Hosta 'Gold Standard'

	Treatment Applied 04/16/2020 Dormant Hosta	Rate/ac	1st Eval. Efficacy[x] 4 WAT[z] (5/13)	2nd Efficacy 7 WAT (5/27)	3rd Efficacy 7 WAT (6/5)	4th Efficacy 12 WAT (7/8)	1st Phyto.[y] 4 WAT (5/13)	2nd Phyto. 7 WAT (5/27)	3rd Phyto. 7 WAT (6/5)	4th Phyto. 12 WAT (7/8)
1	**1X Tower 6EC + ½ X Dimension 2EW**	**21 oz + 16 oz**	10.0b	9.0b	8.5a	4.8b	4.0b	1.0a	0.0a	0.0a
2	**Tower 6EC + Pendulum Aqua Cap**	**24 oz + 50.4oz**	9.5ab	8.8b	7.8a	5.8c	3.3ab	1.3a	0.0a	0.0a
3	**½ Tower 6EC + 1X Pennant Magnum**	**10.5 oz + 32oz**	9.0ab	8.0ab	7.6a	4.0ab	3.5ab	0.0a	0.0a	0.0a
4	**½ Tower 6EC + ½ Pennant Magnum**	**10.5 oz + 16 oz**	8.5a	8.8b	8.4a	6.8c	3.8ab	0.5	0.0a	0.0a
5	**Dacthal Flowable**	**12.67 oz**	8.5a	8.3ab	8.0a	5.5bc	3.5ab	0.0a	0.0a	0.0a
6	**Devrinol DF-XL + Dimension**	**8 lb. + 32 oz**	9.5ab	8.9b	7.8a	4.0ab	4.3b	0.5a	0.0a	0.0a
7	**Control**	**--**	9.8ab	7.3a	7.0a	3.0a	2.5a	0.8a	0.0a	0.0a

z = weeks after treatment

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

X = Efficacy (Eff.) ratings are based on a 0-10 scale with 10 being complete control, 0 no weed control, and >7 commercially acceptable control.

≠ = Treatments with different letters signify efficacy was statistically different at p=0.05 using LS means following ANOVA in SAS.

Table 5: Effects of newer herbicides and their combinations on large crabgrass (*Digitaria sanguinalis*)

Treatments	Weed counts					Weed fresh weight (g)
	Week 2	Week 4	Week 6	Week 8	Week 10	Week 10
Control (no herbicides)	2.3a*	4.3a	4.5a	4.5a	4.5a	67.9a
1×Tower + 1/2×Dimension	1.3b	2.3b	2b	2b	1.5b	34.2b
1×Tower + 1×Dimension	0c	0c	0.75c	0c	0c	0c
1×Tower + 1×Pendulum Aquacap	0c	0c	0.5c	0c	0c	0c
½ × Tower + 1 × Pennant Magnum	0c	0c	0c	0c	0c	0c
½ × Tower + ½ × Pennant Magnum	0c	0c	0c	0c	0c	0c

*Weed counts and weed fresh weights followed by the same letter are not significantly different within a column. Dr. Saha, PI

Table 6: Effects of older herbicides and their combinations on large crabgrass (*Digitaria sanguinalis*)

Treatments	Weed counts					Weed fresh weight (g)
	Week 2	Week 4	Week 6	Week 8	Week 10	Week 10
Control (no herbicides)	2.3a*	4.3a	4.5a	4.5a	4.5a	67.9a
Devrinol	0b	0b	0c	0b	0b	0b
Devrinol + Trifluralin	0.5b	0.5b	1.8b	0b	0b	0b
Devrinol + Dimension	0.5b	0.8b	2b	0.5b	0b	0b
Dacthal	0.8b	0.8b	2.5b	0b	0b	0b

*Weed counts and weed fresh weights followed by the same letter are not significantly different within a column. Dr. Saha, PI

Fig 2. A. Shown is large crabgrass and **B.** common ragweed at 10 WAT. Treatment 1 is in the top left and treatment 2 is in the top right, and the numbering proceeds down the left and right columns, ending with the control or treatment 10 in the bottom right. The treatment numbers which are as follows: 1. 1 × Tower + ½ × Dimension; 2. 1 × Tower + 1 × Dimension; 3. 1 × Tower + 1 × Pendulum Aquacap; 4. ½ × Tower + 1 × Pennant Magnum; 5. ½ × Tower + ½ × Pennant Magnum; 6. Devrinol; 7. Devrinol + Trifluralin; 8. Devrinol + Dimension; 9. Dacthal; 10. Control (no herbicides). Dr. Saha, PI.

Table 7: Effects of newer herbicides and their combinations on common ragweed (*Ambrosia artemisiifolia*)

Treatments	Weed counts					Weed fresh weight (g)
	Week 2	Week 4	Week 6	Week 8	Week 10	Week 10
Control (no herbicides)	3a	2a	2.5a	2.3a	0.8a	14.3a
1×Tower + 1/2×Dimension	0.3b	0.8b	0b	0b	0b	0c
1×Tower + 1×Dimension	0b	0.3c	0.5b	0.5b	0b	0c
1×Tower + 1×Pendulum Aquacap	0.3b	0.3c	0b	0.5b	0b	0c
½ × Tower + 1 × Pennant Magnum	0b	0.5c	0.5b	0.5b	0b	0c
½ × Tower + ½ × Pennant Magnum	0.8b	1b	0.8b	0.5b	0.3b	3.94b

*Weed counts and weed fresh weights followed by the same letter are not significantly different within a column. Dr. Saha, PI

Table 8: Effects of older herbicides and their combinations on common ragweed (*Ambrosia artemisiifolia*)

Treatments	Weed counts					Weed fresh weight (g)
	Week 2	Week 4	Week 6	Week 8	Week 10	Week 10
Control (no herbicides)	3a*	2a	2.5b	2.3b	0.8a	14.3a
Devrinol	1.8b	1.3b	1.5c	1.5c	0.5a	6.2b
Devrinol + Trifluralin	0.5c	0.3c	0.8d	0.8d	0a	0c
Devrinol + Dimension	1.3ab	1b	2.3b	1.5c	0a	0c
Dacthal	1.3ab	1.3b	3.3a	3.3a	0.5a	5.2b

*Weed counts and weed fresh weights followed by the same letter are not significantly different within a column. Dr. Saha, PI

Table 9. Ray Wiegand's Nursery, Lenox, MI seven species as listed along the left side were evaluated with two treatments from 11/18/2020 to 06/14/2021 at 17 WAT, 21 WAT and 30 WAT. Each phytotoxicity mean represents six replications of one-gallon containerized herbaceous plants. Phytotoxicity and efficacy ratings were taken after overwintering to observe phytotoxicity and efficacy of dormant applications in a polyhouse into June. Phytotoxicity scoring was conducted according to Bayer Crop Science ratings where 1= Best, 2 = No symptoms but stunting, 3 = Slight chlorosis, 4= Malformation and chlorosis and 5 = Dead (severe distortion and chlorosis).

Species	***Tmt***	***Rate***	***Phyto. Start-11/18/20***	***Phyto. Eval 1-3/16/21***	***Phyto Eval 2-4/15/21***	***Phyto Eval 3-06/14/21***	***Av. Phyto over dates***
			Dormant	*Dormant*	*Emerged*	*1*	*1*
i.Hosta 'Patriot	***Control***	**-**			*1*		
	1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	*Dormant*	*Dormant*	*Emerged*	*1*	*1*
					1		
ii.Panicum virgatum			*Dormant*	*Dormant*	*Emerged*	*1*	*1*
'Shenandoah'	***Control***	**-**			*1*		
	1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	*Dormant*	*Dormant*	*Emerged*	*1*	*1*
					1		
iii.Paeonia			*Dormant*	*Dormant*	*Emerged*	*1*	*1*
'Benjamin Franklin'	***Control***	**-**			*1*		
	1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	*Dormant*	*Dormant*	*Emerged*	*2*	*1.5*
					1		

iv.Achillea 'Terracoto'	***Control***	**-**	*Dormant*	*Dormant*	*Emerged 1*	*1*	*1*
	1X Tower 6EC + ½ X Dimension 2EW		*Dormant*	*Dormant*	*Emerged 1*	*1*	*1*
v.Ascelepias incarnata	***Control***	**-**	*Dormant*	*Dormant*	*Dormant*	*1*	*1*
	1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	*Dormant*	*Dormant*	*Dormant*	*1*	*1*
vi.Vinca minor	***Control***	**-**	*0*	*0*	*Emerged 1*	*1*	*1*
	1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	*0*	*0*	*Emerged 1*	*1*	*1*
vii. Hemerocalis 'Stella D Oro'	***Control***	**-**	*0*	*0*	*Emerged 1*	*1*	*1*
	1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	*0*	*0*	*Emerged 1.3*	*1*	*1.15*

Fig. 3. A, B. and C (Left). A. (Top left) *Hosta* 'Patriot' showing left to right Treatments 5, 4,3,2,and 1. Treatment 1 (far right is the control, and treatment 5 (far left) 1X Tower EC + ½ Dimension 2EW on June 14, 30 weeks after treatment (WAT) at Ray Wiegand's Nursery, Lenox, MI. This was a dormant trial with application in November, 2020. 1X Tower EC + ½ Dimension 2EW were fuller than the controls. **B. (Middle left)** *Hemerocallis* 'Stella D' Oro, as for A, the far right plant is the control, and far left is 1X Tower EC + ½ Dimension 2EW on June 14, 30 weeks after treatment (WAT). **C. (Bottom left)** *Panicum virgatum* 'Shenandoah' showing the same order of treatments as in A and B. Photos by: Dr. H. Mathers.

The results for treatment 2, 3 and 4 (middle treatments in each of the three species shown above) are not presented in this report as they were granular herbicide treatment and not part of the research. However, for the readers information, Treatment 2, 3 and 4 were Marengo G a 125 lb/ac, 200 lb/ac and 300 lb/ac applied over-the-top (OTT) in covered houses with dormant plants.

Table 10 (A, B, C, D, E). Present results of five species (names are listed in the 2nd column of each table initiated on June 24, 2021 to compare the phytotoxicity of the species to the 1X Tower + ½ Dimension spray to the control and the same treatment + 22% of the normal rate of 9 oz of Marengo SC (i.e., 2 oz/ac added) to improve efficacy. See bottom of table 4 for phytotoxicity scores.

Table 10A. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 06/24/2021.

Phlox paniculata 'Bright Eyes' #1 pots

Treatment	Rate(ai)[v]	2 WAT[z]	3 WAT	4 WAT	6 WAT	9 WAT	1st Ht	1st GI	End Ht	End GI	Δ[w] HT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	3.4 b	3.6 b	6.2 c	4.0 b	2.0 b	7	185	9	555	+2	+370b
1X Tower 6EC + ½ X Dimension 2EW + Marengo SC	**21 oz + 16 oz + 2 oz**	6.0 c	7.6 c	9.2 d	9.6 d	9.6 d	6	117	4	20	-2	-97d
Untreated	--	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	7	171	13	735	+6	+560a

Table 10B. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 06/24/2021.

Iris germanica 'Stepping Out' #1 pots

Treatment	Rate(ai)[v]	2 WAT[z]	3 WAT	4 WAT	6 WAT	9 WAT	1st Ht	1st GI	End Ht	End GI	Δ[w] Ht	ΔGI
1X Tower 6EC + ½ X Dimension 2	**21 oz + 16 oz**	0.0 a	0.0 a	0.0 a	0.0 a	1.4 a	7	38	13	512	+6	+474b
1X Tower 6EC + ½ X Dimension 2EW + Marengo SC	**21 oz + 16 oz + 2 oz**	0.0 a	0.0 a	0.0 a	1.2 a	0.8 a	7	56	14	225	+7	+169c
Untreated	--	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	7	65	16	1051	+9	+986a

Table 10C. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 06/24/2021.

Dianthus gratianopolitanus 'Vivid Cherry Charm' #1 pots

Treatment	Rate(ai)[v]	2 WAT[z]	3 WAT	4 WAT	6 WAT	9 WAT	1st Ht	1st GI	End Ht	End GI	ΔHT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0.0 a	0.0 a	0.0 a	1.4 a	0.0 a	3	68	5	164	+2	+96
1X Tower 6EC + ½ X Dimension 2EW + Marengo SC	**21 oz + 16 oz + 2 oz**	0.0 a	0.0 a	0.0 a	0.8 a	3.8 b	4	69	4	123	no	+57
Untreated	--	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	3	90	5	188	+2	+98

Table 10D. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 06/24/2021.

Phlox paniculata 'Fashionably Early' #1 pots

Treatment	Rate(ai)[v]	2 WAT[z]	3 WAT	4 WAT	6 WAT	9 WAT	1st Ht	1st GI	End Ht	End GI	ΔHT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0.0 a	0.0 a	0.0 a	0.8 a	0.0 a	14	1204	14	2098	no	+894
1X Tower 6EC + ½ X Dimension 2EW + Marengo SC	**21 oz + 16 oz + 2 oz**	0.0 a	0.0 a	0.0 a	3.8 b	4.4 b	16	1699	16	1687	no	-12
Untreated	--	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	16	1176	16	2227	no	+1051

Table 10E. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 06/24/2021.

Hemerocallis 'Passionate Returns' #1 pots

Treatment	Rate(ai)[v]	2 WAT[z]	3 WAT	4 WAT	6 WAT	9 WAT	1st Ht	1st GI	End Ht	End GI	ΔW HT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	19	119	16	4102	no	+3983
Untreated	--	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	18	126	17	2856	no	+2730

Table 11. A companion efficacy trial was conducted for the phytotoxicity trials presented in Table 4 (A,B,C,D and E) with the same treatments The efficacy trial was conducted with common wood sorrel (*Oxalis stricta)* seed gathered a few weeks before seeding on June 28, 2021. The seed was imbibed for 24 hrs. before seeding in 1 gallon pots and applications followed immediately. Germination began on July 9, 2021 (11 days after treatment, DAT) in the controls only. Some germination did occur in one pot of treatment 3 at 59 DAT. The 1st evaluation was conducted on July 12 (14 DAT) and followed on July 24 (26 DAT), Aug. 24 (59 DAT) and Sept. 25 (13 weeks after treatment 13 WAT), weights were also evaluated at 13 WAT. The average of four replication/ treatment are presented. Counts of weeds were done up to 7/24/21 but after that ratings were conducted where 0 was no control, and 10 is perfect control.

Treatment	Rate(ai)[v]	11 DAT Weed #'s	14 DAT Weed #'s	26 DAT Weed #'s	59 DAT Rating	13 WAT Rating	Wt. 13 WAT
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0 a	0 a	0 a	10 a	10 a	0
1X Tower 6EC + ½ X Dimension 2EW + Marengo SC	**21 oz + 16 oz + 2 oz**	0 a	0.0 a	0 a	9 b	8 b	6 g
Untreated	--	0 a	15 b	33 c	0 a	0 a	55.5g

Table 12 (A, B, C and D). Present results of four species (names are listed in the 2nd row of each table initiated on July 21,2021 to compare the phytotoxicity of the species to the 1X Tower + ½ Dimension spray, 2X Tower + 1X Dimension to the control. Since the 1X Tower + ½ Dimension had provided such low phytotoxicity to the herbaceous perennial some common annual bedding plants were added. See bottom of table 4 for phytotoxicity scores.

Table 12A. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 07/21/2021.

Hosta 'Frances William' – C400 pots

Treatment	Rate(ai)[v]	0 WAT[z]	3 WAT	4 WAT	6 WAT	1st Ht	1st GI	End Ht	End GI	ΔwHT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0.0 a	4.5 b	3.0 b	3.0 b	7.0	714	8.5a	998	+1.5	+284
2X Tower 6EC + 1 X Dimension 2EW	**21 oz + 16 oz**	0.0 a	3.5 b	2.0 b	2.0 d	13.0	1112	8.6a	491	-4.4	-621
Untreated	--	0.0 a	0.0 a	0.0 a	0.0 a	9.0	1252	8.5a	1047	-0.5	-205

Table 12B. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 07/21/2021.

Echinacea purpurea – C600 pots

Treatment	Rate(ai)[v]	0 WAT[z]	3 WAT	4 WAT	6 WAT	1st Ht	1st GI	End Ht	End GI	ΔwHT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0.0 a	0.8 a	3.0 b	0.0 a	23.8	6511	18.8	4194	-5.0	-2317
2X Tower 6EC + 1 X Dimension 2EW	**21 oz + 16 oz**	0.0 a	1.5 b	2.0 b	2.0 b	28.5	9182	20.8	5238	-7.7	-3944
Untreated	--	0.0 a	0.0 a	0.0 a	0.5 a	24.3	4920	21.3	5371	-3.0	+451a

Table 12C. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 07/21/2021.

Geranium calliope 'Orange Splash' - C400 pots

Treatment	Rate(ai)[v]	0 WAT[z]	3 WAT	4 WAT	6 WAT	1st Ht	1st GI	End Ht	End GI	ΔwHT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0.0 a	4.0 b	6.0 c	4.8 b	10.0a	1483	12.5a	2033	2.5	+550
2X Tower 6EC + 1 X Dimension 2EW	**21 oz + 16 oz**	0.0 a	5.0 b	7.0 c	6.0 b	10.0a	1420	8.3b	987	-1.7	-433
Untreated	--	0.0 a	0.0 a	3.0 a	2.8 a	10.8a	1340	12a	1410	1.2	+80

Table 12D. Phytotoxicity ratings on selected herbaceous perennials at Ray Wiegand's Nursery, Lenox, MI, Initiated 07/21/2021.

Coleus 'Beauty of Lyon'

Treatment	Rate(ai)[v]	0 WAT[z]	3 WAT	4 WAT	6 WAT	1st Ht	1st GI	End Ht	End GI	ΔwHT	ΔGI
1X Tower 6EC + ½ X Dimension 2EW	**21 oz + 16 oz**	0.0 a	3.0 b	5.0 c	2.5 b	10.9a	1731	12.0b	1496	1.1	-235b
2X Tower 6EC + 1 X Dimension 2EW	**21 oz + 16 oz**	0.0 a	5.0 c	6.0 c	3.8 b	11.4a	2047	12.5b	1909	1.1	-138b
Untreated	--	0.0 a	0.0 a	0.0 a	0.0 a	10.3a	1459	16a	2996	5.7	+1537a

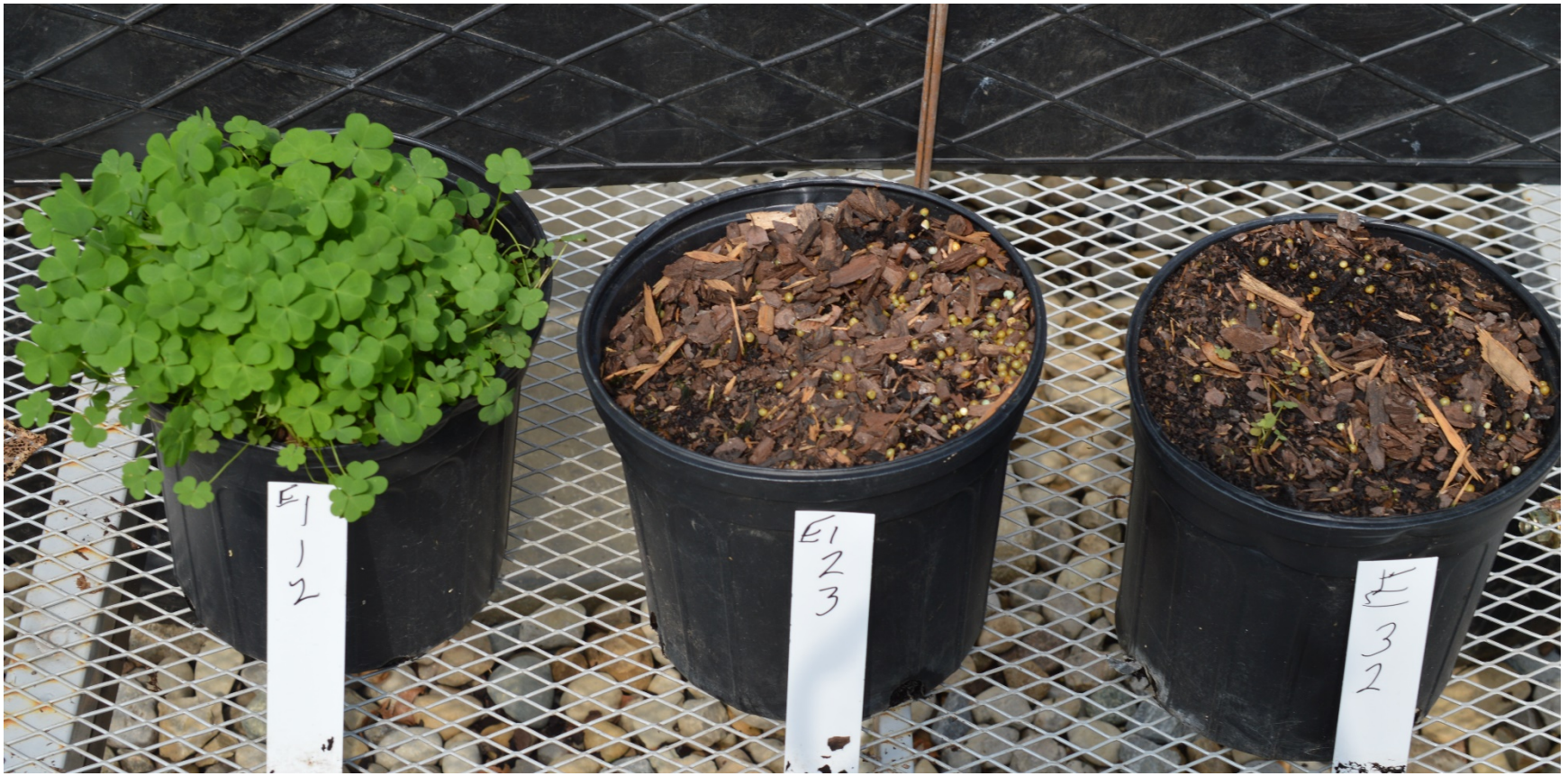


Fig 4. Above. A companion efficacy trial Reported in Table 11 is shown above. The efficacy trial was conducted with Common wood sorrel (*Oxalis stricta)* seed gathered a few weeks before seeding on June 28, 2021. The seed was imbibed for 24 hrs. before seeding in 1 gallon pots and applications followed immediately. Germination began on July 9, 2021 (11 days after treatment, DAT) in the controls only. Some germination did occur in one pot of treatment 3 (second number on tags)(far right) at 59 DAT. The control treatment one is at the far left of the photo. Oxalis is a difficult weed in MI nursery fields and containers. This photo was taken on Aug. 24 (59 DAT).

OBJECTIVES

Provide the approved project's objectives.

#	Objective	Completed? Yes	No*
1	Evaluate different rates for efficacy (weed control) of three liquid ornamental herbicides determine in the previous 2017-2019 SCBG (Tower, Pennant and Dimension), three previously older/ unevaluated liquids (Dacthal, Devrinol and Trifluralin) alone and in various combinations as tank mixes in HP crops in MI nursery fields/containers from December 2019 to summer 2021 at three locations.	X	
2	Evaluate phytotoxicity of three previously studied, three unstudied ornamental herbicides alone and in combinations previously untested in HP crops, as used in objective 1, on-site in MI nursery fields/containers from December 2019 to summer 2021 at three locations.	X	
3	Discover much needed information for shrewd MI HP growers that are conducive to their current equipment resources and cultural practices and are environmentally sound for field and container stock in season-long programs, via the study of controls found at the three current sites for application in two additionally sites that will be added in February 2021.	X	
4	Determine the effectiveness of the older herbicide formulations versus the newer herbicides at reducing and eradicating the problematic species that have proliferation in MI nursery fields/containers.	X	

*If no is selected for any of the listed objectives, you must expand upon this in the challenges and lessons learned sections.

N/A

ACCOMPLISHMENTS

List your accomplishments for the project's period of performance, including the impact they had on the project's beneficiaries, and indicate how these accomplishments assist in the fulfillment of your project's objective(s), outcome(s), and/or indicator(s).

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	Meet with growers in November 2019 to decide treatments that would best fit their weed control and current cultural practices.	Towards Outcome 3, 4, 5 and 8 – initial site visits established a baseline to gauge program impact on economic returns, resilient systems and enhance competitiveness of the sector.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
2	Presented two presentations at the MNLA Great Lakes Trade Exposition (GLTE) in 2020: a. Mathers, H.M. 2020. Sustainable landscape weed management. 2020 GLTE Michigan Nursery and Landscape Association. 150 industry members. Lansing, MI. (January 28). b. Mathers, H.M. 2020. How safe is glyphosate? 2020 GLTE Michigan Nursery and Landscape Association. 175 industry members. Lansing, MI. (January 28). Presented one virtual presentation at GLTE in 2021: i. Mathers, H.M. 2021. New herbicides and new uses. Presented with Zoom for Virtual Michigan Nursery and Landscape Association (MLNA) GLTE for January 25, 2021. This presentation was posted for 60 days by GLTE. 230 people viewed your presentation live, and 23 people viewed the recording afterwards. Three articles were written in the MNLA, Michigan Landscape Magazine with a circulation to 8200 industry members: ✓ Mathers, H.M. 2021. IR-4 Weed Study Results in the Midwest Region: Part 1: Marengo 74SC Michigan Landscape: 64(3):55-59. ✓ Mathers, H.M. 2020. The issues surrounding herbicide drift. Part 1: Crop sensitivity. Michigan Landscape: 63(4):42-44. ✓ Mathers, H.M. 2020. Nostoc control with OHP Kalmor. Michigan Landscape: 63(1):40-43.	Exceeding outcome 3, 4, 5 and 8. Exceeding Outcome 3, indicator 1a. i.e., of reaching 600 industry members by having 588 audience members for three talks at GLTE (despite COVID-19) and publishing three articles reaching 8200 people with each. Although, there was no opportunity for in person surveying in 2020 or 2021, we consider that Outcome 4, indicator 2a, 50 growers adoption of recommended practices; outcome 4, indicator 2b and 2c. 50 grower reduced pesticide use and reduced costs per ac for pesticides and Outcome 5, indicator 8,250 growers gained science-based tools via outreach programs. We also consider outcome 4, 2d is meet as Walters Gardens exceeds the 600 acres requirement in this indicator with 1,500 acres in field grown daylilies and Hosta, by itself. Outcome 5, indicator 6 was meet at Walters, Gardens Alive and Wiegand's. Outcome 8, indicator 5 increased revenue was reached at Walter Gardens alone.
3	The best treatment in the 2020 evaluations trial was **Tower 6EC (21 oz/ac) + Dimension 2EW (16 oz/ac**). This treatment is an alternative to Walters conventional program of, Gallery SC + Pendulum 3.3 EC. The Tower 6EC (21 oz/ac) + Dimension 2EW (16 oz/ac) has	Meeting Objective1,2, 3 and 4 by evaluating newer- Tower, Pennant and Dimension and older Dacthal, Devrinol and Trifluralin in efficacy and phytotoxicity trials to determine the best treatment, **Tower 6EC (21 oz/ac) + Dimension 2EW (16 oz/ac)**.

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	outperformed and out-lasted Walters Gallery + Pendulum conventional program, in six trials lasting (9-20 weeks) evaluated in multiple years and has shown its utility on a wide variety of species (see 22 genera/sp. listed below where Tower 6EC (21 oz/ac) + Dimension 2EW (16 oz/ac) has been trialed and has shown little phytotoxicity and good efficacy: *Achillea* 'Terracoto' *Allium* 'Millennium' *Asclepias incarnata* *Dianthus gratianopolitanus* 'Vivid Cherry Charm' *Geranium calliope* 'Orange Splash' *Hemerocallis* 'Happy Returns' *Hemerocallis* 'Passionate Returns' *Hemerocallis* 'Stella D Oro' *Hosta* 'Francee' *Hosta* 'Frances William' *Hosta* 'Gold Standard' *Hosta* 'Patriot *Iris germanica* 'Stepping Out' *Iris sibirica* 'Sparkling Rose' *Kniphofia pyromania*™ series 'Orange Blaze' *Kniphofia thomsonii* 'Gold Rush' *Paeonia* 'Benjamin Franklin' *Panicum virgatu*m 'Shenandoah' *Panicum virgatum* 'Shenandoah' *Phlox paniculata* 'Fashionably Early' *Sanguisorba minor* 'Little Angel' *Vinca minor*	This finding of a new herbaceous perennial standard treatment with little phytotoxicity on a wide variety of herbaceous perennial species/genera, including the big three, *Hosta, Hemerocallis* and *Iris.* The new standard has even shown utilization on some extremely herbicide sensitive species such as *Paeonia* and *Phlox* and on herbicide sensitive annuals such as *Geranium*. Meeting outcome 4, 2a, 2b, 2c, 2d; outcome 5, indicator 8, and Outcome 8, indicator 5.
4	By finding this new standard that can be used for so many field and container grown herbaceous genera/species, we enhanced the competitiveness of specialty crop and access for new growers, creating sustainable practices for increased yields and reduced inputs. This crop sector becomes more resilient and diverse by these findings and moves to improve the MI economy. We have started providing this program to HP growers in MI.	Exceeding outcome 3, 4, 5 and 8.

CHALLENGES AND DEVELOPMENTS

Provide any challenges to the completion of your project or any positive developments outside of the project's original intent that you experienced during this project. Also, provide the corrective

actions you took to address these issues. If you did not attain an approved objectives, outcome(s), and/or indicator(s), provide an explanation in the Corrective Actions column.

#	Challenge or Development	Corrective Action or Project Change
1	The major challenge to this project was COVID-19. The ban on out-of-state travel and reduced assess to in-person meetings meant no surveying could be conducted to assess some of our outcome indicators.	We still completed three industry presentations to high audience numbers and completed three magazine articles presented to the industry that served to show meeting and exceeding several of our outcome indicators.
2	COVID-19 also reduced the number of trial locations.	We had wanted to add some sites in 2021 but with the continuing issues of COVID-19 and business shut-down continuing into Spring 2021 in MI meant we were unable to do this.
3	COVID-19 restricting trial travel.	More isolated locations had to be used as test sites in 2021. This was done to reduce exposure of researchers to COVID and keep our sites with three nurseries.

LESSONS LEARNED

Provide recommendations or advice that others may use to improve their performance in implementing similar projects.

Previous relationship built with cooperators be it for herbicides or host sites proved invaluable when problems such as COVID-19 arose.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

Describe your plans for continuing the project (sustainability; capacity building) and/or disseminating the project results.

Three presentations are planned at the MNLA 2022 GLTE in January. The new standard herbicide program is already being advocated to the MI industry.

BENEFICIARIES

Number of project beneficiaries: 8,788 Enter Number of Project Beneficiaries

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

Provide the results of the project outcome(s) and indicator(s) as approved in your application and project proposal. The results of the outcome(s) and indicator(s) will be used to evaluate the performance of the Program on a national level.

OUTCOME MEASURE(S)

Select the Outcome Measure(s) that were approved for your project.

- ☐ **Outcome 1**: Enhance the competitiveness of specialty crops through increased sales
- ☐ **Outcome 2**: Enhance the competitiveness of specialty crops through increased consumption
- ☑ **Outcome 3**: Enhance the competitiveness of specialty crops through increased access
- ☑ **Outcome 4**: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources
- ☑ **Outcome 5**: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems
- ☐ **Outcome 6**: Enhance the competitiveness of specialty crops through increasing the number of viable technologies to improve food safety
- ☐ **Outcome 7**: Enhance the competitiveness of specialty crops through increased understanding of the ecology of threats to food safety from microbial and chemical sources
- ☑ **Outcome 8**: Enhance the competitiveness of specialty crops through enhancing or improving the economy as a result of specialty crop development

OUTCOME INDICATOR(S)

Provide the indicator approved for your project and the related quantifiable result. If you have multiple outcomes and/or indicators, repeat this for each outcome/indicator (add more rows as needed).

#	Outcome and Indicator	Quantifiable Results
1	**Outcome 3, Indicator 1.a.** Of the 600-total number of consumers or wholesale buyers reached, 300 will gain knowledge about producing and preserving specialty crops.	We reached 588 consumers and wholesale buyers via trade presentations at GLTE, and another 12+ via site visits and questions answered through the two years
2	**Outcome 4, Indicator 2.a.** Adoption of best practices and technologies resulting in increased yields, reduced inputs, increased efficiency, increased economic return and conservation of resources. 50 growers/producers will indicate adoption of recommended practices.	From the presentation at GLTE 21, *New herbicides and new uses,* 253 growers verbally adopted 8 new herbicides as BMP's contributing to meeting outcome 4, indicator 2a, 2b and 2c of 50 growers. One participant commented: Dr. Mathers' presentation was very helpful on alternatives for Snapshot. By reaching 253 growers we far exceeded outcome 4 indicator 2a of 50.
3	**Outcome 4, Indicator 2.b** 50 growers/producers will be reporting reduction in pesticides used per acre.	Each of the 8 new herbicides researched and presented in the GLTE 2021 presentation to 253 growers, have longer efficacy than older products, reducing the pounds required per acre, and increasing

		environmental safety and thus meeting outcome 4 indicator 2b.
4	**Outcome 4, Indicator 2.c** 50 producers will be reporting reduced costs per acre.	Each of the 8 new herbicides researched and presented in the GLTE 2021 presentation to 253 growers, have longer efficacy than older products, reducing the pounds required per acre and costs per acre and meeting outcome 4 indicator 2b. Additionally, a 50% reduction in weeding time was found and valued at $188 Mn annually for one company, exceeding outcome 4, indicator 2c.
5	**Outcome 4, Indicator 2.d** 600 acres will be in best management practices developed in this grant.	Walters Gardens has 1,500 acres in field grown *Hemerocallis* and *Hosta*. We developed 3 new herbicide programs for these two crops, and one new sprayable standard for as large variety of their crops, far surpassing outcome 4, indicator 2d with just this one company
6	**Outcome 5, Indicator 2.** Number of innovations adopted 8.	Three participants in the GLTE 21 presentation indicated Hannah Mathers' focus on (Pre-Emergent Herbicides), gave the industry-specific details, gave quality advice/recommendations, and commented on how difficult good information on this topic is to get. The 8 new lower active ingredient loading herbicides presented in the talk to 253 growers have shown adoption and meeting outcome 5 indicator 2.
7	**Outcome 5, Indicator 6.** Number of first respondents trained in early detection and rapid response to combat plant pests (i.e., weeds) 25.	By keeping the GLTE 21 presentation posted for 60 days. 23 people viewed the recording afterwards to received more in-depth training as they learned at their own pace. Originally, we had hoped to train 25 growers/ producers as first responders for outcome 5 indicator 6; however, reaching 23, while a pandemic was raging meets this expectation.
8	**Outcome 5, Indicator 8.** Number of growers/producers that gained knowledge about science-based tools through outreach and education programs 250.	Several new science-based tools (i.e., new herbicides/herbicide timings/herbicide tank mixes/ HP herbicide rotations) were delivered to 8,250 industry members via three presentations, and three trade magazine articles, exceeding the 250 growers originally indicated 33 times.

9	**Outcome 8, Indicator 5.** Increased revenue/ increased savings (in dollars) $10,000,000.	One company participating in this grant, Walters Gardens, has indicated spending $376 Mn on hand weeding, with the development of two new standard programs their weeding time is cut by half, for a savings of $188 Mn annually, Outcome 8, indicator 5 was far exceeded.

DATA COLLECTION

Explain what data was collected, how it was collected, the evaluation methods used, and how the data was analyzed to derive the quantifiable indicator.

(See Research Results listed below pages 2- 20)

ADDITIONAL INFORMATION

Provide additional information available (i.e., publications, websites, photographs) that is not applicable to any of the prior sections.

Fig. 5. Photo taken at Walters Gardens, Zeeland, MI in June, 2020 showing a crew weeding a *Hemerocallis* field. One of the MNLA trials was in this fields and is indicated in the foreground with flags and orange wooden stakes. Note, the crew are wearing face masks due to the COVID-19 pandemic. The pandemic created further issues for the MI nursery industry restricting labor for weeding and making herbicide controls even more important.

The Authorized Individual must sign this statement after the applicable report form is completed.

I certify that the statements and information contained in these documents are true, accurate, and complete.