Evaluation of four rates of Marengo G in comparison to BroadStar

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Background. Marengo G is a new product marketed by OHP that contains 0.0224% indaziflam as the active ingredient for the nursery industry. The objectives of this study were to determine the phytotoxicity of four rates of Marengo G on seven species at two locations, the efficacy and duration of efficacy on three weed species and compare efficacy and phytotoxicity to an industry standard, BroadStar and untreated control.

Materials and Methods. Two cooperating nurseries were selected for the phytotoxicity evaluations of Marengo G; Studebaker Nursery (New Carlisle, OH) and Willoway Nurseries (Huron, OH). Species selected at Studebaker included Viburnum x'Juddi', Hydrangea paniculata 'Little Lamb', and Hemerocallis 'Stella d'oro'. Viburnum and Hydrangea were in #3 (3 gallon) trade size pots, and the Hemerocallis was in a #1 (one gallon) trade size pot. Species selected at Willoway included Rhododendron 'Nova Zembla' and Pieris 'Red Mill' in #1 containers, Azalea 'Karen' and Ilex xmeservea 'Blue maid' in #2 containers, and Hydrangea paniculata 'Limelight' and Viburnum x'Juddi' in #3 containers. Treatments were applied on May 1, 2013 and reapplied on June 26, 2013 at Willoway. Treated pots were placed on gravel pads in two recently uncovered polyhouses at Willoway (Huron) (Fig.1). Two houses were used as only the south ends of each house were used. At Studebaker treatments were initially applied on May 6, 2013 and reapplied on June 17. Treated pots were placed on a gravel pad adjacent to uncovered poly-houses (Fig. 2). Evaluations consisted of visual ratings at 1 WAT (weeks after treatment), 2 WAT, and 4 WAT at Willoway and 1 WAT, 2 WAT, 4 WAT and 1 WA2T (weeks after second treatment). The trials were set up in a completely randomized design within each species with each treatment having four replications and three subsamples/replication or 12 plants per treatment (Figs. 1 and 2).



Fig. 1. Phytotoxicity trial set-up at Willoway nursery (Huron) on May 1, 2013 *Azalea* 'Karen' is shown in the foreground to the left, *Hydrangea paniculata* 'Limelight' is shown in the foreground to the right and behind the *Azaleas* on the left. In the background are the *Rhododendron* 'Nova Zembla' behind the *Hydrangea* and in the background on the left is the *Ilex*

xmeservea 'Blue maid.' The Viburnum x'Juddi', remaining Azaleas and the Pieris were located in the next polyhouse to the west.



Fig. 2. Phytotoxicity trial set-up at Studebaker nursery on May 6, 2013 *Viburnum* x'Juddi' in foreground in #3 black plastic pots followed by *Hydrangea paniculata* 'Little Lamb' in white Proven Winner pots and *Hemerocallis* 'Stella d'oro' in background in 1 gallon black pots.

The efficacy portion of the study was initiated on June 11, 2013 at The Ohio State University, Columbus, OH. Thirty seeds each of three species of weeds; large crabgrass (Digitaria sanguinalis), Creeping yellow woodsorrel (Oxalis stricta), and bittercress (Cardamine hirsute) were applied to #1 containers consisting of a 85% pine bark, 10% comtil (composted sewage sludge) and 5% pea gravel. Evaluations for efficacy consisted of weed counts at 2 WAT, 4 WAT, and 8WAT and also a visual rating at 8 WAT. For both phytotoxicity and efficacy, rates of Marengo G included 100 lbs/ac, 150 lbs/ac, 200 lbs/ac, and 400 lbs/ac. BroadStar (flumioxazin, Valent U.S.A.) was applied at 150 lbs/ac as an industry standard. Efficacy pots received 1 tablespoons of Osmocote Pro 17-5-11 fertilizer as a top-dress. The trial was set up in a completely randomized design within each species with each treatment having six replications and no subsamples/replication on a gravel pad in a retractable roof greenhouse, where side walls were left open (Fig. 3) and the roof was set to close when day temperatures exceeded 80°F outside to structure (Fig. 3). All data was analyzed using SAS® Proc Mixed. For the phytotoxicity data, treatment means were compared to the untreated means using Dunnett's t-test with α = 0.10 and 0.05. Least squares means (LSmeans) was used to separate all possible comparisons for the efficacy data.



Fig. 3. OHP efficacy trial set-up on June 11, 2013 at Ohio State University, Columbus, OH in a retractable roof greenhouse with three species of weeds and six replications per species.

Results and discussion.

Phytotoxicity. At Willoway there were on-going problems with nutrition problems that we feel masked some of the treatment effects of the herbicides. Size variation in plants could be found in many species such as *Pieris* and *Rhododendron* that seemed attributable to treatment; however, these did not indicate significant difference over all replications (Fig. 4 A and B). At Willoway, *llex xmeservea* was the only species that showed a significant difference from the control, at 1 and 2 WAT but was still commercially acceptable (Table 1). *Viburnum* did show some phytotoxicity from the Marengo G at 150 (2.2) and 200 lbs/ac (2.9) at 4 WAT; however, the plants were still commercially acceptable and not different from the untreated (Table 1).



Fig. 4. A. At Willoway Huron, OH, *Pieris* 'Red Mill' control (left) versus Marengo G at 400#/ ac (right) showing some stunted growth. **B.** *Rhododendron* 'Nova Zembla' Marengo G at 200#/ ac (left) versus the control (right) showing stunting and leaf distortion.

At Studebaker, all three species tested showed some susceptibility from the Marengo G. *Viburnum* showed significant damage from Marengo G at 150, 200 (Fig. 5)



and 400 lb./ac that started as leaf distortion and advanced in severity over time.

Fig. 5. *Viburnum* X 'Juddi' at Studebaker nursery showing leaf distortion from 200 lb./ac application of Marengo G at 1WAT.

The BroadStar at Studebaker also caused significant injury to all three species. On Viburnum damage became significant at 2 WAT (Table 2). Only Marengo G at 400 lb./ac and the BroadStar provided ratings that were above commercially acceptable at 1 WA2T on the *Viburnum*.

The *Hydrangea* was significantly injured from all treatments with the exception of the Marengo at 200 lbs. Injury from the 400 lb./ac rate was the most severe (Fig. 6 A-C). The injury from the 400 lb./ac rate was not statistically different than the BroadStar injury at 150 lb./ac. We believe the Marengo G 200 lb./ac rate may have been inadvertently not applied to the *Hydrangea* and *Hemerocallis* (Table 2). Data from this trial also supports previous research for *Hydgrangea* species (OSU 2012 Yearly Research Summary Reports). *Hydrangea* is very susceptible to indaziflam, showing stunting, whitening, and brittle stems. The *paniculata* species are more tolerant than the *macrophylla* species based on our data, but it is still inadvisable to apply indaziflam to any *Hydrangea* cultivars.







Fig. 6 A, B and C. A. Hydrangea control at 2WAT at Studebaker

paniculata 'Little Lamb' nursery. **B.** Marengo G

400 lb./ac showing leaf yellowing, puckering and stunting 2WAT at Studebaker Nursery. **C.** Close up of injury with 400 lb./ac.

Although the *Hemerocallis* did show injury from the Marengo G (Fig. 7 A-B and D), the plants were still commercially acceptable versus the control (Fig. 7E). However, the damage caused by BroadStar was much more severe (Fig.7 C) and also persisted longer. This data correlates well with previous data (2012 Yearly Research Summary Reports); *Hemerocallis* shows stunting initially, but grows out of the injury very well by the end of the trial.



Fig. 7. A, B, C, D and E. Hemerocallis 'Stella d' Oro' 2WAT at Studebaker Nursery **A.** Marengo G applied at 400 lb./ac. **B.** Marengo G applied at 150 lb./ac and **C.** BroadStar applied at 150 lb./ac. **D.** Marengo G at 100 lb./ac. **E.** Control.

Efficacy. Large crabgrass and bittercress both had poor emergence, which is evident by the low weed counts for the untreated pots (Table 3). However, all Marengo treatments and the BroadStar controlled bittercress and crabgrass very well (Table 3). The woodsorrel had very good emergence, which is evident by the high weed counts for the untreated pots (Fig. 8)(Table 3). At 4 WAT, all treatments provided significantly lower counts for woodsorrel than the untreated control, with the 400 lb/ac rate giving the best control, having an average of 0.6/pot. By 8 WAT, residual control had decreased for all treatments, with the lowest woodsorrel count provided by the 400 lb/ac rate of Marengo G. By 13 WAT, there was no residual control left for any of the treatments (Fig. 8). The woodsorrel had re-seeded, which is why there are no counts for woodsorrel at 13 WAT. At 13 WAT spurge (*Chamaecyce prostrata*) and common groundsel (*Senecio vulgaris*) were present throughout all the treatments. This would suggest that at typical Marengo G rates of 200 lb/ac, a reapplication should be made by 8 WAT for control of these weed species.

Table 1. Phytotoxicity visual ratings of four rates of Marengo G in comparison to BroadStar and Untreated control to selected container ornamentals at Willoway Nursery.

| Anododenaron Nova Zembia | | | | lick Ameservea Blue Mala | | | | | |
|--------------------------|--------|--------------------|-------|------------------------------------|-----------|--------|--------|--------|-------|
| Treatment | Rate | 1 WAT ^z | 2 WAT | 4 WAT | Treatment | Rate | 1 WAT | 2 WAT | 4 WAT |
| Marengo G | 100 lb | 0.0 ^{yx} | 0.3 | 0.8 | Marengo G | 100 lb | 0.0 | 0.0 | 0.0 |
| Marengo G | 150 lb | 0.0 | 0.3 | 0.6 | Marengo G | 150 lb | 0.0 | 0.0 | 0.3 |
| Marengo G | 200 lb | 0.0 | 0.0 | 0.8 | Marengo G | 200 lb | 1.3 ** | 0.6 ** | 0.3 |
| Marengo G | 400 lb | 0.0 | 0.0 | 0.3 | Marengo G | 400 lb | 0.0 | 0.0 | 0.0 |
| BroadStar | 150 lb | 0.0 | 0.0 | 0.0 | BroadStar | 150 lb | 0.0 | 0.0 | 0.0 |
| Untreated | | 0.0 | 0.1 | 0.6 | Untreated | | 0.0 | 0.0 | 0.0 |
| Azalea 'Karen' | | | | Viburnum x'Juddi' | | | | | |
| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | Treatment | Rate | 1 WAT | 2 WAT | 4 WAT |
| Marengo G | 100 lb | 1.1 | 1.4 | 1.3 | Marengo G | 100 lb | 1.6 | 0.6 | 1.0 |
| Marengo G | 150 lb | 0.0 | 0.0 | 0.3 | Marengo G | 150 lb | 1.5 | 2.1 | 2.2 |
| Marengo G | 200 lb | 0.5 | 0.8 | 1.1 | Marengo G | 200 lb | 1.8 | 1.8 | 2.9 |
| Marengo G | 400 lb | 1.0 | 1.0 | 0.9 | Marengo G | 400 lb | 1.1 | 0.9 | 1.4 |
| BroadStar | 150 lb | 0.3 | 0.2 | 0.3 | BroadStar | 150 lb | 0.8 | 0.9 | 0.7 |
| Untreated | | 1.2 | 0.6 | 0.4 | Untreated | | 1.2 | 1.2 | 1.2 |
| Pieris 'Red Mill' | | | | Hydrangea paniculata 'Little Lamb' | | | | | |
| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | Treatment | Rate | 1 WAT | 2 WAT | 4 WAT |
| Marengo G | 100 lb | 0.0 | 0.0 | 0.0 | Marengo G | 100 lb | 0.3 | 0.0 | 0.0 |
| Marengo G | 150 lb | 0.0 | 0.0 | 0.0 | Marengo G | 150 lb | 0.1 | 0.5 | 0.5 |
| Marengo G | 200 lb | 0.0 | 0.0 | 0.0 | Marengo G | 200 lb | 0.5 | 0.3 | 0.2 |
| Marengo G | 400 lb | 0.0 | 0.0 | 0.0 | Marengo G | 400 lb | 0.2 | 0.0 | 0.0 |
| BroadStar | 150 lb | 0.0 | 0.0 | 0.0 | BroadStar | 150 lb | 0.8 | 0.6 | 0.0 |
| Untreated | | 0.0 | 0.0 | 0.0 | Untreated | | 0.0 | 0.0 | 0.0 |

Rhododendron 'Nova Zembla'

llex xmeservea 'Blue Maid'

z = weeks after treatment

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

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

| Table 2. Phytotoxicity visual ratings of four rates of Marengo G in comparison to BroadStar and |
|---|
| Untreated control to selected container ornamentals at Studebaker Nursery. |
| Hemerocallis 'Stella d'Oro' |

| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | 1 WA2T | | |
|------------------------------------|---------|--------|--------|--------|--------|--|--|
| Marengo G | 100 lbs | 2.6 | 2.7 ** | 2.8 ** | 1.5 * | | |
| Marengo G | 150 lbs | 1.4 | 2.7 ** | 2.6 ** | 0.8 | | |
| Marengo G | 200 lbs | 1.9 | 1.1 | 1.8 | 1.0 | | |
| Marengo G | 400 lbs | 0.5 | 2.4 ** | 2.5 ** | 1.2 | | |
| BroadStar | 150 lbs | 4.0 ** | 5.1 ** | 4.8 ** | 2.3 ** | | |
| Untreated | | 1.1 | 0.8 | 0.5 | 0.1 | | |
| Hydrangea paniculata 'Little Lamb' | | | | | | | |
| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | 1 WA2T | | |
| Marengo G | 100 lbs | 3.3 ** | 3.3 ** | 2.3 ** | 2.8 ** | | |
| Marengo G | 150 lbs | 4.2 ** | 4.6 ** | 2.9 ** | 3.5 ** | | |
| Marengo G | 200 lbs | 0.9 | 0.7 | 0.0 | 0.8 | | |
| Marengo G | 400 lbs | 4.8 ** | 5.3 ** | 4.3 ** | 4.7 ** | | |
| BroadStar | 150 lbs | 4.8 ** | 4.7 ** | 3.0 ** | 3.9 ** | | |
| Untreated | | 0.0 | 0.1 | 0.0 | 0.8 | | |
| Viburnum x'Juddi' | | | | | | | |
| Treatment | Rate | 1 WAT | 2 WAT | 4 WAT | 1 WA2T | | |
| Marengo G | 100 lbs | 0.7 | 0.2 | 0.3 | 1.3 | | |
| Marengo G | 150 lbs | 1.6 | 1.3 * | 1.7 | 2.9 ** | | |
| Marengo G | 200 lbs | 0.6 | 0.2 | 2.1 * | 2.7 * | | |
| Marengo G | 400 lbs | 1.9 | 1.7 ** | 2.3 ** | 3.1 ** | | |
| BroadStar | 150 lbs | 1.7 | 1.5 ** | 2.5 ** | 3.5 ** | | |
| Untreated | | 0.9 | 0.2 | 0.2 | 1.7 | | |

z = weeks after treatment

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

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

Table 3. Weed Counts and visual ratings of three species of weeds in one gallon containers from four rates of Marengo in comparison to BroadStar and Untreated check.

| Digitaria sanguinalis | | 2 WAT ^z | 4 WAT | 8 WAT | 13 W | AT |
|-----------------------|--------|---------------------|---------|---------|-------------|--------|
| | | | | | | Visual |
| Treatment | Rate | | Ratings | | | |
| Marengo | 100 lb | 0.5 ^y ab | 0.7 ab | 0.5 a | 0.5 no diff | 8.0× a |
| Marengo | 150 lb | 0.8 ab | 0.7 ab | 0.3 a | 0.3 no diff | 8.7 a |
| Marengo | 200 lb | 1.3 b | 0.8 ab | 0.7 a | 0.5 no diff | 7.5 ab |
| Marengo | 400 lb | 0.3 a | 0.4 a | 0.3 a | 1.0 no diff | 7.8 a |
| BroadStar | 150 lb | 0.5 ab | 0.7 ab | 0.3 a | 1.5 no diff | 6.3 ab |
| Untreated | | 2.8 c | 1.7 b | 1.7 b | 1.3 no diff | 4.5 b |
| Oxalis stricta | | 2 WAT | 4 WAT | 8 WAT | 13 W | AT |
| | | | | | | Visual |
| Treatment | Rate | | Ratings | | | |
| Marengo | 100 lb | 5.8 bc | 4.2 a | 8.8 ab | no diff | 0.0 c |
| Marengo | 150 lb | 7.8 c | 4.4 a | 13.7 bc | no diff | 0.0 c |
| Marengo | 200 lb | 4.0 abc | 3.5 a | 5.3 ab | no diff | 3.8 b |
| Marengo | 400 lb | 1.3 a | 0.6 a | 2.5 a | no diff | 6.0 a |
| BroadStar | 150 lb | 3.2 ab | 3.3 a | 9.2 ab | no diff | 0.7 c |
| Untreated | | 18.3 d | 20.2 b | 20.0 c | no diff | 0.0 c |
| Cardamine hirsute | | 2 WAT | 4 WAT | 8 WAT | 13 W | AT |
| | | | | | | Visual |
| Treatment | Rate | | Ratings | | | |
| Marengo | 100 lb | 0.5 a | 2.8 ab | 1.0 a | 0.0 no diff | 9.2 ab |
| Marengo | 150 lb | 0.8 a | 0.4 a | 1.0 a | 1.5 no diff | 6.6 b |
| Marengo | 200 lb | 0.2 a | 0.5 a | 0.8 a | 0.7 no diff | 9.2 ab |
| Marengo | 400 lb | 0.8 a | 1.0 a | 0.8 a | 1.0 no diff | 8.7 ab |
| BroadStar | 150 lb | 0.2 a | 0.2 a | 0.0 a | 0.0 no diff | 10.0 a |
| Untreated | | 3.3 b | 4.4 b | 3.7 b | 1.0 no diff | 7.3 ab |

z = weeks after treatment

y = Visual ratings based on a 0-10 scale with 0 being no control and 10 perfect control with \geq 7 commercially acceptable

x = Treatment means followed by the same letter in the same column are not significantly different based on Ismeans ($\alpha = 0.05$)



Fig. 8 Woodsorrel emergence 2 WAT at Marengo G 150 lb./ac rate.



Fig. 9 Marengo G at 200 lb/ac at 13 WAT. Notice the numerous small woodsorrel than has germinated in the pot.