

## Biathlon G for Use in Annual Landscape Beds Compared to Snapshot, FreeHand and Specticle G

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Note<sup>1</sup>: This report uses the, *Summary of Herbicide Mechanism of Action (MOA) According to the Herbicide Resistance Action Committee (HRAC) and Weed Science Society of America (WSSA) Classification* system ([wssa.net/wp-content/uploads/HerbicideMOAClassification.pdf](http://wssa.net/wp-content/uploads/HerbicideMOAClassification.pdf)) and specifically the WSSA number classification system ex. PPO Inhibitors (Protoporphyrinogen oxidase) as group 14.

Note<sup>2</sup>: All rated score evaluations of phytotoxicity were measured on a 0 to 10 scale, where 0 represented no phytotoxicity,  $\geq 3$  represents commercially unacceptable injury and 10 represented plant death (Barolli et al., 2005; Collins et al. 1999; Duray and Davies, 1989; Mathers and Case, 2010; Samtami et al., 2007). This rated score is a standard measure accepted in all major weed and horticultural science journals with each interval representing a 10% increase in injury over the whole plant ex. 3 would be 30% injury and 5 would be 50%, etc. All rated score evaluations of efficacy were measured on a 0 to 10 scale, where 10 represents complete control and  $\geq 7$  represents commercially acceptable weed control and 10 no control. As with phytotoxicity scoring, this is a standard method for efficacy measures, have the same citations as listed for phytotoxicity and each interval represents a 10% loss of weed control over the test plot.

**Background.** This trial was conducted with the goal of promoting Biathlon (Oxyfluorfen + prodiamine) (OHP, Inc., Mainland, PA 19451) in the landscape market. The market currently is approximately 85% SnapShot 2.5 TG (isoxaben + trifluralin) (Dow AgroSciences, LLC, Indianapolis, IN 46268) with minimal but increasing competition from FreeHand 1.75G (dimethenamid-p + pendimethalin, BASF Corporation, Research Triangle Park, NC 27709). The industry needs rotation products that can be used in mulched and un-mulched landscape beds that provide efficacy on a variety of weed species but low phytotoxicity with common annual bedding plants. Therefore, our objectives were to compare Biathlon G at 1X, 1.5X and 2X (100, 150 and 200 lb/ ac, respectively) applied to mulched and un-mulched beds with un-mulched beds applied with FreeHand 1.75G 1X (150 lb/ ac), Snapshot 2.5 TG (isoxaben + trifluralin) (Dow AgroSciences, LLC, Indianapolis, IN 46268) 1X (200 lb/ac) and Specticle G (indaziflam)

(Bayer Crop Science Inc, Research Triangle Park, NC) 1X (200 lb/ac). All four products were labeled for landscape use but some species were not labelled. To observe any growth and quality impacts on the turf, all trial beds were located adjacent to turf. A total of eleven treatments were evaluated including, mulched only and a weedy check for phytotoxicity on seven bedding plant species and efficacy “native” weed control. Because all landscape beds were newly established in spring 2016, native weeds and seed bank were plentiful.

**Significance.** Rotational products are not available for annual bed maintenance. Again, 85% of the industry uses SnapShot 2.5TG repeatedly and with no rotation. SnapShot contains isoxaben a cellulose inhibiting product (Group 21) for broadleaf control and trifluralin a mitosis inhibitor (Mi) product (Group 3) for grass control. Rotating out of the Mi (Group 3) mode of action (MoA) is extremely difficult in landscape settings due to lack of available products. FreeHand offers a limited rotation as it contains pendimethalin (Group 3) and a long-chain fatty acid inhibitor dimethenamid-p (Group 15) which is still a Mi. Therefore, FreeHand contains two Mi’s. Biathlon offers a superior rotation to FreeHand as it contains oxyfluorfen a PPO inhibitor (Group 14) and prodiamine (Group 3). Specticle offers a true rotation away from Mi products as it contains only indaziflam a cellulose inhibitor (Group 29). Group 29 herbicides inhibit cellulose biosynthesis (Myers et al., 2009) which is different than isoxaben (Group 21) although in the same MoA. Although beyond the scope of this study, Biathlon for the fall (mid-August applications) could be of great value as oxyfluorfen often has improved efficacy in autumn applications.

### **Goal and Impact:**

This research is very significant as it presents herbicide control information in the format most likely to result in product choice i.e. side-by-side statistics. Without side-by-side comparisons landscapers’ will often make herbicide choices based on convenience; however, optimal efficacy and least phytotoxicity become determinants with side-by-side comparisons. The greatest impacts of the research will be in two areas: 1) more efficient and effective herbicide use for landscape professionals, thus lower herbicide usage and costs; and 2) greater herbicide choices for landscape professionals, thus increasing control and preventing herbicide resistance in weeds.

### **Materials and Methods:**

#### Planted

6/2/2016

#### Initiation

6/15/2016

The seven common annuals used in this bedding plant trial, with their respective trial assigned number were:

1. *Salvia* 'Rhea'
2. *Coleus* 'Wizard® Mix'
3. *Antirrhinum* (Snapdragon) 'Montego™ Formula Mix'
4. *Impatiens walleriana*
5. *Ageratum* 'Hawaii Blue'
6. *Calendula* (Marigold) 'Bonanza Yellow'
7. *Petunia* 'Celebrity Blue'.

Two 36 count flats of each species were obtained from Acorn Farms, Inc., Galena, OH greenhouses in late May, 2016. Fifty five of the best 72 plants of each species were planted for 385 bedding plants total. The seven species were planted in 11 treatment plots of 20" X 20" with each species on a 9" center. Each treatment was replicated 5 times. Arrangement of species planting in each plot, treatment plot placement within each replicate and the replicate placement itself were all decided using a random table generator (Fig. 1).

In total, 220 ft. of landscape beds were prepared. Glyphosate was sprayed four weeks prior to planting to kill existing turf and weeds. Cultivation was performed after complete kill was achieved to a depth of 6 inches deep. Organic matter additions of Kurtz Brother's nursery media (85% pine bark and 15% Comtil) (Kurtz Bros. Central Ohio, LLC, Groveport, OH) were added at a rate of 1 cu ft/ 9 ft<sup>2</sup>. Four areas containing one block or replicate each were prepared. Replicates 3 and 5 were contiguous and in partial shade. However, replicate 3 was facing west and replicate 5 was facing north in corner wrapping bed. Replicate 1 was planted facing west and 4 facing south. Replicate 1 received partial shaded most of the day with the exception of late afternoon to evening. Replicate 4 received full sun throughout the day. Replicate 2 was planted 100 ft. away from replicate 4 facing west and also receiving full sun. Each area or block accommodated 11 treatment plots, with 9" between each plot. Three hundred and eighty five bedding plants were planted June 2-3, 2016 (Fig. 2). Plants were allowed to establish for 12 days before herbicides were applied. Osmocote Plus 15-9-12 (8 to 9 month) fertilizer was applied at 1 tbsp/ 60" of plot and over- head irrigation was provided as required in the 12 days. All herbicide applications were conducted on June 15, 2016. Within 30 minutes of application completion 0.7 inch of rain occurred as measured at the Columbus airport (Table 1) 7.6 miles away. Mulch was applied to required treatments (i.e., 1, 3, 5 and 11) on June 16 at 2" deep using Scotts Earthgro® Black Mulch – 12 Month Color (Marysville, OH). Due to rain immediately following herbicide applications, mulch needed to be applied on the 16<sup>th</sup> versus the 15<sup>th</sup>. This experiment utilized a Randomized Complete Block design (RCBD) with blocking on location. 2.75" of rain also occurred on June 23, 2016 providing much needed moisture to all five blocks areas after several weeks of warm temperatures.

**Table 1.** Gahanna, OH temperatures and precipitation during bedding plant trial period of OHP Biathlon (June to Sept., 2016) in Gahanna, OH. *Source:* AccuWeather -- <http://www.accuweather.com/en/us/gahanna-oh/43230/june-weather/2238668?monyr=6/1/2016&view=table>. June was 1°F above normal and had +1.21 inches of rainfall above normal. July was 2°F above average for the month and was -2.3 inches of rainfall drier. August and September were warmer and wetter than average at 4°F and +2.5 inches and 4°F and +1.84 inches, respectively for the month. There were no record highs or lows of rainfall events during this experiment.

Date	Hi/Lo	Precip.	Avg. HI / LO
Sat 6/4	80°/67°	0.07 IN	78°/58°
Sun 6/5	81°/66°	0.05 IN	79°/59°
Mon 6/6	86°/62°	0 IN	79°/59°
Tue 6/7	73°/58°	0 IN	79°/59°
Wed 6/8	73°/52°	0 IN	80°/60°
Thu 6/9	77°/48°	0 IN	80°/60°
Fri 6/10	80°/64°	0.03 IN	80°/60°
Sat 6/11	95°/66°	0 IN	81°/60°
Sun 6/12	84°/61°	0 IN	81°/61°
Mon 6/13	83°/51°	0 IN	81°/61°
Tue 6/14	84°/61°	0 IN	82°/61°
Wed 6/15	89°/66°	0.71 IN	82°/62°
Thu 6/16	85°/65°	0.19 IN	82°/62°
Fri 6/17	86°/64°	0 IN	82°/62°
Sat 6/18	87°/61°	0 IN	82°/62°
Sun 6/19	88°/63°	0 IN	83°/63°
Mon 6/20	92°/67°	0 IN	83°/63°
Tue 6/21	89°/71°	0 IN	83°/63°
Wed 6/22	78°/60°	0.02 IN	83°/63°
Thu 6/23	87°/64°	2.75 IN	84°/64°
Fri 6/24	84°/65°	0 IN	84°/64°
Sat 6/25	89°/58°	0 IN	84°/64°
Sun 6/26	90°/66°	1.15 IN	84°/64°
Mon 6/27	88°/70°	0.25 IN	84°/64°
Tue 6/28	80°/62°	0 IN	84°/64°
Wed 6/29	77°/59°	0 IN	84°/65°
Thu 6/30	80°/55°	0 IN	85°/65°
Fri 7/1	81°/64°	0.14 IN	85°/65°
Sat 7/2	74°/56°	0 IN	85°/65°
Sun 7/3	73°/62°	0 IN	85°/65°
Mon 7/4	72°/62°	0.11 IN	85°/65°
Tue 7/5	84°/69°	0.31 IN	85°/65°
Wed 7/6	87°/64°	0 IN	85°/65°

Thu 7/7	86°/69°	0 IN	85°/65°
Fri 7/8	85°/73°	0 IN	85°/66°
Sat 7/9	82°/65°	0 IN	85°/66°
Sun 7/10	86°/61°	0 IN	85°/66°
Mon 7/11	88°/64°	0 IN	85°/66°
Tue 7/12	88°/66°	0 IN	85°/66°
Wed 7/13	92°/69°	0.18 IN	85°/66°
Thu 7/14	87°/68°	0.15 IN	85°/66°
Fri 7/15	87°/69°	0 IN	85°/66°
Sat 7/16	82°/67°	0 IN	85°/66°
Sun 7/17	87°/61°	0 IN	85°/66°
Mon 7/18	88°/69°	0.37 IN	85°/66°
Tue 7/19	89°/68°	0 IN	85°/66°
Wed 7/20	89°/66°	0 IN	85°/66°
Thu 7/21	91°/66°	0 IN	85°/66°
Fri 7/22	86°/71°	1.07 IN	85°/66°
Sat 7/23	90°/70°	0 IN	85°/66°
Sun 7/24	94°/74°	0 IN	85°/66°
Mon 7/25	92°/76°	0 IN	85°/66°
Tue 7/26	89°/74°	0 IN	85°/66°
Wed 7/27	91°/72°	0 IN	85°/66°
Thu 7/28	81°/71°	0.13 IN	85°/65°
Fri 7/29	83°/67°	0.03 IN	84°/65°
Sat 7/30	87°/70°	0 IN	84°/65°
Sun 7/31	88°/68°	0 IN	84°/65°
Mon 8/1	87°/68°	0 IN	84°/65°
Tue 8/2	90°/67°	0 IN	84°/65°
Wed 8/3	92°/68°	0 IN	84°/65°
Thu 8/4	88°/72°	0 IN	84°/65°
Fri 8/5	93°/72°	0 IN	84°/65°
Sat 8/6	88°/70°	0.19 IN	84°/65°
Sun 8/7	88°/62°	0 IN	84°/65°
Mon 8/8	87°/68°	0 IN	84°/65°
Tue 8/9	91°/69°	0 IN	84°/65°
Wed 8/10	89°/75°	0 IN	84°/65°
Thu 8/11	93°/76°	0.01 IN	84°/65°
Fri 8/12	94°/77°	0 IN	84°/65°
Sat 8/13	92°/75°	0.38 IN	84°/65°
Sun 8/14	77°/70°	1.34 IN	84°/64°
Mon 8/15	84°/70°	0.42 IN	84°/64°
Tue 8/16	85°/71°	0.57 IN	84°/64°
Wed 8/17	79°/70°	0.18 IN	84°/64°
Thu 8/18	84°/67°	0 IN	84°/64°

Fri 8/19	85°/68°	0 IN	84°/64°
Sat 8/20	83°/68°	0.28 IN	84°/64°
Sun 8/21	78°/64°	0 IN	84°/64°
Mon 8/22	78°/57°	0 IN	84°/64°
Tue 8/23	81°/56°	0 IN	83°/64°
Wed 8/24	84°/62°	0 IN	83°/63°
Thu 8/25	88°/71°	0.58 IN	83°/63°
Fri 8/26	88°/71°	0 IN	83°/63°
Sat 8/27	91°/70°	0.53 IN	83°/63°
Sun 8/28	91°/67°	0.81 IN	83°/63°
Mon 8/29	87°/70°	0 IN	82°/62°
Tue 8/30	87°/64°	0 IN	82°/62°
Wed 8/31	84°/69°	0.53 IN	82°/62°
Thu 9/1	76°/60°	0 IN	82°/62°
Fri 9/2	77°/57°	0 IN	82°/61°
Sat 9/3	79°/57°	0 IN	81°/61°
Sun 9/4	82°/57°	0 IN	81°/61°
Mon 9/5	87°/57°	0 IN	81°/60°
Tue 9/6	89°/65°	0 IN	81°/60°
Wed 9/7	90°/70°	0 IN	80°/60°
Thu 9/8	88°/72°	0.09 IN	80°/60°
Fri 9/9	83°/71°	0.52 IN	80°/59°
Sat 9/10	88°/63°	0.76 IN	79°/59°
Sun 9/11	74°/57°	0 IN	79°/58°
Mon 9/12	79°/55°	0 IN	79°/58°
Tue 9/13	82°/56°	0 IN	78°/58°
Wed 9/14	81°/58°	0 IN	78°/57°
Thu 9/15	77°/57°	0 IN	78°/57°
Fri 9/16	86°/60°	0.01 IN	77°/56°
Sat 9/17	81°/70°	0.73 IN	77°/56°
Sun 9/18	82°/69°	0 IN	76°/56°
Mon 9/19	84°/63°	0 IN	76°/55°
Tue 9/20	88°/59°	0 IN	75°/55°
Wed 9/21	87°/61°	0 IN	75°/54°
Thu 9/22	88°/61°	0 IN	75°/54°
Fri 9/23	90°/64°	0 IN	74°/54°
Sat 9/24	80°/61°	0 IN	74°/53°
Sun 9/25	82°/55°	0 IN	73°/53°
Mon 9/26	69°/54°	0.14 IN	73°/52°
Tue 9/27	74°/49°	0 IN	72°/52°
Wed 9/28	61°/54°	0.78 IN	72°/51°
Thu 9/29	68°/56°	0.26 IN	72°/51°
Fri 9/30	65°/60°	1.39 IN	71°/51°

Weed counts were conducted for the first two evaluations and then percent plot using the efficacy rated score explained in the foreword notes. Fresh weights of weeds and plants were also conducted by plot at the end of the study, not by individual species. Each of the seven bedding plant species were rated for phytotoxicity individually within each plot; however, efficacy was conducted over the plot. All treatments were evaluated for phytotoxicity and efficacy at 1, 2, 4, 6, 8, 10, 12 and 14 weeks after treatment (WAT).

**Fig. 1.** Landscape bedding plant plots with 9" between each plant. Seven species of bedding plants were arranged randomly within each plot as shown; however, the figure is not drawn to scale. Each plot was replicated five times. Pine mulch at 2" depth was applied after planting and herbicide applications to select plots. Temperature and rainfall were recorded for the trial duration and supplemental water as required was supplied by over-head- irrigation.

Tmt 8 Rep 3	7	5	1	Rep 3 in Lilac Bed
	6		4	
	3		2	
Tmt 2 Rep 3	1		5	
	6		2	
	7	4	3	
Tmt 4 Rep 3	4		6	In front of Tmt 2, Rep 3
	3		5	
	2	1	7	
Tmt 6 Rep 3	1		5	
	6		7	
	4	2	3	
Tmt 11 Rep 3	6	3	7	
	5		2	
	4		1	
Tmt 7 Rep 3	1		4	
	5		6	
	7	2	3	
Tmt 1 Rep 3	2		7	
	3		6	
	5	4	1	
Tmt 9 Rep 3	7		5	
	6		4	
	1	3	2	
Tmt 3 Rep 3	6		4	
	1		5	

	3	2	7	
Tmt 10 Rep 3	5		2	
	3		4	
	6	1	7	
Tmt 5 Rep 3	3		5	
	4		2	
	1	6	7	
Tmt 11 Rep 5	6		2	Rep 5 in Lilac Bed, In front of Tmt 5, Rep 3
	1		4	
	3	7	5	
Tmt 5 Rep 5	7		4	Next to Tmt 5, Rep 3
	3		2	
	1	6	5	
Tmt 2 Rep 5	4		5	Next to Tmt 5, Rep 5
	3		2	
	1	6	7	
Tmt 9 Rep 5	3		5	In front of Tmt 5, Rep 5 and Tmt 2, Rep 5
	7		4	
	1	6	2	
Tmt 3 Rep 5	6		2	Next to Tmt 9, Rep 5
	5		7	
	4	1	3	
Tmt 8 Rep 5	7		3	Beside Tmt 2, Rep 5
	2		5	
	1	4	6	
Tmt 4 Rep 5	5	1	6	Beside Tmt 8, Rep 5
	3		7	
	2		4	
Tmt 1 Rep 5	4		1	Beside Tmt 4, Rep 5
	3		5	
	2	6	7	
Tmt 7 Rep 5	3		2	Beside Tmt 1, Rep 5
	5		7	
	6	1	4	
Tmt 6 Rep 5	2		5	Beside Tmt 7, Rep 5
	1		7	
	3	6	4	
Tmt 10 Rep 5	4		6	In front of Tmt 4, Rep 5
	1		5	
	3	2	7	
	7		3	



Tmt 6 Rep 1	6		2	Rep 1 in Driveway Bed
	5	4	1	
Tmt 8 Rep 1	1		4	
	2		6	
	3	5	7	
Tmt 5 Rep 1	4		1	
	6		3	
	5	2	7	
Tmt 3 Rep 1	1	6	5	
	2		3	
	4		7	
Tmt 9 Rep 1	3		6	
	5		4	
	7	1	2	
Tmt 11 Rep 1	2		5	
	4		3	
	7	6	1	
Tmt 2 Rep 1	1		4	
	6		3	
	7	5	2	
Tmt 7 Rep 1	7		3	
	4		5	
	2	1	6	
Tmt 1 Rep 1	6		1	
	7		5	
	3	2	4	
Tmt 10 Rep 1	4		5	
	3		6	
	7	1	2	
Tmt 4 Rep 1	2		4	
	5		1	
	3	6	7	
Tmt 1 Rep 4	5	1	7	Driveway Bed
	3		6	
	2		4	
Tmt 4 Rep 4	3		6	Driveway Bed
	4		1	
	7	2	5	
Tmt 8 Rep 4	4		2	Driveway Bed
	1		7	
	6	3	5	

Tmt 5 Rep 4	2		6	Driveway Bed
	5		1	
	3	4	7	
Tmt 7 Rep 4	6		4	Driveway Bed
	5		1	
	3	7	2	
Tmt 2 Rep 4	1		6	Driveway Bed
	2		7	
	4	5	3	
Tmt 10 Rep 4	6		7	Front Bed
	4		1	
	5	2	3	
Tmt 3 Rep 4	5		1	Front Bed
	7		4	
	2	6	3	
Tmt 11 Rep 4	4		1	Front Bed
	3		2	
	7	6	5	
Tmt 9 Rep 4	2		3	Front Bed
	7		1	
	4	5	6	
Tmt 6 Rep 4	5		1	Front Bed
	2		7	
	4	6	3	
Tmt 11 Rep 2	1		6	Front Bed
	3		2	
	5	7	4	
Tmt 8 Rep 2	3		2	Front Bed
	6		5	
	4	1	7	
Tmt 7 Rep 2	3		4	Garden Shed Bed
	7		6	
	5	1	2	
Tmt 6 Rep 2	3		5	Garden Shed Bed
	7		6	
	4	1	2	
Tmt 9 Rep 2	1		6	Garden Shed Bed
	5		4	
	2	7	3	
Tmt 3 Rep 2	3		1	Garden Shed Bed
	2		6	
	7	5	4	

Tmt 1 Rep 2	2		6	Garden Shed Bed
	3		1	
	7	4	5	
Tmt 2 Rep 2	3		4	Garden Shed Bed
	2		1	
	7	5	6	
Tmt 5 Rep 2	4		2	Garden Shed Bed
	7		5	
	1	3	6	
Tmt 10 Rep 2	4		2	Garden Shed Bed
	1		3	
	7	5	6	
Tmt 4 Rep 2	7		6	Garden Shed Bed
	3		4	
	1	5	2	

## Results and Discussion:

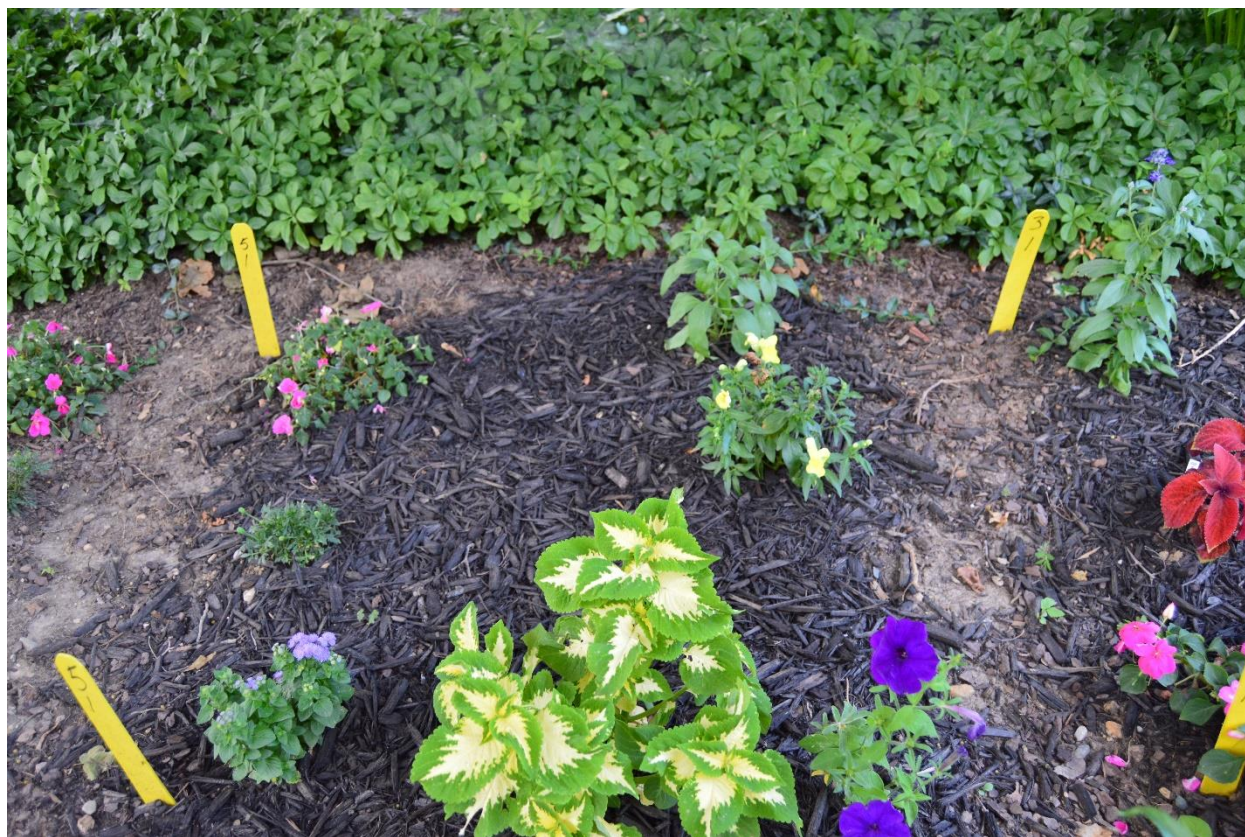
The most efficacious treatments at 14 weeks after treatment (WAT), evaluated by rated scores and fresh weights, were Biathlon 150 lb/ac and 200 lb/ac with mulch (Table 2). Biathlon 100 lb/ac was still above commercially acceptable for weed control at 14 WAT with mulch but not without. Biathlon 150 and 200 lb/ac were commercially acceptable with and without mulch at 14 WAT. The two highest Biathlon rates with mulch were superior; however, in efficacy to the other Biathlon treatments as they were providing near perfect weed control even after 14 weeks. At 14 WAT, only the FreeHand without mulch provided commercially acceptable control comparable to the Biathlon 150 and 200 lb/ac without mulch. The Specticle and Snapshot efficacies' had dropped below commercially acceptable at 6 and 10 WAT, respectively. No treatment combined over species, including the three Biathlon treatments, provided unacceptable phytotoxicity (Table 3). Mulch additions to Biathlon treatments extended efficacy and increased weed control on average by two ratings or 20%. However, mulch by itself provided no increase in efficacy versus bare ground (weedy check) (Table 2). Mulch, however, did reduce phytotoxicity by more than 200 grams (Table 3). Ratings and fresh weights positively correlated for efficacy but not for phytotoxicity (Table 3 and 2, respectively). The lack of correlation for phytotoxicity can be attributed to the sensitivity of individual species to various herbicides (Table 4). Depending on which species was injured differences occurred in plant fresh weights. For example, if impatiens was injured (a large biomass plant) the fresh weights' of the plot went down more than if petunia was effected (a lower biomass plant). Biathlon 100 lb/ac without mulch and no mulch without herbicide increased phytotoxicity for Snapdragon (Table 4). Perhaps the mulch was retaining soil moisture, which was not beneficial to the Snapdragon at 100 lb/ac, but became beneficial when the Biathlon rate was increased to 200 lb/ac (Table 4). Salvia, Coleus and Marigold had no phytotoxicity above commercially acceptable

with any treatment throughout the trial. The impatiens were most susceptible to Specticle as the trial progressed (Table 4). The Petunia 'Celebrity Blue' overall was the most sensitive species evaluated with injury occurring above commercially acceptable with all four herbicides.



**Fig. 2.** OHP bedding plant trial during the 12 day establishment period after planting but before herbicides and/or mulch was applied at Mathers Environmental Science Services, Gahanna, OH. (Photo taken June 3, 2016 by H. Mathers).



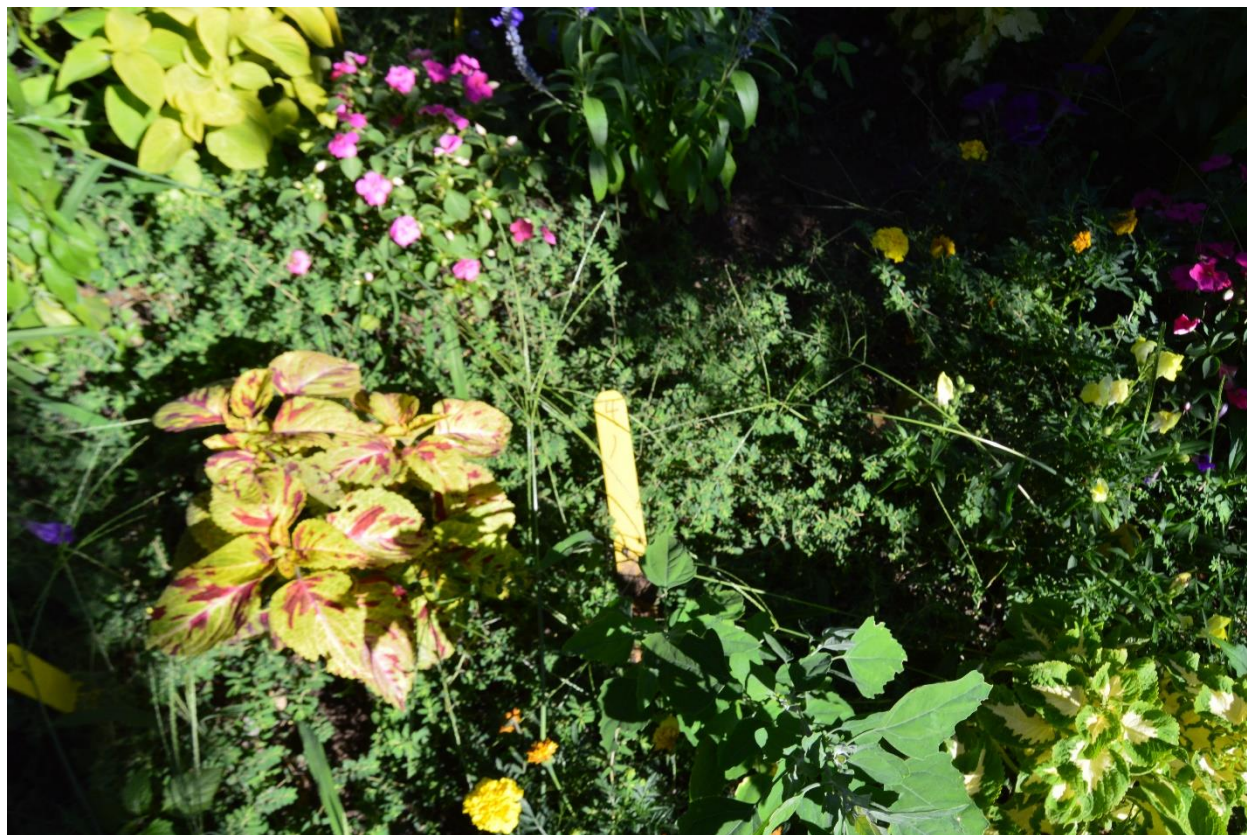


**Fig. 3.** OHP bedding plant trial at 4WAT showing the 200lb/ac Biathlon treatment with mulch in block 1. Generally, all treatment had good efficacy and low phytotoxicity during this period at Mathers Environmental Science Services, Gahanna, OH. (Photo taken July 13, 2016 by H. Mathers).





**Fig. 4.** OHP bedding plant trial at 6 WAT showing the 150 lb/ac Biathlon treatment with mulch in block 4. Weed Control is perfect at this time at Mathers Environmental Science Services, Gahanna, OH. (Photo taken July 27, 2016 by H. Mathers).



**Fig. 5.** OHP bedding plant trial at 8 WAT showing the 150 lb/ac Biathlon treatment with no mulch in block 1. Weed control has fallen to 6.8 or below commercially acceptable with this treatment at Mathers Environmental Science Services, Gahanna, OH. (Photo taken August 10, 2016 by H. Mathers).





**Fig. 6.** OHP bedding plant trial at 12 WAT showing the 200 lb/ac Specticle G treatment with no mulch in block 1. There is significant weed pressure with ground cherry, spotted spurge and crabgrass. Efficacy is well below commercially acceptable at 4.2 at Mathers Environmental Science Services, Gahanna, OH. (Photo taken September 7, 2016 by H. Mathers).





**Fig. 7.** OHP bedding plant trial at 14 WAT showing the 150 lb/ac Biathlon with no mulch in block 3. This treatment even at 14 weeks after is above commercially acceptable at Mathers Environmental Science Services, Gahanna, OH. (Photo taken September 21, 2016 by H. Mathers).

**Table 2.** OHP bedding plant treatment by date interaction for efficacy (over species and replication). Bold values represent the most efficacious treatments at 14 weeks after treatment (WAT) evaluated by rated scores and fresh weights of weeds collected at 14 WAT.

Treatment	Rate/ac	1WAT	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT	14WAT	Average	Weed fresh wt. (g)
1. Biathlon with mulch	100	9.5	9.2	7.6	7.6	6.4	6	5.4	5.4	7.1	106.6
2. Biathlon no mulch	100	9.2	8.3	7	6.8	6.4	5.6	5.4	4.8	6.7	144.8
3. Biathlon mulch	150	10	9.9	9.8	10	9.8	9.8	9	<b>9</b>	<b>9.7</b>	<b>15.8</b>
4. Biathlon no mulch	150	9	8.4	7.6	7.4	6.8	6.4	5.4	5.1	7.0	204.0
5. Biathlon mulch	200	10	9.8	9.6	9.4	9	9	9	<b>8.8</b>	<b>9.3</b>	<b>33.2</b>
6. Biathlon no mulch	200	8.6	8.3	7.4	7.4	6.8	6.2	6	5.8	7.1	115.2
7. FreeHand no mulch	150	9.1	8.4	8	7.8	7.2	6.6	5	4.8	7.1	238.4
8. Snapshot no mulch	200	9	8	7	7	7	3	2	1	5.5	314.2
9. Specticle G no mulch	200	9	8	7	5.2	4.6	4.4	4.2	3.8	5.7	304.0
10. No mulch, no herb.	0	8.7	7.8	6.4	5.2	4	3.2	2.2	1.8	4.9	308.2
11. Mulch, no herb.	0	9	8	6	6	5	3	2	1	5	261.4

**Table 3.** OHP bedding plant treatment by date interaction for phytotoxicity (over species and replication). Bold values represent the most phytotoxic treatments at 14 weeks after treatment (WAT) by fresh weights; however, 14 WAT ratings or averages over the trial period do not necessarily correlate.

Treatment	Rate/ac	1WAT	2WAT	4WAT	6WAT	8WAT	10WAT	12WAT	14WAT	Average	Plant fresh wt. (g)
1. Biathlon with mulch	100	0.1	0.0	0.5	0.5	0.4	0.6	0.9	1.1	0.5	617.4
2. Biathlon no mulch	100	2.3	1.5	1.8	1.5	1.6	2.6	3.3	3.4	2.2	666.4
3. Biathlon mulch	150	1.3	1.0	0.6	1.6	1.3	1.3	1.3	2.1	1.3	682
4. Biathlon no mulch	150	1.9	1.3	1.1	1.1	2.0	1.7	1.5	1.8	1.5	604
5. Biathlon mulch	200	1.5	1.4	1.1	0.9	1.6	1.6	1.4	1.5	1.4	747.2
6. Biathlon no mulch	200	2.2	1.2	0.9	1.3	1.9	2.3	2.2	2.7	1.8	708.2
7. FreeHand no mulch	150	0.1	0.0	0.0	0.3	0.4	0.9	1.1	1.2	0.5	<b>477</b>
8. Snapshot no mulch	200	1.9	0.8	1.4	0.3	1.4	1.3	1.5	2.6	1.4	531.2
9. Specticle G no mulch	200	1.0	0.7	0.9	0.6	1.7	2.1	2.2	2.6	1.5	724.6
10. No mulch, no herb.	0	0.3	0.3	0.4	1.2	0.6	1.2	2.1	2.9	1.1	<b>370.2</b>
11. Mulch, no herb.	0	0.2	0.0	0.1	0.7	1.0	1.0	1.7	2.2	0.9	598.2

**Table 4.** OHP bedding plant phytotoxicity means presented by species for the eight evaluation dates and 11 treatments. Bold values represent the dates and treatments by species when phytotoxicity became commercially unacceptable i.e.  $\leq 3$ . Fresh weights were not collected by species.

***Salvia 'Rhea'***

Treatment	Rate/ac	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	14 WAT	Average
Biathlon, Mulch	100 lb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0750
Biathlon, No Mulch	100 lb	1.4	0.8	0.0	0.0	0.2	0.2	0.8	1.6	0.6250
Biathlon, Mulch	150 lb	0.4	0.8	0.0	0.0	0.0	0.0	0.0	0.6	0.2250
Biathlon, No Mulch	150 lb	2.0	2.0	2.0	2.0	2.6	2.6	2.0	2.0	2.1500
Biathlon, Mulch	200 lb	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.4	0.2000
Biathlon, No Mulch	200 lb	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2250
FreeHand, No Mulch	150 lb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000
Snapshot, No Mulch	200 lb	1.4	1.0	1.2	0.8	0.0	0.0	1.6	2.0	1.0000
Specticle G, Mulch	200 lb	0.6	0.0	0.0	0.0	0.6	0.6	0.0	0.4	0.2750
No Mulch	--	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.6	0.1250
Mulch	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0750

***Coleus 'Wizard® Mix'***

Treatment	Rate/ac	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	14 WAT	Average
Biathlon, Mulch	100 lb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000
Biathlon, No Mulch	100 lb	2.2	1.2	0.0	0.0	0.0	1.2	1.6	2.0	1.0250
Biathlon, Mulch	150 lb	1.6	0.6	0.2	0.0	0.0	0.0	0.0	0.4	0.3500
Biathlon, No Mulch	150 lb	2.0	0.0	0.0	0.0	0.6	0.6	0.0	0.4	0.4500
Biathlon, Mulch	200 lb	1.6	1.2	0.0	0.0	0.6	0.6	1.2	0.0	0.6500
Biathlon, No Mulch	200 lb	2.6	2.2	1.2	1.2	1.0	2.0	2.0	2.0	1.7750
FreeHand, No Mulch	150 lb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000
Snapshot, No Mulch	200 lb	2.0	1.2	0.8	0.8	0.6	0.6	0.6	0.6	0.9000
Specticle G, Mulch	200 lb	2.2	0.6	0.4	0.0	0.6	1.4	0.8	0.8	0.8500
No Mulch	--	0.6	0.0	0.0	0.0	0.0	0.4	1.0	2.4	0.5500
Mulch	--	0.8	0.0	0.4	0.4	0.8	0.8	1.6	0.8	0.7000

***Snaptadragon 'Montego™ Formula Mix'***

Treatment	Rate/ac	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	14 WAT	Average
Biathlon, Mulch	100 lb	0.0	0.0	2.0	2.0	2.0	2.0	2.0	2.6	1.5750
Biathlon, No Mulch	100 lb	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>6.0</b>	<b>6.0</b>	4.5000

Biathlon, Mulch	150 lb	1.0	0.0	0.0	2.0	2.0	2.0	2.0	2.6	1.4500
Biathlon, No Mulch	150 lb	2.4	2.0	2.0	2.0	2.6	2.6	2.0	2.4	2.2500
Biathlon, Mulch	200 lb	2.8	<b>3.4</b>	<b>4.0</b>	<b>4.0</b>	<b>4.6</b>	<b>4.6</b>	<b>4.0</b>	<b>4.0</b>	3.9250
Biathlon, No Mulch	200 lb	0.2	1.6	2.0	2.0	2.2	2.2	2.0	2.0	1.7750
FreeHand, No Mulch	150 lb	0.0	0.0	0.0	2.0	2.0	2.0	2.6	2.0	1.3250
Snapshot, No Mulch	200 lb	1.2	0.4	1.6	1.6	1.0	1.0	1.0	2.4	1.2750
Specticle G, Mulch	200 lb	2.0	2.0	2.0	2.0	2.6	2.6	<b>4.0</b>	<b>4.0</b>	2.6500
No Mulch	--	0.0	2.0	<b>3.0</b>	<b>4.0</b>	<b>4.0</b>	<b>4.0</b>	<b>5.4</b>	<b>5.8</b>	3.5250
Mulch	--	0.0	0.0	0.0	0.6	0.8	0.8	1.4	<b>3.2</b>	0.8500

***Impatiens walleriana***

Treatment	Rate/ac	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	14 WAT	Average
Biathlon, Mulch	100 lb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000
Biathlon, No Mulch	100 lb	1.6	0.8	1.6	0.6	1.0	2.2	2.2	1.6	1.4500
Biathlon, Mulch	150 lb	2.0	2.0	2.0	2.0	2.6	2.6	2.6	<b>3.0</b>	2.3500
Biathlon, No Mulch	150 lb	1.8	1.0	0.0	0.0	0.6	0.6	0.6	0.6	0.6500
Biathlon, Mulch	200 lb	2.0	1.4	1.0	0.0	0.6	0.6	1.4	2.8	1.2250
Biathlon, No Mulch	200 lb	<b>3.2</b>	<b>3.0</b>	2.0	2.0	2.0	2.0	2.0	<b>4.0</b>	2.5250
FreeHand, No Mulch	150 lb	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1250
Snapshot, No Mulch	200 lb	1.6	1.2	1.4	0.6	1.0	1.0	1.4	2.2	1.3000
Specticle G, Mulch	200 lb	1.0	1.0	0.6	0.0	<b>3.6</b>	<b>3.6</b>	<b>3.4</b>	<b>3.8</b>	2.1250
No Mulch	--	0.0	0.0	0.0	0.0	0.0	0.0	2.8	<b>3.8</b>	0.8250
Mulch	--	0.0	0.0	0.0	0.6	0.0	0.0	1.0	<b>3.0</b>	0.5750

***Ageratum 'Hawaii Blue'***

Treatment	Rate/ac	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	14 WAT	Average
Biathlon, Mulch	100 lb	0.6	0.0	0.0	0.0	0.0	0.0	2.0	2.0	0.5750
Biathlon, No Mulch	100 lb	0.4	0.0	1.0	0.0	1.4	2.6	2.2	2.2	1.2250
Biathlon, Mulch	150 lb	1.2	0.0	0.0	0.0	0.8	0.8	0.4	1.0	0.5250
Biathlon, No Mulch	150 lb	2.0	2.0	2.0	2.0	<b>3.4</b>	<b>3.4</b>	2.8	2.8	2.5500
Biathlon, Mulch	200 lb	0.6	0.8	0.0	0.0	0.6	0.6	0.0	0.0	0.3250
Biathlon, No Mulch	200 lb	0.0	0.0	0.8	1.4	2.8	<b>3.8</b>	<b>3.6</b>	<b>4.0</b>	2.0500
FreeHand, No Mulch	150 lb	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.3750
Snapshot, No Mulch	200 lb	0.8	0.0	1.6	1.2	1.8	1.8	1.2	0.6	1.1250
Specticle G, Mulch	200 lb	0.6	0.6	1.0	0.0	1.2	2.0	1.4	1.8	1.0750
No Mulch	--	0.0	0.0	0.0	0.0	0.0	1.0	<b>3.6</b>	<b>3.6</b>	1.0250

Mulch	--	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.8	0.2000
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***Marigold 'Bonanza Yellow'***

Treatment	Rate/ac	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	14 WAT	Average
Biathlon, Mulch	100 lb	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.1500
Biathlon, No Mulch	100 lb	1.4	0.0	1.6	0.0	0.4	1.6	1.6	1.2	0.9750
Biathlon, Mulch	150 lb	1.2	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.3750
Biathlon, No Mulch	150 lb	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.6	0.2250
Biathlon, Mulch	200 lb	0.6	0.8	1.0	0.0	0.6	0.6	0.6	0.6	0.6000
Biathlon, No Mulch	150 lb	1.6	0.6	0.2	1.2	1.8	2.8	2.2	1.0	1.4250
FreeHand, No Mulch	150 lb	0.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	0.3750
Snapshot, No Mulch	200 lb	3.0	0.0	1.0	0.0	1.8	1.8	1.6	2.6	1.4750
Specticle G, Mulch	200 lb	0.0	0.0	0.0	0.0	0.6	1.6	1.6	1.6	0.6750
No Mulch	--	0.0	0.0	0.0	0.0	0.0	0.8	0.8	1.8	0.4250
Mulch	--	0.0	0.0	0.0	0.0	2.0	2.0	3.0	2.2	1.1500

***Petunia 'Celebrity Blue'***

Treatment	Rate/ac	1 WAT	2 WAT	4 WAT	6 WAT	8 WAT	10 WAT	12 WAT	14 WAT	Average
Biathlon, Mulch	100 lb	0.0	0.0	0.6	0.6	0.6	2.0	2.0	2.4	1.0250
Biathlon, No Mulch	100 lb	5.2	3.8	4.4	4.4	4.4	6.4	8.4	9.0	5.7500
Biathlon, Mulch	150 lb	1.6	1.6	1.8	4.4	4.0	4.0	4.0	6.8	3.5250
Biathlon, No Mulch	150 lb	3.1	2.0	2.0	2.0	3.4	3.4	3.2	3.8	2.8625
Biathlon, Mulch	200 lb	3.0	2.0	2.0	2.0	3.4	3.4	2.8	2.4	2.6250
Biathlon, No Mulch	150 lb	2.2	1.2	0.2	1.6	3.4	3.4	3.6	5.8	2.6750
FreeHand, No Mulch	150 lb	1.0	0.0	0.0	0.0	0.6	2.6	2.8	3.4	1.3000
Snapshot, No Mulch	200 lb	2.4	2.0	2.2	2.0	3.2	3.2	3.2	7.4	3.2000
Specticle G, Mulch	200 lb	0.6	0.6	2.6	2.0	3.0	3.0	4.0	6.0	2.7250
No Mulch	--	1.2	0.0	0.0	0.0	0.0	0.0	0.6	2.6	0.5500
Mulch	--	0.6	0.0	0.0	3.0	3.4	3.4	4.4	5.0	2.4750