2020

Washington Asparagus Commission

Asparagus Research Report

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Washington Asparagus Commission

2014 Asparagus Variety Trial-2020 Update

In 2014 this variety trial was established with 26 varieties. The varieties include Guelph Millennium, Jersey Knight, Pacific Purple, Ravel, Ramada, Rapsody, Ramires, Rambo, Raffaello, SWS 1009, Sequoia, Pacific Challenger, Porthos, Mondeo, WB 201, WB 202, WB 203, WB 204, WB 205, WB 206, WB 207, WB 210, UG 20, UGO 25 and Voltaire. Asparagus was graded on spears that were 9 inches, 8 inches, 7 inches, cull and amount of trim. Asparagus was planted at 4.5 feet row spacing with 7 inch in-row spacing. The plots were 4.5' x 15' with 4 replications per variety. Yield data from 2016 to 2020 is presented in table below with average yield arranged from high to low for all varieties:

	2014 Asparagus Variety Trial											
		Net Yields (pounds), ranked by average yield										
TRT #	**VARIETY**	**2016**		**2017**		**2018**		**2019**		**2020**		**Average**
3	RAPSODY	2,827	ghi	6,574	ab	5,170	a	3,245	a	11,518	a	5,867
20	UG 20	5,218	ab	7,553	ab	3,486	bcd	1,853	bcd	5,308	b-e	4,684
11	MONDEO	3,915	b-g	6,906	ab	2,980	b-g	1,813	b-e	6,068	bcd	4,336
5	RAMBO	2,884	ghi	5,499	ab	3,119	b-f	1,748	b-e	7,475	b	4,145
17	WB 206	5,391	a	5,972	ab	3,401	b-e	1,708	b-e	4,223	b-e	4,139
18	WB 207	4,352	a-f	8,014	a	1,241	j	741	fg	6,229	bc	4,115
16	WB 205	4,811	abc	7,238	ab	3,165	b-f	928	efg	4,433	b-e	4,115
24	JERSEY KNIGHT	3,591	c-i	8,437	a	2,674	b-i	1,582	b-f	4,235	b-e	4,104
6	RAFFAELLO	3,531	c-i	6,138	ab	2,999	b-g	2,312	b	5,432	b-e	4,082
14	WB 203	2,710	ghi	5,810	ab	3,422	b-e	1,788	b-e	5,927	bcd	3,931
7	SWS 1009	2,409	i	6,292	ab	3,875	b	1,968	bcd	4,816	b-e	3,872
21	UG024	3,362	d-i	6,121	ab	2,697	b-i	1,610	b-f	5,021	b-e	3,762
4	RAMIRES	2,202	i	4,748	ab	3,621	bc	1,892	bcd	6,081	bcd	3,709
22	UG025	4,657	a-d	6,881	ab	2,209	e-j	1,115	d-g	3,673	b-e	3,707
8	SEQUOIA	3,173	e-i	4,632	ab	3,602	bc	1,794	b-e	4,885	b-e	3,617
13	WB 202	2,842	ghi	7,337	ab	2,013	f-j	1,526	b-g	4,053	b-e	3,554
15	WB 204	4,088	a-g	6,922	ab	2,340	d-j	1,088	d-g	3,221	cde	3,532
12	WB 201	2,304	i	5,175	ab	2,872	b-h	2,138	bc	4,804	b-e	3,459
10	PORTHOS	2,421	i	5,823	ab	2,627	b-i	1,721	b-e	4,508	b-e	3,420
9	PACIFIC CHALLENGER	3,140	e-i	3,864	ab	3,140	b-f	1,789	b-e	5,153	b-e	3,417
2	RAMADA	2,507	hi	1,851	b	3,801	b	1,670	b-e	7,203	b	3,406
26	VOLTAIRE	3,505	c-i	7,059	ab	1,600	ij	1,251	c-g	3,027	cde	3,288
1	RAVEL	2,266	i	2,743	ab	3,098	b-f	1,769	b-e	6,529	bc	3,281
23	GUELPH MILLENINUM	3,042	f-i	6,292	ab	2,466	c-j	1,472	b-g	2,155	de	3,085
19	WB 210	4,540	a-e	6,304	ab	1,772	g-j	662	g	1,878	e	3,031
25	PACIFIC PURPLE	3,908	b-h	5,702	ab	1,724	hij	754	fg	3,058	cde	3,029

Figure 1. Example of 4 common varieties.

Ramada trt 2 | Rhapsody trt 3 | Rambo trt 5 | Mondeo trt 11

Figure 2. Field view of the trial.

2016 Asparagus Variety Trial-2020 Update

In 2016 this variety trial was established with 18 different varieties. These include Bejo 3022 F1, Erasumus F1, Guelph Millennium, Jaleo, Jersey Deluxe, Jersey Knight, Jersey Supreme, Mondeo F1, NJ 1113 F1, Raffael, Ramada, Rambo, Ravel, Rosalie, UGO 25, Verdus F1 and Voltaire. Asparagus was planted at 4.5 feet row spacing with 7 inch in-row spacing at a rate of 22,500 seeds per acre. The plots were 3.75' x 20' with 4 replications per variety. Yield data from 2018 to 2020 is presented in table below with average yield arranged from high to low for all varieties:

		Net Yield (pounds), ranked by average yield						
Trt. #	VARIETY	2018		2019		2020		AVERAGE
5	Verdus F1	1,575	a-d	3,358	b-e	20,670	a	8,534
3	Rosalie	2,205	a	4,910	a	16,374	ab	7,830
2	Erasumus F1	1,992	ab	3,869	ab	15,105	abc	6,989
14	Rapsody	1,612	a-d	3,382	b-e	15,052	abc	6,682
16	Raffaelo	1,368	bcd	3,482	bcd	12,137	bcd	5,662
6	Guelph Millennium	1,627	a-d	3,268	b-e	11,189	bcd	5,361
13	Mondeo F1	1,292	cd	2,647	b-e	9,523	bcd	4,487
15	Ravel	1,530	a-d	3,104	b-e	8,710	b-e	4,448
11	NJ 1113 F1	999	de	2,575	cde	9,528	bcd	4,367
1	Bejo 3022 F1	1,154	cde	3,734	abc	8,074	cde	4,321
10	Jersey Supreme	1,242	cd	2,912	b-e	8,346	cde	4,167
7	Voltaire	978	de	2,888	b-e	8,490	b-e	4,119
18	Ramada	1,040	de	2,403	de	8,810	b-e	4,084
8	Jersey Deluxe	1,625	a-d	2,181	ef	8,208	cde	4,005
9	Jersey Knight	1,814	abc	2,487	de	7,704	cde	4,002
17	Rambo	1,594	a-d	2,562	cde	7,481	cde	3,879
12	UG025	534	e	1,128	fg	4,636	de	2,099
4	Jaleo	1,035	de	483	g	1,257	e	925

Figure 1. Example of 5 common varieties.

High Yielding Asparagus Trial – 2020 Update

Introduction

The objective of this trial is to determine the comparative contribution of variety and plant density has on yield and stand longevity. Jersey Giant was selected as a first-generation hybrid asparagus, Jersey Supreme as a second-generation hybrid variety and Guelph Millennium as a third-generation hybrid variety.

Materials and Methods

The trial was planted from crowns in April, 2013 at 5 planting densities: 20,000, 25,000, 30,000, 35,000 and 40,000 crowns per acre for each variety. For the 20,000 rate the row spacing was 45", in row spacing was 6.95" and the number of rows totaled 6. For the 25,000 rate, the row spacing was 40', in row spacing was 6.25 and the number of rows totaled 7. For the 30,000 rate, the row spacing was 40", in row spacing was 5.22" and the number of rows totaled 7. For the 35,000 rate, the row spacing was 35", the in row spacing was 5.19" and the number of rows totaled 8. For the 40,000 rate, the row spacing was 30", the in row spacing was 5.23" and the number of rows totaled 9. The plot length was 30 ft. There were 15 treatments which were replicated 4 times making the planted area 41,400 square feet but taking up at least one full acre. The crowns needed by variety were: at 20,000 rate needed 1243 crowns, at 25,000 rate needed 1613 crowns, at 30,000 rate needed 1931 crowns, at 35,000 rate needed 2250 and at the 40,000 rate needed 2478 crowns. The total was 9,515 crowns needed by variety.

The trial was harvested for the first time in 2014 for a two-week period.

Results

Results are presented for 2014 through 2020 (Table 1). Data are presented in (Table 2) without 2014 which was only a short harvest. Removing the 2014 results provides a better view of full season average yield.

Table 1. High Yielding Asparagus Trial 2014 - 2020 with 7 Year Average, ranked by average yield.

Trt	Treatment	Net Yield / lbs per acre														
No.	Name	2014		2015		2016		2017		2018		2019		2020		Average
15	GUELPH MILLENNIUM 40,000	371	bcd	12,486	bcd	28,366	a	13,280	bcd	9,202	b	17,393	a	7,413	ef	12,644
12	GUELPH MILLENNIUM 25,000	379	cbcd	13,483	abc	19,728	bcd	15,888	ab	12,138	a	14,745	a	9,754	ef	12,302
14	GUELPH MILLENNIUM 35,000	425	ab	16,146	a	24,011	ab	12,897	cd	10,514	ab	8,842	a	11,923	de	12,108
7	SUPREME 25,000	285	de	15,200	ab	17,131	cde	17,214	a	9,850	ab	10,178	a	8,598	ef	11,208
13	GUELPH MILLENNIUM 30,000	505	a	15,472	ab	17,219	cde	14,134	bc	10,797	ab	9,659	a	6,282	f	10,581
11	GUELPH MILLENNIUM 20,000	402	bc	12,438	bcd	13,210	efg	13,618	bcd	11,423	ab	10,015	a	5,938	f	9,578
9	SUPREME 35,000	358	b-e	13,557	abc	19,759	bcd	8,588	e	5,283	c	4,837	a	12,567	d	9,278
2	GIANT 25,000	328	b-e	11,152	c-f	12,723	efg	11,248	de	6,878	c	6,901	a	15,099	b	9,190
4	GIANT 35,000	364	b-e	11,151	c-f	15,620	def	9,637	e	4,885	c	4,146	a	17,755	a	9,080
3	GIANT 30,000	347	b-e	11,665	cde	16,675	cde	10,900	de	5,500	c	4,202	a	13,058	c	8,907
10	SUPREME 40,000	271	e	9,215	ef	21,364	bc	8,854	e	4,332	c	4,557	a	9,983	ef	8,368
5	GIANT 40,000	315	cde	8,413	f	18,897	bcd	8,541	e	4,163	c	4,609	a	13,395	bc	8,333
1	GIANT 20,000	337	b-e	10,485	c-f	10,988	fg	9,752	e	5,231	c	5,678	a	13,001	c	7,925
8	SUPREME 30,000	307	cde	9,935	def	15,682	def	9,989	e	4,743	c	4,532	a	8,831	ef	7,717
6	SUPREME 20,000	324	cde	9,907	def	9,882	g	10,203	e	6,775	c	6,275	a	7,825	ef	7,313
Means followed by same letter or symbol do not significantly differ (P=.05, LSD)																

Table 2. High Yielding Asparagus Trial 2015 - 2020 with 6 Year Average, ranked by average yield.

Trt	Treatment	Net Yield / lbs per acre												
No.	Name	2015		2016		2017		2018		2019		2020		Average
15	GUELPH MILLENNIUM 40,000	12,486	bcd	28,366	a	13,280	bcd	9,202	b	17,393	a	7,413	ef	14,690
12	GUELPH MILLENNIUM 25,000	13,483	abc	19,728	bcd	15,888	ab	12,138	a	14,745	a	9,754	ef	14,289
14	GUELPH MILLENNIUM 35,000	16,146	a	24,011	ab	12,897	cd	10,514	ab	8,842	a	11,923	de	14,056
7	SUPREME 25,000	15,200	ab	17,131	cde	17,214	a	9,850	ab	10,178	a	8,598	ef	13,028
13	GUELPH MILLENNIUM 30,000	15,472	ab	17,219	cde	14,134	bc	10,797	ab	9,659	a	6,282	f	12,261
11	GUELPH MILLENNIUM 20,000	12,438	bcd	13,210	efg	13,618	bcd	11,423	ab	10,015	a	5,938	f	11,107
9	SUPREME 35,000	13,557	abc	19,759	bcd	8,588	e	5,283	c	4,837	a	12,567	d	10,765
2	GIANT 25,000	11,152	c-f	12,723	efg	11,248	de	6,878	c	6,901	a	15,099	b	10,667
4	GIANT 35,000	11,151	c-f	15,620	def	9,637	e	4,885	c	4,146	a	17,755	a	10,532
3	GIANT 30,000	11,665	cde	16,675	cde	10,900	de	5,500	c	4,202	a	13,058	c	10,333
10	SUPREME 40,000	9,215	ef	21,364	bc	8,854	e	4,332	c	4,557	a	9,983	ef	9,717
5	GIANT 40,000	8,413	f	18,897	bcd	8,541	e	4,163	c	4,609	a	13,395	bc	9,670
1	GIANT 20,000	10,485	c-f	10,988	fg	9,752	e	5,231	c	5,678	a	13,001	c	9,189
8	SUPREME 30,000	9,935	def	15,682	def	9,989	e	4,743	c	4,532	a	8,831	ef	8,952
6	SUPREME 20,000	9,907	def	9,882	g	10,203	e	6,775	c	6,275	a	7,825	ef	8,478
Means followed by same letter or symbol do not significantly differ (P=.05, LSD)														

The purpose of this eight year trial was to determine the relative contribution of crown density and variety to yield. At the time this trial was initiated growers wanted to know what was more important variety or crown density. This trial was designed to shed insight into that question. It is clear that selection of the correct variety is a key determinate of overall yield as five of the six highest yielding treatments was Guelph Millennium. It shows that year over year, almost regardless of plant density, Guelph Millennium was higher yielding. The lowest crown density, GM at 20,000 had an average yield of 11,107 pounds while the highest planting density of Jersey Supreme (40,000) was 9,717 and for Jersey Giant (40,000) was 9,670.

While it is clear that varietal selection is more important than crown density, it is difficult to use this data to determine the optimal number of crowns to plant. In six years out of eight, there was no statistical difference in yield between GM at

40,000 and at 25,000 crowns per acre and on average the difference in yield between these two plant densities was only 3%.

It is my opinion that varietal selection is more important than crown density. From these data, it would seem that planting at 20,000 crowns per acre would result in lower yields as compared to higher plant densities. This may not be true in furrow irrigated asparagus due to the wider row spacing which would result in overly crowded rows required to get the higher plant densities. In that case it is likely that 20,000 may preform better as compared to the much higher density plantings. The results indicated that 40,000 crowns per acre may be suboptimal for Jersey Giant and Jersey Supreme but it does not appear to be disadvantageous to GM. These results indicate that optimum plant densities likely differ by variety. Additionally, how the arrangement of the crowns may allow for greater plant density with less crowding of the crowns. For example a double row of crowns on an 80 inch row spacing may be more advantages than one row of crowns on a 40 inch spacing. Also, the intensity and quality of management will play the role in success of a higher density planting. Since all treatments here were managed the same, presumably that variable should play a role in these results. However, it is likely that a 40,000 crown per acre planting would require more nutrition and water than a 20,000 crown per acre planting. This trial was managed with a typical fertility program for this region with about 250 to 300 pounds of nitrogen per acre. It is possible that a more intensive management program for the higher plant densities may have resulted in higher yields.

Figure 1. Yield view of the trial.

Asparagus Fertility by Variety Trial – 2020 Update

This trial was planted in 2016 with four varieties. These include Guelph Millennium, Jersey Knight, Rapsody and Voltaire. The plots were 7.5’ x 20’ with 6 replications per treatment (Photo 1). In 2020, all of the asparagus was fertilized in March with granular urea of 34.0.0 by a handheld applicator and applied per plot for four different rates. . The standard rate was the medium rate at 156 lbs N/a, the low rate is have of standard medium rate at 78 lbs N/a, the medium-high rate was 50% above standard at 234 lbs N/a, and the high rate was double the standard at 312 lbs N/a. There were no applications during harvest and the after harvest applications was made in early July by a backpack CO_2 boom sprayer (Photo 2) at the rates low at 56 lbs of N/a, medium at 83 lbs of N/a, medium-high at 97 lbs of N/a, and high at a rate of 146 lbs of N/a. As a result, the total N put down in 2020 is 134 lbs/a for low rate, 239 lbs/a for medium rate, 331 lbs/a for medium-high rate, and 458 lbs/a for high rate.

Although the 2019 data did no show significant yield differentiation among treatments and varieties, the further matured plants started showing variations among varieties in 2020. It appears that Rapsody, Jersey Knight, and Voltaire had some yield advantage over Guelph Millennium, and N rate definitely showed a positive dose effect where higher rates generally resulted in better yield. However, statistically the differences are often not significant, thus the N input cost and yield gain need to be considered and balanced. For instance, the highest yield from Rapsody High N (12,661 lbs for Treatment 8) is not statistically higher than Jersey Knight Medium N (9,170 lbs for Treatment 10), but the N input/cost is 2 times higher between medium N and high N rates in this trial. The results of this study will provide important guidelines for making these kind of input VS gain decisions, and the extension of this trial for multiple years is crucial for this goal.

Asparagus Fertility by Variety Trial 2018- 2020								
		Net yield (lbs, ranked by average yield)						
Trt. #	Variety by Fertility Program	2018		2019		2020		AVERAGE
8	Rhapsody High	141	a	9,817	a	12,661	a	7,540
7	Rhapsody Med-High	123	a	10,526	a	10,585	ab	7,078
12	Jersey Knight High	117	a	8,552	a	9,712	abc	6,127
3	Voltaire Med-High	169	a	8,742	a	9,354	a-d	6,089
10	Jersey Knight Medium	141	a	8,678	a	9,170	a-d	5,996
6	Rhapsody Medium	140	a	8,497	a	8,193	bcd	5,610
1	Voltaire Low	135	a	8,367	a	8,259	bcd	5,587
16	Guelph Millennium High	128	a	8,266	a	7,487	bcd	5,293
4	Voltaire High	127	a	8,648	a	7,100	bcd	5,292
9	Jersey Knight Low	128	a	8,147	a	6,745	cd	5,006
14	Guelph Millennium Medium	118	a	8,412	a	6,329	cd	4,953
15	Guelph Millennium Med-High	130	a	7,660	a	7,053	bcd	4,948
5	Rhapsody Low	129	a	7,351	a	6,622	cd	4,701
11	Jersey Knight Med-high	139	a	7,048	a	6,757	cd	4,648
13	Guelph Millennium Low	124	a	7,358	a	6,353	cd	4,612
2	Voltaire Medium	102	a	6,594	a	6,028	d	4,241

Photo 1. Field view with workers harvesting.

Photo 2. After harvest application made by a backpack sprayer.

2019 Replanted Asparagus Variety Trial - 2020 Update

The objective of this trial was to determine if varietal selection when establishing asparagus in a replanting situation can help manage Fusarium. Some new varieties make claims of Fusarium tolerance. Other varieties, such as Guelph Millennium demonstrably grown better than Jersey Knight in a replant situation as observed in a WAC field trip to Michigan. While no claims of resistance or tolerance to Fusarium by this variety is made by Fox Seeds, it is likely that the variety's natural robustness and vigor allows it to simply do better in a replant situation. This is the first trial of which I am aware to screen these varieties for their ability to grow in a replant situation. Many Washington asparagus growers are multigenerational growers and often have limited or no access to ground that has not been previously planted to asparagus. Identifying asparagus varieties that do better in a replant situation would be valuable to the Washington asparagus industry.

This trial was initiated in 2019 a variety trial with 25 varieties, 17 of which have never been evaluated in Washington. The varieties were planted on ground that had been planted to asparagus (v. Jersey Knight) for the previous ten years. Seeds were planted in a greenhouse and transplanted as seedlings in July of 2019. Each variety was planted with four replications. The rows were 45 inches apart with 9 inches between plants and a total of 22 plants per plot. Plants developed normally in 2020 and the first harvest will be in 2021. Guelph Millennium is considered the industry standard.

2019 Asparagus Replant Variety Trial

Variety	Company
198 x 120	Aspara Pacific
317 x 120	Aspara Pacific
38 x 167	Aspara Pacific
38x 120	Aspara Pacific
395 x 120	Aspara Pacific
395 x 167	Aspara Pacific
73 x 167	Aspara Pacific
Aspalim	Limgroup
Radius	Bejo
Canticus	Bejo
Eclipse	Fox Seeds
Equinox	Fox Seeds
Erasmus	Bejo
Exp 66/ NJ 1178	Bejo
Gijnlim	Limgroup
Javelim	Limgroup
Guelph Millennium	Fox Seeds
Radius F1	Bejo
Ramires	Sudwestsaat
Rapsody	Sudwestsaat
Sequoia	Vilmorin
Spartacus F1	Bejo
UG 023	Fox Seeds
Voltaire	Vilmorin
Walker Deluxe	Walker Bros, Inc.

Asparagus Aphid Control 2020

Objective

To evaluate the efficacy of organic and conventional insecticides for control of European asparagus aphid control.

Materials and Methods

An European asparagus aphid (*Brachycorynella asparagi*) trial was conducted in August, 2020 by Agricultural Development Group, Inc., 15 miles north of Pasco, WA. The experimental design was a randomized complete block design with 4 replications with the plot size of 12 ft x 10 ft. Applications for this trial were made by a multi-boom sprayer to apply treatment spray at 20 gallons/acre. The asparagus plots for this trial were not treated with any maintenance insecticide to prevent the possibility of interfering with the existing trial's objectives. The variety was Jersey Knight.

Starting from late July, the asparagus field was sampled weekly by a beat sheet 8 times (2 times for north, south, west, and east, respectively) for aphid count to decide when and where to start the trial in the big asparagus field. The applications were on August 20, August 27, September 3, and September 10. The evaluations for aphid count by using beat sheet were on August 20 (evaluation before first application), August 27, September 3, September 10, and September 17. Two sub-samples were used for each plot (two beat sheet samples per plot). Total aphid count was calculated by adding all aphids counts from all evaluation dates after first application.

Table1. Asparagus aphid insecticide trial, ranked by total number of aphids.

Rating Date				Aug-20-2019	Aug-27-2019	Sep-3-2019	Sep-10-2019	Sep-17-2019	
SE Group No.				1	2	3	4	5	7
Rating Type				Aphid count	Aphid count	Aphid count	Aphid count	Aphid count	Total count
Rating Unit				Number	Number	Number	Number	Number	Number
Number of Subsamples				2	2	2	2	2	2
Days After First/Last Applic.				0 0	7 7	14 7	21 7	28 7	
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1	2	3	4	5	6
1	Untreated				5.1a	6.1a	5.9a	5.4a	6.3a	23.6 a
10	Venerate XL	4	qt/a	ABCD	6.6a	3.1bc	2.9b	2.1b	1.4bc	9.5 b
8	Aza-Direct	1.5	pt/a	ABCD	6.9a	3.4b	2.5bcd	1.8b-e	1.1bc	8.8 bc
8	Pyganic 1.4EC	1	qt/a	ABCD						
5	Aza-Direct	2	pt/a	ABCD	6.3a	2.6bcd	2.8bc	2bc	1.3bc	8.6 bc
6	Pyganic 1.4EC	2	qt/a	ABCD	4.9a	2.3cd	2.3bcd	1.9bcd	1.5b	7.9 bcd
12	Cinnerate	30	fl oz/a	ABCD	5.8a	3.0bcd	2.3bcd	1.6c-f	0.9bc	7.8 b-e
9	Grandevo	3	lb/a	ABCD	6.5 a	2.8 bcd	2.1 cd	1.6 c-f	0.9 bc	7.4 cde
11	Veratran D	10	lb/a	ABCD	5.3a	3.0bcd	2.3bcd	1.4efg	0.6c	7.3 cde
4	Transform	1.5	oz/a	A	7.8 a	2.4 cd	2.1 cd	1.5 def	0.6 c	6.6 de
2	Warrior II	1.92	fl oz/a	A	5.1a	2.1d	2.0d	1.4efg	0.6c	6.1 de
3	Sivanto 200SL	10.5	fl oz/a	A	5.5a	2.1d	1.9d	1.3fg	0.8bc	6.0 e
7	Aza-Direct	2	pt/a	ABCD	4.8a	2.3cd	1.9d	1.0g	0.9bc	6.0 e
7	Pyganic 1.4EC	2	qt/a	ABCD						
LSD P=.05					2.29	0.95	0.73	0.47	0.84	1.80
Standard Deviation					1.59	0.66	0.51	0.33	0.58	1.25
CV					27.16	22.55	19.83	17.3	41.71	14.23
Levene's F					0.978	0.662	1.387	0.612	0.557	0.776
Levene's Prob(F)					0.483	0.763	0.221	0.806	0.85	0.661
Skewness					0.7789*	2.0572*	2.7789*	2.5713*	2.5605*	2.7175*
Kurtosis					0.2119	6.1705*	8.5974*	6.4477*	6.0988*	7.0118*
Replicate F					3.479	2.052	0.780	0.687	0.061	0.790
Replicate Prob(F)					0.0267	0.1257	0.5136	0.5667	0.9797	0.5084
Treatment F					1.368	10.938	18.374	47.665	28.620	59.054
Treatment Prob(F)					0.2336	0.0001	0.0001	0.0001	0.0001	0.0001

Pest Type
I, Insect = Insect
Rating Unit
Number = number

Means followed by same letter or symbol do not significantly differ (P=.05, LSD).
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL.

Results and Discussion

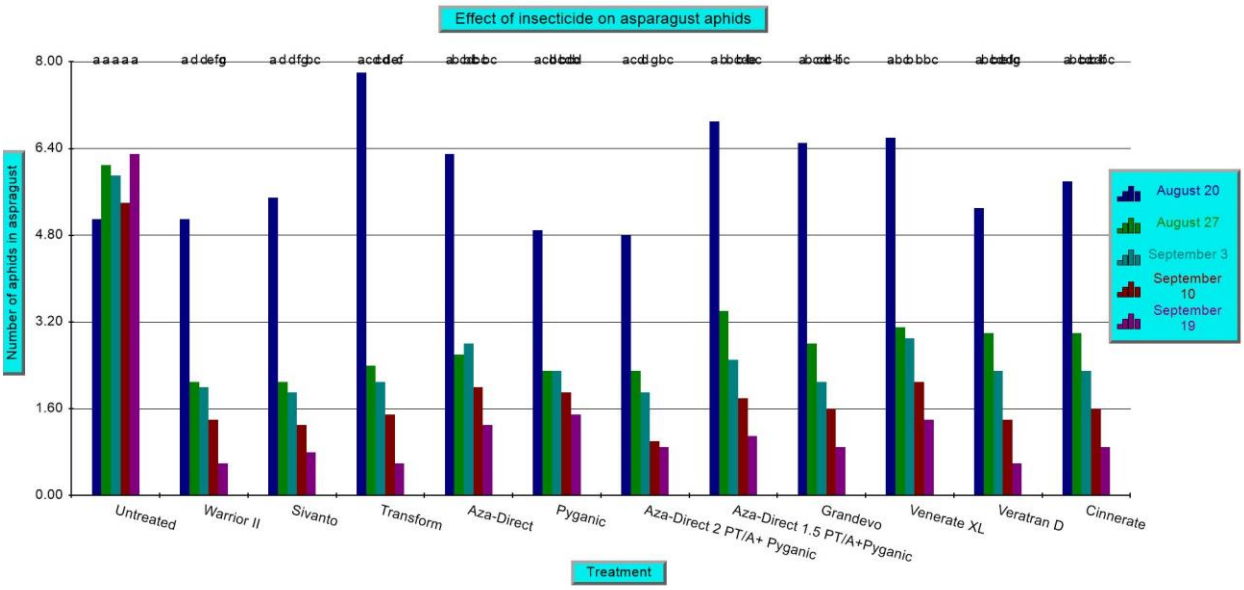
At the time of application aphid numbers were above the recommended threshold of one aphid per plant. The results indicated that treatments Warrior II, Sivanto, and Veratran had lowest aphid number for all evaluation dates after first application. Treatments of Warrior II, Sivanto, and Veratran had 66%, 66%, and 51% significantly less aphid number on August 27; 66%, 68%, and 61% significantly less aphid number on September 3; 74%, 76%, and 74% significantly less aphid number on September 10; 90%, 87%, and 90% significantly less aphid number on September 17, compared to the untreated check on each evaluation date, respectively.

The most important evaluation is data column 6 in Table 1 above, total aphids present after the first application. For the total aphid number from all evaluation dates post treatment, application of Warrior II, Sivanto, Transform, Aza-Direct, Pyganic, Aza-Direct 2pt/a+Pyganic, Aza-Direct 1.5pt/a+Pyganic, Grandevo, Venerae, Veratran, Cinnerate had 74%, 75%, 72%, 64%, 67%, 75%, 63%, 69%, 60%, 69%, and 67% significantly less aphids compared to the untreated check, respectively.

The most effective treatments at reducing European asparagus aphid were Cinnerate, Grandevo, Veratran, Sivanto, Transform, Warrior II and Aza Direct tank mixed with Pyganic at the high rates. Warrior II is normally used as standard, so these treatments showed comparable efficacy in this trial are likely to show comparable efficacy in the field.

One of the objectives in this trial was to identify organically approved treatments for aphids in asparagus. These results show that Aza Direct tank mixed with Pyganic at the high rate, Cinnerate, and Grandevo provided a level of control that was comparable to that of Warrior II and Transform. Aza Direct, Pyganic, Cinnerate and Grandevo are registered for use on asparagus and are OMRI certified. Veratran which also showed comparable efficacy is also OMRI certified but is not registered for use on asparagus. The conventional product, Transform, worked very similarly as Warrior II, as did Sivanto, the next insecticide that is expected to be registered on asparagus for aphid control.

Graph 1. Effect of insecticides on aphid count in asparagus. The evaluations were on August 20, August 27, September 3, September 10, and September 17.



Graph 2. Effect of insecticides on total number of aphids in asparagus. The total number of aphids was calculated by adding all aphids from evaluations on August 20, August 27, September 3, September 10, and September 17.

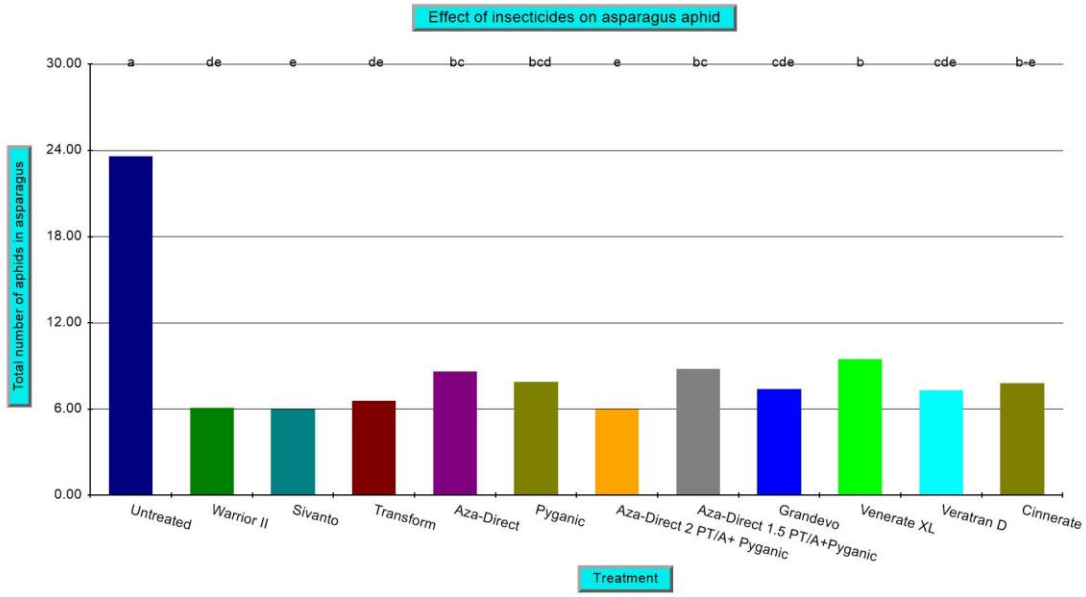


Photo 1. Overall trial site.

Photo 2. Application using multi-boom sprayer.

Photo 3. Counting aphids using beat sheet in asparagus field.

Photo 4. Representative photos for European asparagus aphid.

Photo source: http://entoweb.okstate.edu/ddd/insects/asparagus-aphid.htm

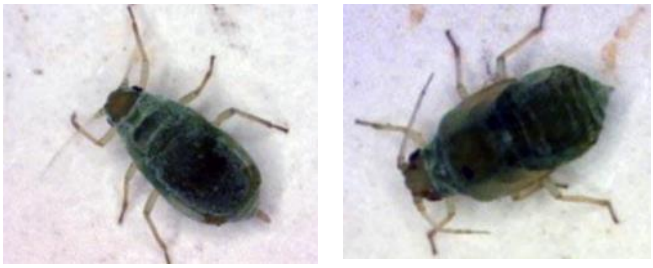


Photo credit: Z. Szendrei, MSU

Asparagus Layby Weed Control 2020 - Location 1

Introduction

Asparagus growers are interested in new herbicides, particularly soil residue herbicides used postharvest. FMC has a tolerance for sulfentrazone for asparagus and is willing to register the product, Spartan 4F with evidence of crop safety. The objective of this study is to generate efficacy and crop safety data that will convince FMC to allow a registration on asparagus, of particular interest to Washington asparagus growers is Spartan 4F's activity against black nightshade.

Materials and Methods

The research staff at Agricultural Development Group, Inc. conducted this layby herbicide trial to evaluate the efficacy of Spartan 4F (Table 1) for pre-emergence and early post-emergence weed control in asparagus, in comparison with Lorox. The experimental design was a RCB with 4 replications with the plot size of 12 ft x 15 ft. Applications for this trial were made by a CO_2 pressurized backpack sprayer (Photo 1) that delivers spray volume at 27 gallons/acre. The trial location was 15 miles north of Pasco in a six-year-old Jersey Knight asparagus field.

Pre-emergence application was made on June 15 (A) right after the last harvest with majority of the above ground shoot cut off, followed by an early-post application at fern initiation on June 26 (B). The asparagus phytotoxicity was rated on a 1 to 10 scale (10 means total death, and 1 means perfect healthy) and weeds population of individual weed species were evaluated at 18, 32, 46, and 74 days after application A (DAA).

Table 1. Treatment list.

Trt No.	Treatment Name	Form Type	Rate	Rate Unit	Appl Code	Appl Description	Rep 1	2	3	4
1	Spartan 4F	L	6	fl oz/a	A	A=After last harvest	101	202	303	409
2	Spartan 4F	L	6	fl oz/a	B	B=Fern initiation	102	208	307	408
3	Spartan 4F	L	12	fl oz/a	A		103	209	301	406
4	Spartan 4F	L	12	fl oz/a	B		104	201	302	405
5	Spartan 4F	L	6	fl oz/a	A		105	204	306	401
	Spartan 4F	L	6	fl oz/a	B					
6	Spartan 4F	L	24	fl oz/a	A		106	207	305	404
7	Spartan 4F	L	24	fl oz/a	B		107	203	309	402
8	Lorox	D	3	lb/a	B		108	205	308	407
9	Untreated						109	206	304	403

Photo 1. Example of backpack spraying.

Results and Discussion

First all, there was acceptable but noticeable phytotoxicity from all early-post applications (B) at 18, 32, 46, and 60 DAA (Table 1; Photo 2, 3, 4, and 5). Treatment 2 with Spartan at the low rate 6 fl oz/a, Treatment 4 at medium rate 12 fl oz/a, Treatment 5 with both pre and early-post application of low rate, and Treatment 7 at high rate 24 fl oz/a, as well as Treatment 8 Lorox early-post all resulted in 2.3 to 3.5 phytotoxicity ratings by 18 DAA, and the damage maintained until 46 DAA. Also, there was a slight dose (rate) effect where the higher rates consistently resulted in numerically higher phytotoxicity rating. However, the injury on asparagus started to recover on 60 DAA and eventually reach 1.5 or lower ratings by 74 DAA.

Redroot pigweed, common barnyardgrass and Russian thistle were the dominant weeds early in this study from 18 to 46 DAA, where black nightshade become prevalent as well later from 60 to 74 DAA. All treatments successfully control the weeds at 18 days after preemergence application A which is also 7 days after -post application (B), and the suppression effect was maintained until 74 DAA.

Generally, pre-emergence application (highlighted in yellow) very obviously although not statistically, resulted in better control than early-post application (highlighted in green) within each rate. For instance, the common barnyardgrass, Russian thistle, and black nightshade weed pressure thrived from previously 11.3 %, 5.8%, and 0% at 32 DAA to 26.3%, 10%, and 17.5% by 60 DAA respectively in untreated check, the pre-emergence applications of Spartan at 6 fl oz/a (Treatment 1), 12 fl oz/a (Treatment 3), 24 fl oz/a (Treatment 6), and double applied pre-emergence or early-post at 6 fl oz/a (Treatment 5) resulted in only 0.5% to 1.3% common barnyardgrass, 0% to 1.3% Russian thistle, 1.3% to 5.3% black nightshade while the early-post application of Spartan from low to high rate (Treatments 2, 4, and 7) resulted in 3% to 6.3% barnyardgrass, 1.3% to 5.8% Russian thistle, and 3.8% to 8.8% black nightshade.

It is interesting to point out that although redroot pigweed also exhibited the similar trend where the pre application is better than then early-post application when the Spartan rate is low or medium consistently from 18 to 74 DAA. However, it appears that redroot pigweed is more sensitive to the high rate 24 fl oz/a as an early-post application which resulted in lower (1.3%) coverage then its pre application (3.8%) later in the study at 60 and 74 DAA when weed pressure become heavier.

It is also important to mention that there appeared to have internal competition among the weeds which may have influenced the coverage ratings. For example, when black nightshade started to thrive by 60 DAA, it spread extensively and occupied some of the original barnyardgrass area resulted in the reduction of barnyard coverage from 6.3% of 6 fl oz/a pre-emergence application on 46 DAA to only 1.3% of the same treatment on 60 DAA, from 15% of 6 fl oz/a early-post application on 46 DAA to only 6.3% of the same treatment on 60 DAA.

Overall, Spartan pre-emergence application at low, medium, or high rates resulted in statistically the same performance which is better than their early-post applications. The level of efficacy is promising and on par (early-post) or even better (pre) than the compared Lorox treatment. Considering the obvious phytotoxicity from early-post applications as well as higher rates, and the superior performance of pre-emergence applications, it is recommended to use the Spartan at low 6 fl oz/a rate as a pre-emergence application immediately after the last harvest to bare soil after tillage.

Photo 2. Example of phytotoxicity at 32 DAA of Treatment 2 (early-post application B of Spartan at 6 fl oz/a). The phytotoxicity level was rated as 2 in this case with slight discoloration.

Photo 3. Example of phytotoxicity at 32 DAA of Treatment 4 (early-post application B of Spartan at 12 fl oz/a). The phytotoxicity level was rated as 2 in this case with slight discoloration.

Photo 4. Example of phytotoxicity at 32 DAA of Treatment 5 (double applications of Spartan at 6 fl oz/a at both pre and early-post stage). The phytotoxicity level was rated as 2 in this case with slight discoloration.

Photo 5. Example of phytotoxicity at 32 DAA of Treatment 7 (early-post application B of Spartan at 24 fl oz/a). The phytotoxicity level was rated as 3 in this case with slight discoloration and stunt of growth.

Table 2. ANOVA table of the mean separation of different weeds for different treatments on all rating dates.

Pest Name				Redroot pigweed	Common barnyard grass	Common puncturevine	Russian thistle	
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				7/3/2020	7/3/2020	7/3/2020	7/3/2020	7/3/2020
Rating Type				CANWEE	CANWEE	CANWEE	CANWEE	phyto
Rating Unit				% cover	% cover	% cover	% cover	1-9
Days After First/Last Applic.				18 7	18 7	18 7	18 7	18 7
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	1*	2*	3*	4*	5*
1	Spartan 4F	6	fl oz/a	A	0.0b	2.8bcd	0.0b	0.8bc	1.0d
2	Spartan 4F	6	fl oz/a	B	1.3b	5.8b	0.0b	0.8bc	2.3c
3	Spartan 4F	12	fl oz/a	A	0.0b	0.8cd	0.0b	0.0c	1.0d
4	Spartan 4F	12	fl oz/a	B	0.0b	4.5bc	0.0b	2.3bc	3.0b
5	Spartan 4F	6	fl oz/a	A	0.0b	0.8cd	0.0b	0.0c	2.3c
	Spartan 4F	6	fl oz/a	B					
6	Spartan 4F	24	fl oz/a	A	0.0b	0.0d	0.0b	0.0c	1.0d
7	Spartan 4F	24	fl oz/a	B	0.0b	4.0bcd	0.0b	0.8bc	3.5a
8	Lorox	3	lb/a	B	0.0b	2.8bcd	0.0b	3.0b	2.5c
9	Untreated				8.8a	10.0a	2.3a	5.8a	1.0d
LSD P=.05					1.68	4.10	1.00	2.33	0.47
Treatment Prob(F)					0.0001	0.0012	0.0013	0.0004	0.0001

Pest Name				Redroot pigweed	Common barnyard grass	Common puncturevine	Russian thistle	
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				7/17/2020	7/17/2020	7/17/2020	7/17/2020	7/17/2020
Rating Type				CANWEE	CANWEE	CANWEE	CANWEE	phyto
Rating Unit				% cover	% cover	% cover	% cover	1-9
Days After First/Last Applic.				32 21	32 21	32 21	32 21	32 21
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	6*	7*	8*	9*	10*
1	Spartan 4F	6	fl oz/a	A	0.0b	4.0bc	0.0b	1.3bc	1.0d
2	Spartan 4F	6	fl oz/a	B	2.5b	8.3ab	0.0b	1.3bc	2.3c
3	Spartan 4F	12	fl oz/a	A	1.3b	0.8c	0.0b	0.0c	1.0d
4	Spartan 4F	12	fl oz/a	B	0.0b	5.0bc	0.0b	2.8abc	3.0b
5	Spartan 4F	6	fl oz/a	A	0.0b	0.8c	0.0b	0.0c	2.3c
	Spartan 4F	6	fl oz/a	B					
6	Spartan 4F	24	fl oz/a	A	0.0b	0.0c	0.0b	0.0c	1.0d
7	Spartan 4F	24	fl oz/a	B	0.0b	4.5bc	0.0b	0.8bc	3.5a
8	Lorox	3	lb/a	B	0.0b	3.3bc	0.0b	3.5ab	2.5c
9	Untreated				8.8a	11.3a	2.3a	5.8a	1.0d
LSD P=.05					3.49	5.48	1.00	3.11	0.47
Treatment Prob(F)					0.0003	0.0047	0.0013	0.0098	0.0001

Pest Name				Redroot pigweed	Common barnyard grass	Common puncturevine	Russian thistle	
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				7/31/2020	7/31/2020	7/31/2020	7/31/2020	7/31/2020
Rating Type				CANWEE	CANWEE	CANWEE	CANWEE	phyto
Rating Unit				% cover	% cover	% cover	% cover	1-9
Days After First/Last Applic.				46 35	46 35	46 35	46 35	46 35
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	11*	12*	13*	14*	15*
1	Spartan 4F	6	fl oz/a	A	1.0b	6.3cd	0.5b	1.5a	1.0d
2	Spartan 4F	6	fl oz/a	B	6.3ab	15.0ab	1.0ab	1.8a	2.0c
3	Spartan 4F	12	fl oz/a	A	3.0b	3.5cd	0.0b	0.0a	1.0d
4	Spartan 4F	12	fl oz/a	B	1.3b	8.8bc	0.0b	3.3a	3.0a
5	Spartan 4F	6	fl oz/a	A	0.0b	2.0cd	0.0b	0.0a	2.0c
	Spartan 4F	6	fl oz/a	B					
6	Spartan 4F	24	fl oz/a	A	0.0b	0.0d	0.0b	0.5a	1.0d
7	Spartan 4F	24	fl oz/a	B	0.8b	7.5bcd	0.0b	1.0a	3.0a
8	Lorox	3	lb/a	B	0.5b	6.0cd	0.0b	6.0a	2.5b
9	Untreated				13.3a	21.3a	2.3a	7.0a	1.0d
LSD P=.05					7.97	8.26	1.28	5.15	0.28
Treatment Prob(F)					0.0365	0.0005	0.0148	0.0720	0.0001

Pest Name				Redroot pigweed	Common barnyard grass	Common puncturevine	Russian thistle	Black Nightshade	
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				8/14/2020	8/14/2020	8/14/2020	8/14/2020	8/14/2020	8/14/2020
Rating Type				CANWEE	CANWEE	CANWEE	CANWEE	CANWEE	phyto
Rating Unit				% cover	% cover	% cover	% cover	% cover	1-9
Days After First/Last Applic.				60 49	60 49	60 49	60 49	60 49	60 49
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	16*	17*	18*	19*	20*	21*
1	Spartan 4F	6	fl oz/a	A	0.0b	0.5c	0.0a	0.8c	5.3bc	1.0c
2	Spartan 4F	6	fl oz/a	B	5.0b	6.3b	0.0a	2.5bc	8.8b	1.3bc
3	Spartan 4F	12	fl oz/a	A	2.5b	1.3c	0.0a	0.0c	3.8bc	1.0c
4	Spartan 4F	12	fl oz/a	B	5.0b	3.8bc	0.0a	5.8b	3.8bc	2.0a
5	Spartan 4F	6	fl oz/a	A	2.5b	0.0c	2.0a	1.3c	1.3c	1.5b
	Spartan 4F	6	fl oz/a	B						
6	Spartan 4F	24	fl oz/a	A	3.8b	1.3c	0.0a	1.3c	1.3c	1.0c
7	Spartan 4F	24	fl oz/a	B	1.3b	3.0bc	0.0a	1.3c	5.0bc	2.0a
8	Lorox	3	lb/a	B	1.3b	2.5bc	0.0a	2.8bc	5.0bc	2.0a
9	Untreated				13.8a	26.3a	3.8a	10.0a	17.5a	1.0c
LSD P=.05					5.81	3.97	3.13	3.78	5.39	0.36
Treatment Prob(F)					0.0030	0.0001	0.1883	0.0003	0.0001	0.0001

Pest Name				Redroot pigweed	Common barnyard grass	Common puncturevine	Russian thistle	Black Nightshade	
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				8/28/2020	8/28/2020	8/28/2020	8/28/2020	8/28/2020	8/28/2020
Rating Type				CANWEE	CANWEE	CANWEE	CANWEE	CANWEE	phyto
Rating Unit				% cover	% cover	% cover	% cover	% cover	1-9
Days After First/Last Applic.				74 63	74 63	74 63	74 63	74 63	74 63
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	22*	23*	24*	25*	26*	27*
1	Spartan 4F	6	fl oz/a	A	0.0c	0.5c	0.0a	0.8c	5.3bc	1.0a
2	Spartan 4F	6	fl oz/a	B	6.3b	7.0b	0.0a	2.5bc	8.8b	1.0a
3	Spartan 4F	12	fl oz/a	A	2.5bc	1.3c	0.0a	0.0c	3.8bc	1.0a
4	Spartan 4F	12	fl oz/a	B	5.0bc	3.8bc	0.0a	5.8b	3.8bc	1.5a
5	Spartan 4F	6	fl oz/a	A	2.5bc	0.0c	2.0a	1.3c	1.3c	1.3a
	Spartan 4F	6	fl oz/a	B						
6	Spartan 4F	24	fl oz/a	A	3.8bc	1.3c	0.0a	1.3c	1.3c	1.0a
7	Spartan 4F	24	fl oz/a	B	1.3bc	3.0bc	0.0a	1.3c	5.0bc	1.5a
8	Lorox	3	lb/a	B	1.3bc	2.8c	0.0a	2.8bc	5.0bc	1.5a
9	Untreated				13.8a	27.5a	3.8a	12.5a	21.3a	1.0a
LSD P=.05					5.90	4.03	3.13	4.19	6.56	0.55
Treatment Prob(F)					0.0030	0.0001	0.1883	0.0001	0.0001	0.1643

Asparagus Layby Weed Control 2020 - Location 2

Materials and Methods

The research staff at Agricultural Development Group conducted this layby herbicide trial on a second location 3 miles east of Pasco, WA to evaluate the efficacy of same Spartan 4F treatments (Table 1) for pre-emergence and early post-emergence weed control in asparagus, in comparison with Lorox. The experimental design was a randomized complete block design with 4 replications with the plot size of 12 ft x 15 ft. Applications for this trial were made by a CO_2 pressurized backpack sprayer (Photo 1) that delivers spray volume at 27 gallons/acre. The variety was Guelph Millennium.

Pre-emergence application was made on June 26 (A) after the last harvest, followed by an early-post application at fern initiation on July 3 (B). The asparagus phytotoxicity was rated on a 1 to 10 scale (10 means total death, and 1 means perfect healthy) and weeds population of individual weed species were evaluated at 7, 14, 28, 42, 56, and 70 days after application A (DAA).

Table 1. Treatment list.

Trt No.	Treatment Name	Form Type	Rate	Rate Unit	Appl Code	Appl Description	Rep 1	2	3	4
1	Spartan 4F	L	6	fl oz/a	A	A=after last harvest	101	202	303	409
2	Spartan 4F	L	6	fl oz/a	B	B=7 days after A	102	208	307	408
3	Spartan 4F	L	12	fl oz/a	A		103	209	301	406
4	Spartan 4F	L	12	fl oz/a	B		104	201	302	405
5	Spartan 4F	L	6	fl oz/a	A		105	204	306	401
	Spartan 4F	L	6	fl oz/a	B					
6	Spartan 4F	L	24	fl oz/a	A		106	207	305	404
7	Spartan 4F	L	24	fl oz/a	B		107	203	309	402
8	Lorox	D	3	lb/a	B		108	205	308	407
9	Untreated						109	206	304	403

Photo 1. Application B at about 10 days after end of harvest made by a backpack sprayer.

Results and Discussion

The injury on asparagus (phytotoxicity) was heavier in this trial compared to the Eltopia location. Phytotoxicity was observed from all treatments including pre-emergence and early-post applications (Table 1). It is likely that the increased level of phytotoxicity is associated with the sandier soil at this location. The soil at the Eltopia location is 62% sand and the soil at the Pasco location is more than 95% sand. Treatment 2 with Spartan at the low rate 6 fl oz/a, Treatment 4 at medium rate 12 fl oz/a, Treatment 5 with both pre and early-post application of low rate, and Treatment 7 at high rate 24 fl oz/a, as well as Treatment 8 Lorox early-post resulted in 4.8 to 6.8 phytotoxicity ratings by 7 DAA, and the damage maintained until 42 DAA (Photo 2, 3, 4, and 5). Again, there was a slight dose (rate) effect where the higher rates consistently resulted in numerically higher phytotoxicity rating. Similar to the other location, the injury on asparagus started to recover on 56 DAA and eventually reach <3 ratings for early-post treatments and <1.8 for pre-emergence treatments by 70 DAA. Clearly the phytotoxicity

is associated with application of Spartan when asparagus spears are present. Additionally, the higher rate of Spartan which is associated with the most damage is twice the rate that would be labeled for asparagus.

Redroot pigweed and black nightshade were the dominant weeds in this study. Untreated check already reached 12.5% redroot pigweed and 25% black nightshade by 7 DAA. All pre-emergence treatments successfully control the weeds at 7 DAA with 0 coverage of any weeds. Early-post application was not made yet by 7 DAA thus the weed pressure developed in those treatment plots at 7 DAA.

However, by 14 DAA which was also 7 days after application B, all treatments significantly reduced the weed pressure with 0% weeds from all Spartan treatments (pre and early-post) and 1.3% from the compared Lorax early-post treatments. This excellent control effect was maintained by all treatments until 56 DAA. While untreated check reached 50% black nightshade coverage, it also started recovery in treated plots with 2.5% to 6.8% black nightshade coverage which is still significantly lower than untreated, suggesting around 86 to 94% control efficacy. Meanwhile, redroot pigweed was still maintained at 0%.

Black nightshade further developed by 70 DAA, with the coverage increased to 4.3% to 12% in treated plots, compared to 50% in untreated check. However, the suppression effect is still significant with 76 to 91% control efficacy. Redroot pigweed appeared to be very susceptible to treatment in this trial without any recovery (100% control) by 70 DAA.

Overall, Spartan pre-emergence or early-post application at low, medium, or high rates resulted in statistically the same performance with excellent control on both redroot pigweed and black nightshade. The control efficacy is very promising and on par (early-post) or even better (pre) than the compared Lorox treatment. Although both pre and early-post applications resulted in injury on asparagus, the pre-emergence treatments eventually recovered to around 1 phytotoxicity ratings while early-post treatments still had 2.3 to 2.5 ratings. Thus, it is recommended to use the Spartan as a pre-emergence application at low rate as there was no obvious dose effect on control efficacy.

Photo 2. Example of phytotoxicity at 28 DAA of Treatment 2 (early-post application B of Spartan at 6 fl oz/a). The phytotoxicity level was rated as 6 in this plot for both discoloration and stunt of growth.

Photo 3. Example of phytotoxicity at 28 DAA of Treatment 5 (double applications of Spartan at 6 fl oz/a at both pre and early-post stage), plant on the right side has the damage, in comparison with health plant on the left. The phytotoxicity level was rated as 7 in this plot for both discoloration and stunt of growth.

Photo 4. Example of phytotoxicity at 28 DAA of Treatment 4 (early-post application B of Spartan at 12 fl oz/a). The phytotoxicity level was rated as 6 in this plot for both discoloration and stunt of growth.

Photo 5. Example of phytotoxicity at 28 DAA of Treatment 7 (early-post application B of Spartan at 24 fl oz/a). The phytotoxicity level was rated as 7 in this plot for both discoloration and stunt of growth.

Table 2. ANOVA table of the mean separation of different weeds for different treatments on all rating dates.

Pest Name				Redroot pigweed	Black nightsh>		Redroot pigweed	Black nightsh>
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				7/3/2020	7/3/2020	7/3/2020	7/10/2020	7/10/2020
Rating Type				CANWEE	CANWEE	phyto	CANWEE	CANWEE
Rating Unit				% cover	% cover	1-10	% cover	% cover
Days After First/Last Applic.				7 7	7 7	7 7	14 7	14 7
Trt No.	Treatment Name	Rate	Unit	Appl Code	1*	2*	3*	4*	5*
1	Spartan 4F	6	fl oz/a	A	0.0c	0.0c	1.0a	0.0b	0.0b
2	Spartan 4F	6	fl oz/a	B	17.5ab	15.0b	1.0a	0.0b	0.0b
3	Spartan 4F	12	fl oz/a	A	0.0c	0.0c	1.0a	0.0b	0.0b
4	Spartan 4F	12	fl oz/a	B	20.0a	22.5a	1.0a	0.0b	0.0b
5	Spartan 4F	6	fl oz/a	A	0.0c	0.0c	1.0a	0.0b	0.0b
	Spartan 4F	6	fl oz/a	B					
6	Spartan 4F	24	fl oz/a	A	0.0c	0.0c	1.0a	0.0b	0.0b
7	Spartan 4F	24	fl oz/a	B	22.5a	22.5a	1.0a	0.0b	0.0b
8	Lorox	3	lb/a	B	12.5b	16.3b	1.0a	1.3b	1.3b
9	Untreated				12.5b	25.0a	1.0a	25.0a	37.5a
LSD P=.05					7.09	4.38	.	8.60	4.68
Treatment Prob(F)					0.0001	0.0001	1.0000	0.0001	0.0001

Pest Name					Redroot pigweed	Black nightsh>		Redroot pigweed
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				7/10/2020	7/24/2020	7/24/2020	7/24/2020	8/7/2020
Rating Type				Phyto	CANWEE	CANWEE	Phyto	CANWEE
Rating Unit				1-10	% cover	% cover	1-10	% cover
Days After First/Last Applic.				14 7	28 21	28 21	28 21	42 35
Trt No.	Treatment Name	Rate	Unit	Appl Code	6*	7*	8*	9*	10*
1	Spartan 4F	6	fl oz/a	A	2.3e	0.0b	0.0b	2.3e	0.0b
2	Spartan 4F	6	fl oz/a	B	5.5b	0.0b	0.0b	5.5b	0.0b
3	Spartan 4F	12	fl oz/a	A	2.3e	0.0b	0.0b	2.3e	0.0b
4	Spartan 4F	12	fl oz/a	B	6.0b	0.0b	0.0b	6.0b	0.0b
5	Spartan 4F	6	fl oz/a	A	6.8a	0.0b	0.0b	6.8a	0.0b
	Spartan 4F	6	fl oz/a	B					
6	Spartan 4F	24	fl oz/a	A	3.3d	0.0b	0.0b	3.3d	0.0b
7	Spartan 4F	24	fl oz/a	B	7.0a	0.0b	0.0b	7.0a	0.0b
8	Lorox	3	lb/a	B	4.8c	0.0b	0.0b	4.8c	0.0b
9	Untreated				1.0f	37.5a	45.0a	1.0f	40.0a
LSD P=.05					0.74	12.79	4.86	0.74	11.23
Treatment Prob(F)					0.0001	0.0001	0.0001	0.0001	0.0001

Pest Name				Black nightsh>		Redroot pigweed	Black nightsh>	
Crop Name				Asparagus	Asparagus	Asparagus	Asparagus	Asparagus
Rating Date				8/7/2020	8/7/2020	8/21/2020	8/21/2020	8/21/2020
Rating Type				CANWEE	Phyto	CANWEE	CANWEE	Phyto
Rating Unit				% cover	1-10	% cover	% cover	1-10
Days After First/Last Applic.				42 35	42 35	56 49	56 49	56 49
Trt No.	Treatment Name	Rate	Unit	Appl Code	11*	12*	13*	14*	15*
1	Spartan 4F	6	fl oz/a	A	0.0b	2.3e	0.0b	3.8b	1.3e
2	Spartan 4F	6	fl oz/a	B	0.0b	5.5b	0.0b	4.5b	3.0ab
3	Spartan 4F	12	fl oz/a	A	0.0b	2.3e	0.0b	2.8b	1.5de
4	Spartan 4F	12	fl oz/a	B	0.0b	6.0b	0.0b	5.8b	3.0ab

5	Spartan 4F	6fl oz/a	A	0.0b	6.8a	0.0b	4.5b	3.0ab
	Spartan 4F	6fl oz/a	B					
6	Spartan 4F	24fl oz/a	A	0.0b	3.3d	0.0b	2.5b	2.0cd
7	Spartan 4F	24fl oz/a	B	0.0b	7.0a	0.0b	6.3b	3.5a
8	Lorox	3lb/a	B	0.0b	4.8c	0.0b	6.3b	2.5bc
9	Untreated			47.5a	1.0f	37.5a	50.0a	1.0e
LSD P=.05				4.66	0.74	10.03	7.15	0.55
Treatment Prob(F)				0.0001	0.0001	0.0001	0.0001	0.0001

Pest Name				Redroot pigweed	Black nightsh>	
Crop Name				Asparagus	Asparagus	Asparagus
Rating Date				9/4/2020	9/4/2020	9/4/2020
Rating Type				CANWEE	CANWEE	Phyto
Rating Unit				% cover	% cover	1-10
Days After First/Last Applic.				70 63	70 63	70 63
Trt No.	Treatment Name	Rate	Rate Unit	Appl Code	16*	17*	18*
1	Spartan 4F		6fl oz/a	A	0.0b	6.8b	1.0e
2	Spartan 4F		6fl oz/a	B	0.0b	6.5b	2.5ab
3	Spartan 4F		12fl oz/a	A	0.0b	4.3b	1.3de
4	Spartan 4F		12fl oz/a	B	0.0b	9.0b	2.3bc
5	Spartan 4F		6fl oz/a	A	0.0b	9.0b	2.3bc
	Spartan 4F		6fl oz/a	B			
6	Spartan 4F		24fl oz/a	A	0.0b	5.8b	1.8cd
7	Spartan 4F		24fl oz/a	B	0.0b	12.0b	3.0a
8	Lorox		3lb/a	B	0.0b	8.3b	2.3bc
9	Untreated				37.5a	50.0a	1.0e
LSD P=.05					10.03	9.70	0.69
Treatment Prob(F)					0.0001	0.0001	0.0001

Asparagus Organic Weed Control 2020- Robovator Trial

Objective

To evaluate the feasibility of utilizing robotic weeding equipment: Robovator for organic weed management without unacceptable yield damage in asparagus field.

Materials and Methods

The research staff at Agricultural Development Group, Inc. conducted this unique weed control trial, evaluating the potential of a robotic weeder: Robovator (Photo 1) for organic asparagus weed management scenarios.

Robovator is developed by an engineering company: F Poulsen Engineering ApS, in Hvalsø, Denmark. We rented the equipment for its US dealer Pacific Ag Rentals located in California. To better introduce this equipment, related product information from Robovator.com is listed below:

The Robovator is a robot that is equipped with a special plant detection camera above each row of crop. It has a mechanical tool (much like a hoe) which is operated by hydraulic power.

The "intelligent" weeding tools are normally staying in the row but are moved out of the row when a crop plant is passing. The hydraulic components are very robust and designed for operating at high speed and long life.

The specially designed plant detection cameras fitted on each parallelogram continuously monitors the passing plants. If a crop plant passes, the computer will send a signal to the hydraulic controlled tool which at the specified time will be moved out of the row. When the crop plant has passed, the tool will be moved into the row again. If there is a gap in the row e.g. one or more plants are missing, the tool will just stay in the row.

The automatic lateral control will make sure that the machine stays in the exact position even if the tractor goes off track.

Features:

- *High performance of mechanical components*
- *Automatic lateral alignment of machine*
- *Each hoeing tools individually controlled by separate cameras*
- *Hydraulic operated for long life*
- *On-board hydraulic and electric power supply*
- *Very simple to operate, also for the unskilled operator.*
- *Individual electronic adjustment of hoeing parameters during operation*
- *Hoeing tools are protected from overload by springs*
- *Suitable for transplanted or direct seeded crops until closing of the rows*

- *Detection of weeds by discriminating between plant seizes*
- *High capacity, depending on soil and plant conditions – up to 1.5 - 2/hour.*
- *Low power requirement of only 5 KW*

Operating range:

- *Plant sizes: from 1" - 12"*
- *Distances between plants: from 2" to infinite*
- *Bed Spacing 60" - 84"*
- *Row Spacing 8" - 40"*
- *Speed: 1 – 3 mph depending on plant and weed density*
- *Available in 6-12 lines per bed with a single machine with up 3 machines on a stacker bar.*
- *8 line machine available with ability to do 4 - 40" beds*

Limitations:

- *Plants are overlapping, the row is closed.*
- *Weed size is same as or larger than crop size (requires hand crew).*

We received the equipment on June-1st (Photo 1), and the technicians from Pacific Ag Rentals helped us to setup the machine and trained us to operate the machine (Photos 2, 3, 4, 5, and 6). Following the training, we calibrated and tested the machine on an asparagus field for a week to get familiar with the settings and tricks before started this trial. The model we received can cover 6 rows at the most. The basic working mechanism is: there is a camera detection system plus a robotic cutting arm system attached for each row, and the camera is Infront of the robotic arms when the machine pass through plants and weeds thus detect and process the weeds first, then followed by the arms to engage and cut accordingly. The computing capacity of the camera system is one of the most crucial factors for success.

To evaluate the impact on yield and weed control efficacy, we operated this equipment right after harvest on June-8th with 4 replications each occupied a 300 ft long asparagus row, and then harvest the treated rows next day (June-9th) to mimic normal harvesting scenarios, and compared it to nearby un-weeded row under same settings as untreated check for yield difference (Photos 7 and 8). The weed and asparagus change before and after operation was also assessed (Photos 9 and 10) as weed control efficacy ratings at 1, 8, and 15 days after weeding on June-9th, June-16th, and June-23rd. Additionally, we conducted the trial on both green and purple asparagus for more comprehensive results.

Results and Discussions

Obviously, the equipment achieved very consistent weed control efficacy for around 50% weed removal for the green asparagus and around 60% weeds removal in the purple asparagus, which is optimistic results if we only consider the control efficacy and potential save of following manual weeding labor cost.

However, the impact to the yield which is presented in columns 7, 8, 9, and 10 in Table 1 tells different story. Obviously, there was a significant influence of yield for both green (47% reduction) and (38% reduction) purple asparagus. The amount of economic lost is highly likely not worth the saved labor cost, in addition to the rental cost ($19,000 for a month).

During the calibration and testing procedures, we discovered that the unique/complicated growth pattern of asparagus which has shoots come out of the ground randomly without leaf tissues, created an unavoidable difficulty for the visual analysis dependent mechanism of this machine to accurately distinguish the weeds from the asparagus shoots. Increase the number of rows it covers, will further increase the burden of computing by the system and thus causes more variances and chaos. As a result, we found that the greatest number of rows to cover at the mean time without creating an uncontrollable chaos is 3-rows, but to assess the most accurate effect we used only 1 arm system (running 1 row only at a time) for this trial.

Furthermore, the hydraulic powered cutting arms were also not delicate/fast enough to select between asparagus shoots and weeds due to the narrow spacing within the row/shoots, even the cameras/computer recognized the differences, thus creating unnecessary damage.

Overall, considering the main purpose of using this machine is to manage weeds within the row during harvesting season, the significant impact to yield unfortunately limited its capability/potential for proper organic weed management.

Table 1. Treatment effect on weed control efficacy at different dates and impact on yield.

Crop Name	Green Asparagus	Green Asparagus	Green Asparagus	Purple Asparagus	Purple Asparagus	Purple Asparagus
Rating Date	6/9/2020	6/16/2020	6/23/2020	6/9/2020	6/16/2020	6/23/2020
Rating Type	weed contro	weed contro	weed contro	weed contro	weed contro	weed contro
Rating Unit	%	%	%	%	%	%
Trt Treatment No. Name	1*	2*	3*	4*	5*	6*
1No practice	0.0b	0.0b	0.0b	0.0b	0.0b	0.0b
2Robovator	55.0a	50.0a	50.0a	60.0a	57.5a	57.5a
LSD P=.05	9.19	.	.	.	7.96	7.96
Treatment Prob(F)	0.0003	1.0000	1.0000	1.0000	0.0002	0.0002

Crop Name	Green Asparagus	Purple Asparagus	Green Asparagus	Purple Asparagus
Rating Date	6/9/2020	6/9/2020	6/9/2020	6/9/2020
Rating Type	yield	yield	yield lost	yield lost
Rating Unit	lbs	lbs	%	%
Trt Treatment No. Name	7*	8*	9*	10*
1No practice	7.75a	5.68a	0.0b	0.0b
2Robovator	4.08b	3.48b	47.3a	38.0a
LSD P=.05	0.542	1.162	6.15	16.07
Treatment Prob(F)	0.0002	0.0092	0.0001	0.0049

Photo 1. An overall look of Robovator once attached to a tractor.

Photo 2. Technicians from Pacific Ag Rentals are helping with attaching the machine to tractor.

Photo 3. Attachment of the PTO system form the tractor to the Robovator for power source of the generator that powers the hydraulic and computer system on the machine.

Photo 4. Pacific Ag Rentals technician is showing how to operate the computer system through a panel controller (in his hand).

Photo 5. Pacific Ag Rentals technician is showing how to set up the robotic weeding arms in the field.

Photo 6. Pacific Ag Rentals technician is showing how to attach the extra camera and robotic arm system for extended length of the machine to cover more rows.

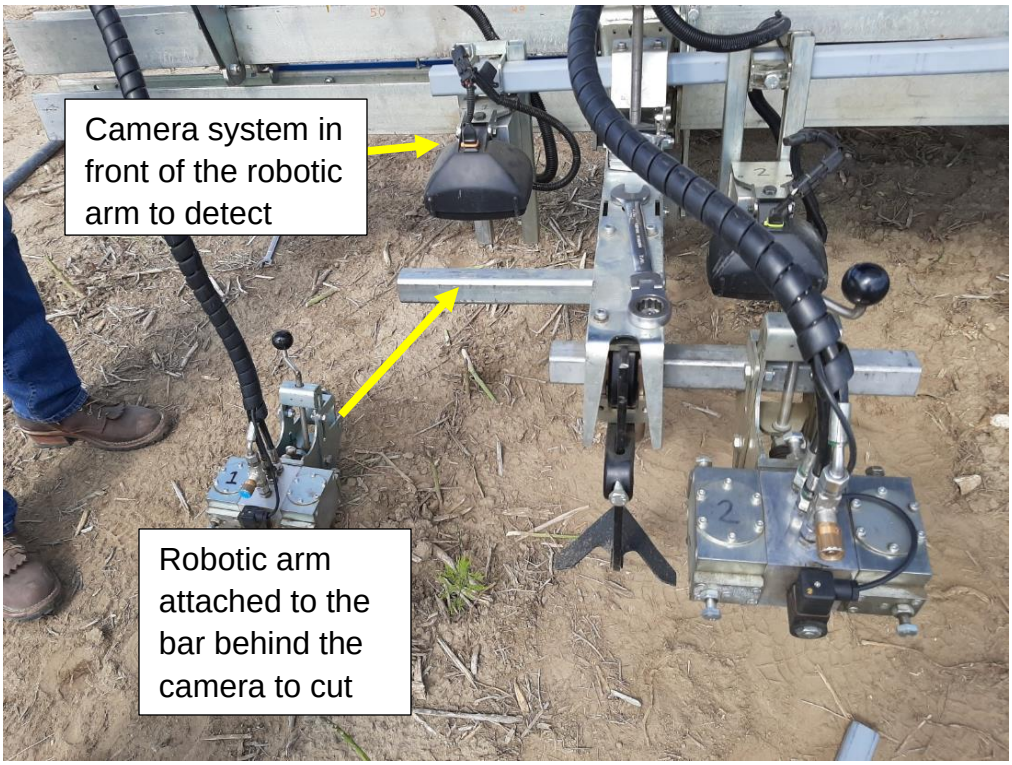


Photo 7. Example of plot setup and harvesting difference between untreated row (right side) and treated row (left side) for the green asparagus.

Table 8. Example of plot setup and harvesting difference between untreated row (right side) and treated row (left side) for the purple asparagus.

Photo 9. Assessment of weed removal efficacy.

Photo 10. Comparison of weeded (left) and untreated check (right) asparagus rows.