OREGONmint UPDATE

NEWSLETTER OF THE OREGON MINT COMMISSION Spring 2021

Weed Management in Mint in Oregon

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During the 2019-2020 growing season, three trials in peppermint were performed in western Oregon and one in Central Oregon to identify the best herbicide use patterns for weed management in mint and to evaluate new herbicides with potential for registration in the mint industry. Our group also participated in a multi-state MIRC funded weed management research project.

The primary objectives of these trials were to provide data in support of the registration of herbicide products. Therefore, many of the herbicides and use patterns discussed in this newsletter are not registered for use in peppermint in Oregon. For a current list of registered herbicides and uses refer to the mint chapter in the Pacific Northwest Weed Management Handbook (https://pnwhandbooks.org/weed). We thank the many growers and industry agronomists that cooperated with us to complete these trials.

One trial was completed to evaluate experimental herbicides for weed control in peppermint in western Oregon. A total

Table 1. Experimental herbicide evaluation for weed control in peppermint.

				Peppermint 3/2020	Common groundsel 3/2020	Epilobium 3/2020	Prickly lettuce 3/2020	Peppermint 7/2020	Peppermint 8/2020
	Treatment	Rates		Injury (%)	Control (%)	Control (%)	Control (%)	Injury (%)	Yield (lb/A)
1	untreated			0.0 b	0.0 c	0.0 e	0.0 b	0.0	70.95
2	paraquat oxyflurofen	0.5 0.75	lb ai/a lb ai/a	90.0 a	97.7 a	96.7 a	97.5 a	0.0	89.08
3	paraquat oxyflurofen pyroxasulfone	0.5 0.75 0.09	lb ai/a lb ai/a lb ai/a	90.0 a	98.9 a	96.7 a	100.0 a	0.0	81.98
4	flumioxazin	0.128	lb ai/a	87.5 a	57.7 b	83.3 ab	50.8 a	0.0	69.75
5	saflufenacil MSO AMS	0.0445 1 1.67	lb ai/a % v/v lb ai/a	90.0 a	97.7 a	100.0 a	100.0 a	0.0	83.29
6	saflufenacil MSO AMS	0.135 1 1.67	lb ai/a % v/v lb ai/a	90.0 a	97.7 a	100.0 a	100.0 a	0.0	75.58
7	saflufenacil paraquat MSO AMS	0.0445 0.5 1 1.67	lb ai/a lb ai/a % v/v lb ai/a	90.0 a	98.9 a	93.3 a	100.0 a	0.0	73.53
8	pyridate MSO	0.625 1	lb ai/a % v/v	0.0 b	1.8 c	33.3 cde	0.0 b	0.0	75.93
9	pyridate pyroxasulfone MSO	0.625 0.09 1	lb ai/a lb ai/a % v/v	0.0 b	0 c	46.7 bcd	2.3 b	0.0	72.80
10	pyridate MSO	0.94 1	lb ai/a % v/v	0.0 b	10.0 c	66.7 abc	0.0 b	0.0	68.75
11	pyridate pyroxasulfone MSO	0.94 0.09 1	lb ai/a lb ai/a % v/v	0.0 b	0 c	80.0 ab	0.0 b	0.0	70.73
12	asulam	0.75	lb ai/a	0.0 b	87.7 a	6.7 de	2.3 b	0.0	72.28
13	asulam	1.5	lb ai/a	0.0 b	91.2 a	26.7 cde	12.3 b	0.0	78.90

Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls).

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of 13 treatments were evaluated and included tankmixes of Gramoxone, Goal 2XL, Zidua, Chateau, Sharpen, Tough and Asulox. Treatments were sprayed on February 12 with an adapted bicycle CO_2 pressurized sprayer for small plots (8 by 20 ft). Common groundsel, Epilobium (*Epilobium* spp.) and prickly lettuce control (evaluated on March 20), as well as crop injury (March 20 and July 1) and oil yield (August 20) were evaluated. We observed that treatments containing Gramoxone, Goal 2XL, Chateau and Sharpen caused initial visual injury to peppermint, but normal growth resumed and no differences were observed by the July 1 evaluation. Common groundsel control was superior for Gramoxone + Goal 2XL, Gramoxone + Goal 2XL + Zidua, Sharpen and Asulox. Epilobium control was only inferior with Asulox and low rates of Tough. Gramoxone + Goal 2XL, Gramoxone + Goal 2XL + Zidua and Sharpen provided the best control of prickly lettuce. Crop oil yield was similar among the treatments (Table 1).

A second set of trials was completed to evaluate tolpyralate and tiafenacil as new weed control tools for peppermint in western and Central Oregon. The focus of these trials was to evaluate these two new herbicides from ISK Biosciences for their potential for registration in the mint industry. Tolpyralate is commercialized in the Midwest as Shieldex, primarily for post-emergence weed control in corn, while tiafenacil is a new compound with post-emergence activity that will likely become available for wheat growers in the fall of 2021.

We tested several rates of these herbicides and compared them to Gramoxone, Goal 2XL and Sharpen at two application dates

Table 2a. Evaluating tolpyralate and tiafenacil as new weed control tools for peppermint, western Oregon.

					Peppermint 5/11/20	Peppermint 6/17/20	Peppermint 8/20/20
	Treatments	Rates		Application timing	Injury (%)	Injury (%)	Yield (lb/A)
1	untreated				0.0	0.0 d	49.75
2	paraquat	0.5	lb ai/a	A	0.0	0.0 d	43.43
	oxyflurofen	0.75	lb ai/a	A			
3	tolpyralate	0.026	lb ai/a	A	0.0	0.0 d	48.20
	MSO	1	% v/v	A			
4	tolpyralate	0.035	lb ai/a	A	0.0	0.0 d	36.57
	MSO	1	% v/v	A			
5	tiafenacil	0.0438	lb ai/a	A	0.0	0.0 d	39.20
	MSO	1	% v/v	A			
6	tiafenacil	0.0656	lb ai/a	A	0.0	0.0 d	44.44
	MSO	1	% v/v	A			
7	saflufenacil	0.0445	lb ai/a	A	0.0	0.0 d	45.40
	MSO	1	% v/v	A			
	AMS	1.67	lb ai/a	A			
8	saflufenacil	0.135	lb ai/a	A	0.0	0.0 d	43.40
	MSO	1	% v/v	A			
	AMS	1.67	lb ai/a	A			
9	saflufenacil	0.0445	lb ai/a	A	0.0	0.0 d	52.74
	paraquat	0.5	lb ai/a	A			
	MSO	1	% v/v	A			
	AMS	1.67	lb ai/a	A			
10	tolpyralate	0.026	lb ai/a	B	0.0	36.3 c	46.08
	MSO	1	% v/v	B			
11	tolpyralate	0.035	lb ai/a	B	0.0	36.3 c	51.46
	MSO	1	% v/v	B			
12	tiafenacil	0.0438	lb ai/a	B	0.0	70.0 b	44.43
	MSO	1	% v/v	B			
13	tiafenacil	0.0656	lb ai/a	B	0.0	80.0 a	56.18
	MSO	1	% v/v	B			

Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls). A. Dormant application (February 4). Application after peppermint resumed growth (May 11). Columns without multiple comparison analysis: data did not meet ANOVA assumptions.

in the Willamette Valley. The first application was on dormant peppermint, while the second was soon after the crop resumed growth. Crop safety was excellent regardless of application timing, with visual injury pattern similar to the current grower standards. No reduction in oil yield was observed (Table 2a). We will continue to evaluate these herbicides in the future and work with ISK Biosciences and IR-4 for their registration in mint crops.

The same treatment protocol was conducted in peppermint in Central Oregon. Unfortunately, the second-year stand suffered from severe *Verticillium* wilt, which was not apparent in the establishment year, nor when the trial was established. Oil yields were taken, but were non-informative due to extreme variability presumably resulting from disease and therefore yield data are not presented here. Similar to results seen in western Oregon, crop safety of dormant season (pre-emergent) treatments appeared comparable to current grower standards in early visual evaluations prior to the onset of wilt symptoms. In contrast, post-emergent treatments with both tiafenacil and tolpyralate caused severe crop injury. By harvest, post-emergent tolpyralate treatments had largely recovered, but tiafenacil treatments did not. Interestingly, the visual severity of *Verticillium* wilt symptoms was notably reduced in tolpyralate post-emergent (but not pre-emergent) treatments. This effect was striking enough to warrant attempts at replication and other further investigation this growing season. The primary weeds present in the trial were prickly lettuce and common groundsel. Post-emergent control of both species was good with tolpyralate and excellent with tiafenacil, although neither compound appeared to provide much, if any, soil residual

Table 2b. Evaluating tolpyralate and tiafenacilas as new weed control tools for peppermint, Central Oregon.

					Peppermint			Common groundsel		Prickly lettuce	
				Application	5/2020	6/2020	8/2020	2 WAT*	5 WAT*	2 WAT*	5 WAT*
	Treatment	Rates		Timing	Injury (%)	Injury (%)	Injury (%)	Control (%)	Control (%)	Control (%)	Control (%)
1	untreated				0a	0a	0a	0a	0a	0a	0a
2	paraquat	0.5	lb ai/a	A	0a	2ab	3a	97de	100e	100d	100f
	oxyflurofen	0.75	lb ai/a	A							
3	tolpyralate	0.026	lb ai/a	A	5ab	3abc	2a	10b	86bc	60b	95def
	MSO	1	% v/v	A							
4	tolpyralate	0.035	lb ai/a	A	6ab	6bcd	5a	13b	93cde	62b	97ef
	MSO	1	% v/v	A							
5	tiafenacil	0.0438	lb ai/a	A	8ab	5abc	3a	96de	93cde	100d	99f
	MSO	1	% v/v	A							
6	tiafenacil	0.0656	lb ai/a	A	4ab	5bcd	7a	97de	100e	100d	100f
	MSO	1	% v/v	A							
7	saflufenacil	0.0445	lb ai/a	A	4ab	5bcd	7a	95d	99e	100d	100f
	MSO	1	% v/v	A							
	AMS	1.67	lb ai/a	A							
8	saflufenacil	0.135	lb ai/a	A	28b	18d	8a	99e	100e	100d	100f
	MSO	1	% v/v	A							
	AMS	1.67	lb ai/a	A							
9	saflufenacil	0.0445	lb ai/a	A	9ab	9cd	10a	97de	100e	100d	100f
	paraquat	0.5	lb ai/a	A							
	MSO	1	% v/v	A							
	AMS	1.67	lb ai/a	A							
10	tolpyralate	0.026	lb ai/a	B	-	76e	3a	73c	84b	73bc	76b
	MSO	1	% v/v	B							
11	tolpyralate	0.035	lb ai/a	B	-	81ef	13a	76c	91bcd	76c	81bc
	MSO	1	% v/v	B							
12	tiafenacil	0.0438	lb ai/a	B	-	91f	55b	96de	95cde	96d	91cd
	MSO	1	% v/v	B							
13	tiafenacil	0.0656	lb ai/a	B	-	93f	60b	97de	97de	97d	94cde
	MSO	1	% v/v	B							

Within a column, means followed by the same letter(s) are not significantly different (Tukey's multiple comparison procedure, P=0.05.) Application timing: A. applied to dormant peppermint on March 12; B. applied to 4" height spring regrowth on May 23.

* WAT= weeks after treatment. Weed control was evaluated 2 and 5 weeks after the respective application, with A treatments evaluated 3/26 (2WAT) and 4/16 (5WAT) and B treatments evaluated 6/5 and 6/26. Evaluation made only on weeds emerged at the time of herbicide application; no soil residual activity was evident or considered and considerable groundsel emerged after application. Weeds were at optimum size at A application timing (2-4" height), but quite large at time of B applications (8-12" height), so performance at this timing was considerably better than direct numerical comparison might seem to indicate.

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activity. Weed control and mint injury data are presented in Table 2b.

A third trial supported by the MIRC compared Zidua, Fierce and Anthem Flex for weed control and crop safety in peppermint and contributed data to the national effort to register the herbicide pyroxasulfone in all mint-growing production regions. Treatments were applied on February 3. Crop safety was evaluated April 3, May 11 and June 17. Common groundsel control was evaluated May 11. Plots containing Sharpen, tiafenacil and Chateau exhibited crop injury that was no longer visible at the June evaluation. Common groundsel control was poor with Sharpen (40-50 percent control), likely due to plants emerging after the application. Fierce provided 99 percent control of common groundsel. Tiafenacil did not exhibit activity on common groundsel. Oil yield was comparable across treatments (Table 3).

Trials are planned or in progress for the 2021 growing season in western and Central Oregon. One will be to initiate work with fluroxypyr (Starane Ultra) to support potential registration across the country and improve post-mergence broadleaf weed control options in mint. This will be a national effort in cooperation with our MIRC weed science project that has developed over the last several years. In addition, tolpyralate (Shieldex) is a new post-emergence herbicide that is currently registered in corn that was developed by ISK Biosciences and was mentioned earlier. Although limited information about this molecule is available, considering it was registered in the United States and Canada in 2017, it exhibits strong activity on broadleaf weeds such as common lambsquarters, redroot pigweed and velvetleaf, as well as grass weeds such as barnyardgrass. Given the physicochemical characteristics of tolpyralate, particularly low potential of translocation (i.e. contact activity), it has great potential for fitting in the Oregon mint production systems as a dormant burndown application or in double cut systems. Furthermore, tolpyralate would be an important tool in the herbicide resistance management toolbox since it is a group 27 herbicide with a different target site compared to clomazone (Command 3ME), which is already registered in peppermint. We will continue to work with ISK Biosciences on these promising new herbicides to explore their potential use in mint.

Table 3. Comparing Zidua, Fierce and Anthem Flex for weed control and crop safety in peppermint.

				Peppermint 4/2020	Peppermint 5/2020	Groundsel 5/2020	Peppermint 6/2020	Peppermint 8/2020
	Treatments	**Rates**		**Injury (%)**	**Injury (%)**	**Control (%)**	**Injury (%)**	**Yield (lb oil/A)**
1	untreated			0.0	0.0	0.0 c	0.0	46.48
2	terbacil paraquat	1.2 0.5	lb ai/a lb ai/a	15.0 b	0.0	49.9 bc	0.0	41.95
3	pyroxasulfone	0.09	lb ai/a	0.0 b	0.0	33.2 bc	0.0	46.45
4	pyroxasulfone	0.18	lb ai/a	0.0 b	0.0	73.8 ab	0.0	46.80
5	saflufenacil MSO AMS	0.0445 1 1.67	lb ai/a % v/v lb ai/a	52.5 a	3.2	47.4 bc	0.0	43.90
6	saflufenacil MSO AMS	0.089 1 1.67	lb ai/a % v/v lb ai/a	57.5 a	2.3	41.1 bc	0.0	49.38
7	saflufenacil MSO AMS	0.135 1 1.67	lb ai/a % v/v lb ai/a	55.0 a	10.1	39.5 bc	0.0	44.28
8	pyroxasulfone saflufenacil MSO AMS	0.09 0.0445 1 1.67	lb ai/a lb ai/a % v/v lb ai/a	47.5	0.0	33.2 bc	0.0	44.33
9	pyroxasulfone-carfentrazon NIS	0.14 0.25	lb ai/a % v/v	5.0	0.0	39.5 bc	0.0	43.30
10	pyroxasulfone-flumioxazin NIS	0.214 0.25	lb ai/a % v/v	55.0	12.2	99.4 a	0.0	42.55
11	tiafenacil MSO	0.0438 1	lb ai/a % v/v	55.0	3.2	0.0 c	0.0	47.63
12	tiafenacil MSO	0.0656 1	lb ai/a % v/v	65.0	6.0	0.0 c	0.0	46.35

Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls). Columns without multiple comparison analysis: data did not meet ANOVA assumptions.

Identifying Economic Action Thresholds to Inform *Verticillium* Wilt Management Decisions

Jeremiah Dung and Jeness Scott, COAREC, Oregon State University

Soil sampling prior to field establishment can be performed to assess soilborne populations of *Verticillium dahliae* and inform management decisions to reduce the risk of *Verticillium* wilt in mint. However, there are no clear guidelines on what constitutes an economic action threshold for soilborne inoculum of *V. dahliae* in mint production and the inoculum levels required to cause *Verticillium* wilt may vary among different commercial mint cultivars. A greenhouse trial was conducted in 2020 to evaluate peppermint (*Mentha piperita*), Scotch spearmint (*M. gracilis*), native spearmint (*M. spicata*) and cornmint (*M. arvensis*) cultivars for *Verticillium* wilt resistance when challenged with increasing levels of soilborne *V. dahliae* microsclerotia (MS).

Field soils were collected from the Central Oregon Agricultural Research and Extension Center (COAREC) and mixed with perlite (3:1). The soil:perlite mixture was infested with MS of several mint strains of *V. dahliae*. The soil:perlite mixture was infested at rates of 0, 1, 5, 10, 20, 50 or 100 MS/cc soil and then placed in one gallon pots. Five peppermint cultivars (Black Mitcham, M-83-7, Redefined Murray Mitcham, Todd's Mitcham and B-90-9), two Scotch spearmint cultivars (Scotch and S770), two native spearmint cultivars (native and N83-5) and two cornmint cultivars (Shivalik and Paraguayan) were included in the trial. Each treatment combination was replicated four times and plants were arranged in a randomized complete block design in the COAREC greenhouse.

Eight disease evaluations were performed for all 11 mint cultivars and seven inoculum levels that were tested. A significant effect of inoculum level was observed for AUDPC values of peppermint, but not for Scotch spearmint, native spearmint or cornmint. Both cornmint cultivars remained relatively symptomless throughout the trial, with plants showing occasional mild apical chlorosis at the higher inoculum levels early in the trial, only to recover. Both native spearmint cultivars were also mostly symptomless throughout the trial, with some plants exhibiting mild chlorosis or asymmetrical growth. Scotch spearmint was more susceptible than native spearmint and cornmint, but the Scotch S770 cultivar exhibited greater resistance than the standard cultivar, especially at the highest inoculum level.

Table 1. Area under disease progress curve values for five peppermint cultivars (Black Mitcham, M-83-7, Redefined Murray Mitcham, Todd's Mitcham and B-90-9), two Scotch spearmint cultivars (Scotch and S770), two native spearmint cultivars (native, N83-5) and two cornmint cultivars (Paraguayan and Shivalik) grown in the presence of 0, 1, 5, 10, 20, 50 or 100 *Verticillium dahliae* microsclerotia/cc soil.

	V. dahliae microsclerotia/cc soil						
Mint cultivar	**0**	**1**	**5**	**10**	**20**	**50**	**100**
Black Mitcham	0.0	100.4	143.8	118.4	174.1	88.9	278.9
B-90-9	0.0	73.6	128.3	32.3	4.9	169.3	97.8
Redefined Murray	0.0	4.9	97.4	6.5	29.8	143.1	9.1
Todd's Mitcham	0.0	1.6	4.9	65.8	117.4	9.1	174.4
M-83-7	0.0	6.5	10.3	30.6	19.9	13.5	83.6
Scotch	0.0	11.6	11.6	34.9	11.6	0.0	65.9
Scotch S770	0.0	7.8	23.3	11.6	11.6	11.6	15.5
Native	0.0	3.9	11.6	0.0	12.9	0.0	0.0
Native N83-5	0.0	2.6	0.0	0.0	3.9	7.9	0.0
Paraguayan	0.0	0.0	0.0	0.0	0.0	0.0	7.8
Shivalik	0.0	1.3	0.0	1.3	0.0	2.5	2.5

Table 2. Final yield ratios of peppermint cultivars planted in *Verticillium*-infested soil. Yield ratios < 1 indicated reduced yields compared with the mean yield of the non-inoculated control treatment. Treatments followed by the same letters are not significantly different from each other using Fisher's protected LSD test.

Cultivar	Yield ratio	
M-83-7	0.97	a
Todd's Mitcham	0.84	ab
Redefined Murray	0.81	ab
B-90-9	0.68	bc
Black Mitcham	0.55	c

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Black Mitcham peppermint was the most susceptible of all of the mint species and cultivars tested and disease was observed on at least one of four replicate plants at all inoculum levels (Table 1). Some plants of B-90-0 also exhibited disease at low inoculum levels (1 and 5 MS/cc soil). Redefined Murray and Todd's Mitcham cultivars were relatively more resistant, though some plants expressed symptoms at 5 and 10 MS/cc soil. Overall, M-83-7 exhibited the greatest resistance to *V. dahliae*.

Three harvests were conducted during the trial. In general, yield reductions were more severe for the second and/or third cutting compared to the first and in many cases yield reductions were the only measurable effect of *Verticillium* infection (especially in cornmint and native spearmint). By the end of the trial, significant differences in yield were observed among peppermint and Scotch spearmint cultivars (Tables 2 and 3). Preparations are in place to repeat this trial in 2021.

Table 3. Final yield ratios of Scotch spearmint cultivars planted in *Verticillium*-infested soil. Yield ratios < 1 indicated reduced yields compared with the mean yield of the non-inoculated control treatment. Treatments followed by the same letters are not significantly different from each other using Fisher's protected LSD test.

Cultivar	Yield ratio	
Scotch S770	1.19	a
Scotch spearmint	0.83	b

Electronic Mint Pest Alert eNewsletter Regarding Control of Mint Root Borer, Cutworm Complex and Loopers (Year 7)

Christy Tanner, Clare Sullivan, Darrin Walenta and Navneet Kaur, Oregon State University

During the 2020 growing season, the Electronic Mint Pest Alert eNewsletter was sent to mint growers and fieldmen for the seventh year running. This eNewsletter shared region-specific information about mint root borer, cutworm complex and loopers in the Willamette Valley, Central Oregon and Eastern Oregon mint production regions. This program used growing degree-day (GDD) models based on local weather data, combined with field scouting in each region to assist growers and fieldmen with pest management decisions for these pest species in mint. There were 120 recipients of the eNewsletter for the 2020 crop year. In addition to sending the eNewsletter directly to subscribers, all information in the eNewsletter was made available on the mint pest alert website (http://blogs.oregonstate.edu/mintpestalert/), along with resources on MRB biology and management. Three objectives guided this program:

1. To deliver region-specific insect development information as an IPM-decision support tool for larval pest control throughout mint production areas in Oregon;
2. To assist growers, fieldmen and industry representatives in maximizing the effectiveness of Coragen® to control eggs and larvae of mint root borer (MRB), cutworms, armyworms and loopers and
3. To provide degree-day information that will benefit those using traditional products like Orthene® and Lorsban Advance®.

Mint Pest Pressure in 2020

In the Willamette Valley, three commercial mint fields were monitored weekly starting in early June. Trapping results showed the MRB peak capture occurred during the week of July 16-23 with an average of 9.6 moths per trap across the three fields. This was slightly later than the timing of the peak predicted by the GDD model (July 15). Numbers of alfalfa loopers were elevated in late June and early July based on sweep net samples, but populations were relatively low throughout the season over all.

There was a good match between the GDD model predicted peak and the observed MRB trap captures in Central Oregon, with both occurring on July 15. The four monitored fields had an average of 4.4 MRB adult moths per trap during peak flight. This season had overall low counts of cutworms and loopers compared to other years.

Figure 1. Adult Ligurian leafhopper.

Four fields were monitored in the Baker Valley of northeastern Oregon. The GDD model predicted that peak flight would occur on July 21, but the highest number of moths captured occurred slightly early on July 15. Trap counts were low throughout the season with a maximum of 1.5 moths per trap. Sampling efforts revealed small numbers of cutworm larvae, with less than one larvae per sample on average. The species found included variegated cutworm moth larvae, mint cutworm larvae and two redback cutworm adult moths were found later in the season.

Figure 2. Characteristic damage caused by Ligurian leafhopper.

A New Invasive Pest

Bill Gerth at the OSU Plant Clinic reported a new invasive leafhopper called the Ligurian leafhopper (*Eupteryx decemnotata* Rey, Hemiptera: Cicadellidae, Figure 1), so samplers were on the lookout for this pest. Two adult Ligurian leafhoppers were found in sweep net samples in one of the western Oregon fields in the monitoring program, marking the first time that this pest has been reported in a commercial mint field in Oregon.

This pest is native to the Mediterranean where they are an important pest of culinary herbs including peppermint, sage, basil, rosemary, oregano and lemon balm. Like other leafhoppers, the Ligurian leafhopper damages plants by puncturing plant cells and feeding on the sap inside. This leaves a characteristic stippling pattern (Figure 2) that can look similar to injury caused by thrips or mites. No damage was observed when the leafhoppers were found, suggesting that there was not a large population present. Keep watch for any unfamiliar tiny (3mm or 0.12 in long), yellow-green leafhoppers in your mint fields and report sightings to your county Extension agent. At this time, little is known about the potential impacts of this pest and careful monitoring will be key to limiting any potential damage.

Newsletter Survey Results

To evaluate the mint pest alert program and continue to improve the information provided, a survey is sent to recipients of the eNewsletter after each growing season. The survey covers current management practices, knowledge of insect development, the value of the information in the eNewsletter and whether more research is needed. Some of the changes made for the 2020 crop year included providing more information about the life cycles, GDD models and identifying characteristics of the different larval pests.

There were 17 responses to the 2020 survey, up from nine responses the previous year. Two-thirds of respondents ranked mint root borer as their worst pest and cutworms as their second worst pest, indicating that the mint pest alert is focusing on the correct species. The personal communications of the team members with different stakeholders statewide indicated that other problematic pests are symphylans, spider mites and strawberry root weevil and need additional research work in the pest management area – the eNewsletter does not provide any insect development or management information for symphylans, spider mites or root weevils currently.

The survey results indicated that the recipients of the eNewsletter gained knowledge related to insect development and the use of Coragen® by reading the eNewsletter (Table 1). The recipients reported that the information in the eNewsletter had some influence on their pest management decisions in terms of both application timing and product choice (Table 2). In terms of current pest control practices, 40 percent of survey respondents used Coragen® either pre- or post-harvest, whereas 26 percent relied on traditional insecticides, 4.4 percent used in-season application of Orthene, and 21 percent used fall application of Lorsban and Mocap.

Table 1. e-Newsletter recipient knowledge level of insect development based on GDD and the use of Coragen®, before and after reading the eNewsletter (1=uninformed, 5=fully informed)

	Insect Development		Use of Coragen®	
	- average rating -		- average rating -	
	Before	After	Before	After
Response	3.0*	4.3	3.3**	4.0

**Knowledge level rating of insect development in 2019: Before=3.3., After=4.27*

*** Knowledge level rating of Coragen® use in 2019: Before=3.2, After=4.8*

Table 2. Influence of eNewsletter on insecticide application timing and insecticide product choice (1= no influence, 5= heavy influence)

	Application timing	Product choice
Response*	2.9	2.9

**Influence rating in 2019: Application timing=3.1, Product choice=3.2*

All respondents agreed that the eNewsletter was valuable and this project should continue for the 2021 crop year. Although the number of survey responses have been low, there has been extremely high support of the eNewsletter continuing from all respondents since it started in 2014. There was also full support for additional research on other arthropod pest species that could be controlled with Coragen®.

If you have not been receiving the eNewsletter and would like to sign up or you have any suggested improvements for the eNewsletter, please contact Christy Tanner (Christy.tanner@ oregonstate.edu).

Crop Pest Losses & Impact Analyses Show Long-term Results of IPM Strategies

Isaac Sandlin and Chris Hedstrom, Oregon IPM Center, Oregon State University

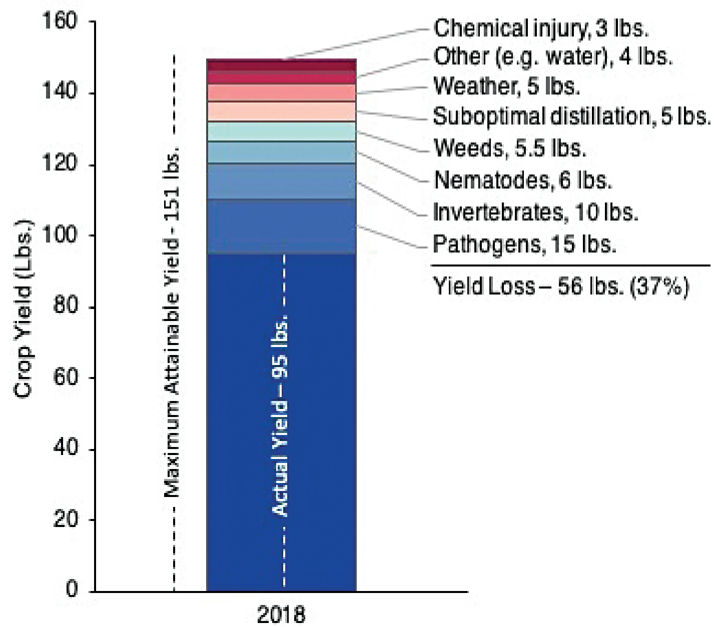
In January 2019, folks from across Oregon's mint industry gathered in Gleneden Beach, Oregon for the Oregon Mint Growers annual meeting to catch up on the latest research and regulatory news while visiting with colleagues from around the state. On the last day of the conference, a small subset of the attendees gathered in Longhouse Room C of the Salishan resort to participate in the Oregon mint industry's very first Pest Losses Impact Survey. These growers and crop consultants voluntarily (and heroically) sat down for more than two hours to scrutinize the details of their growing season in an effort to gain a deeper understanding of how pests and pest management strategies affect crop yield.

Led by Katie Murray from the Oregon IPM Center (now executive director for Oregonians for Food and Shelter) and Peter Ellsworth, director of the Arizona Pest Management Center, participants answered detailed questions about loss due to specific pests, acreage infested, active ingredients utilized and costs of control.

The data was compiled, analyzed and put into a report released in February (https://catalog.extension.oregonstate.edu/em9309) by Oregon State University. The report reveals some critical trends in the mint-growing community, including estimations on the costliest pests to control and the most damaging pests to the growers bottom line. While the data collected in a single survey is useful, the project's real strength comes when surveys are performed year after year, revealing long-term trends and impacts.

This report, combined with critical IPM needs identified in the IPM Strategic Plan for Mint (https://catalog.extension.oregonstate.edu/em9299 - updated October 2020), helps stakeholders throughout Oregon's mint-growing community better understand pest management needs. By periodically collecting this type of data and updating these reports, extension agents and researchers can help IPM consultants and growers reduce risk, reduce cost and sustainably manage pests.

Figure 1. Per acre crop yield and loss estimates for the 2018 Oregon peppermint pest losses survey, based on 9 respondents representing approximately 24 percent of Oregon's peppermint acreage under cultivation. Factors reported in the "other" category include water and irrigation issues, as well as general management issues.



Links:

- Measuring the Economic Impact of Pests and Pest Management on Oregon Peppermint: https://catalog.extension.oregonstate.edu/em9309
- Integrated Pest Management Strategic Plan for Oregon, Washington, and Idaho Mint Crops: https://catalog.extension.oregonstate.edu/em9299

Mint Industry Research & Regulatory Update

Steve Salisbury, Mint Industry Research Council Research and Regulatory Coordinator

I hope that you all have made it through the virtual meeting season, and you were able to attend some of the many meetings held. My hat's off to all the state mint commissions and grower associations that were able to organize and hold their annual meetings through virtual platforms. That is no small feat and it certainly shows the determination and commitment of the industry and strong leadership from those organizations. We are all looking forward to getting back in person to meet, but in the meantime we'll make the best of what we can do.

Since many of you may not have attended the virtual mint meetings, I wanted to provide a quick summary of some of the highlights from the pesticide report as well as a quick overview of the 2021 MIRC research plan. As always, if you have any questions or thoughts then please get in contact with me. I am happy to visit with you.

Probably the biggest news to share on the pesticide front is that Tough herbicide (pyridate) was granted a full Section 3 federal registration and has been labeled in many of the states in the US. This full registration eliminates the need for the Section 18 process and provides growers with the full label options including the ability to apply Tough to both single-cut and double-cut mint. This has been a longtime coming and a true "welcome back" for a product that was lost and made a priority clear back in 2006. I hope that you all can utilize this tool where you need it.

The Tough label allows for a maximum of two applications per season at 24.0 fl oz per acre per application. Remember that it is a contact herbicide, so your spray coverage (gallons per acre) and the addition of a surfactant is important. Trials have shown that MSO is the surfactant of choice. The pre-harvest interval (PHI) is still 49 days, which makes it pretty tight for use between cuttings of double-cut mint. We are working with IR-4 to obtain a shorter PHI that will improve the timeline associated with that application. The requested PHI is 30 days, and we are hopeful that the research will gain that approval in the future.

Many thanks to Belchim Crop Protection for all their support in bringing Tough back to the mint growers. This could not have been possible without their support and commitment. Also on a good note, now that the Section 3 has been granted there is a good chance that the cost of the herbicide to the growers should be less than it has been these past few years. That is always welcome news in the field; excellent weed control that is affordable. Thank you!

Another new tool that we have been anxiously awaiting is Warrior (lambda-cyhalothrin) insecticide. This will be the mint industry's first pyrethroid registered, and it has been pursued at the request of the growers for cost-effective early or late season control of cutworms and armyworms. The MIRC's request is currently sitting in the queue at IR-4 and ready for submission to the EPA. The unfortunate news is that all pyrethroids are still under review by the EPA, which means the agency will not allow the request to be submitted for consideration yet. Once the registration review is complete, then our request will go to EPA for full consideration. In other words, we are ready, but need to be patient and wait for the green light.

Steve Salisbury

I am happy to report that we received support from BASF to allow IR-4 to begin working on the residue research for Sharpen (saflufenacil) herbicide. Many of you have been asking for this herbicide and the MIRC has put in a great effort for several years with on-farm trials to generate the data to support it. Saflufencil continues to show great post-emergent weed control applied during dormancy or at dormancy break for many challenging broadleaf weeds. We are still a few years from a label in hand, but we are excited that the process has officially begun.

On the nematicide front, fluopyram is getting very close to an EPA submission that is anticipated to be this coming summer. The MIRC nematode research at the University of Idaho Parma station continues to show positive results with fluopyram. Adding new actives to our nematicide options is critical to our IPM strategy since there is currently only two available and they are regularly under regulatory scrutiny. In addition to fluopyram, there are a few other actives that Dr. Hafez is evaluating that may very well be candidates for new labels.

The nematode research is part of the 2021 research plan for the MIRC and IPM research continues to be a priority for the industry. The multi-state weeds research project continues to be strong and is evaluating candidate herbicides for future consideration. In 2021, the weeds scientists have added Starane Ultra (fluroxypyr) to the treatment list. This is a direct result of grower requests that I have fielded for a few years.

Up until late 2020, fluroxypyr for mint did not have any support from the registrant and therefore was not worth pursuing. Corteva has now expressed their support as long as we have multiple years of crop safety data to support its use on mint. There is some data amongst our weed science group from trials several years ago, which allows the team to build upon for mint. They will evaluate fluroxypyr at an early post-emergence timing for both weed control and crop safety. We are in the early stages

(continued on page 10)

(continued from page 9)

of product registration development, but we are starting on this herbicide with registrant support.

Also included in the 2021 MIRC research plan is *Verticillium* wilt research by Dr. Jeremiah Dung. He is beginning the final year of developing and establishing an economic action threshold for *Verticillium dahliae*. The value of this knowledge is easy to appreciate. If an action threshold can be determined prior to planting mint, then a grower can choose a more resistant variety or type of mint or avoid the field all together.

The MIRC funded two new entomology projects this year with Dr. Doug Walsh at Washington State and Dr. Justin Clements at University of Idaho. One project will be developing a novel pheromone mating disruption strategy for improved mint root borer control, and the other study is focused on spider mite management in mint. Mint root borers continue to be a significant pest to manage and there is always concern regarding the development of resistance in the mite populations in mint fields. The pheromone disruption concept is an interesting idea that could lead to the development of a non-chemical control strategy. While the mite work will include evaluating new candidate acaracides for potential registration in mint and study resistance development. The MIRC welcomes Dr. Clements to the mint research community and appreciates this collaborative effort between the two entomologists.

Other projects for 2021 include a final year of evaluating the interaction between irrigation management and nitrogen fertilizer in spearmint, genomic and cultivar development and the effects of peppermint scent on the human behavior of eating, caloric intake and weight loss. Overall, the MIRC continues to strive for a well-rounded research program that addresses our four main areas of priority. We appreciate our relationship with the research community and those as passionate about mint and the desire to support and progress the crop and industry as we are.

If you have any questions, comments or thoughts you'd like to share, then please reach out to me. I appreciate your input and interest. I wish you all a safe and productive crop season, and I look forward to being able to see you in person and shake hands. Until then, stay safe.

Evaluating the Use of Cover Crops to Control Wilt, Reduce Nematodes and Improve Soil Quality

Clare Sullivan and Jeremiah Dung, Oregon State University

Progress to Date

A field trial is being conducted at the Central Oregon Agriculture Research and Extension Center (COAREC) in Madras to evaluate cover crops for their effect on levels of *V. dahliae*, *P. penetrans* and other mint-pathogenic nematodes in the soil, soil nutrient status and soil water holding capacity and mint yield. An infested trial area was established in March 2020 with mint-pathotypes of *V. dahliae*. Soil samples were taken from each plot in August 2020 and analyzed for baseline levels of *V. dahliae*, nematodes and soil fertility and water holding capacity by Dr. Dung's lab, OSU's Nematode Testing Service and OSU's Central Analytical Lab, respectively. Four cover crop treatments (Caliente 199, Nemat Arugula, Control Radish and Master White Mustard) were direct-seeded into the wheat stubble on August 18 and fertilized with 100 lbs N/Acre.

Project Status and Plans for 2021

The cover crops initially established well, but growth became significantly stunted. We believe there are a combination of factors delaying growth: 1) initial competition from volunteer wheat; 2) allelopathic effects from the hard red spring wheat residue; 3) slowed growth due to smoky conditions in September; and 4) irrigation being shut off for 10 days late September through early October due to water shortages. Consequently, we will re-establish the cover crop treatments in the same plots in spring 2021. Cover crop treatments will be terminated at early flower and soil sampling will be conducted as in the original plan to measure any effects on nematodes and *V. dahliae*. The field will be left fallow until mint is planted fall 2021. Disease and yield evaluations will be conducted in 2022.

Table 1. Mean levels of *Verticillium dahliae* microsclerotia, root lesion nematodes (*Pratylenchus thornei* and *P. neglectus*, stunt nematodes (*Tylenchorynchus* sp.) and non-plant-parasitic nematodes in plots sampled in August 2020.

V. dahliae	Pratylenchus	Tylenchorynchus	Non-plant-parasitic nematodes
99.5 (± 275.6)	214.2 (± 216.9)	7.5 (± 9.8)	248.3 (± 101.0)

Mint Varietal Improvement Update

Mark Lange, Washington State University and Kelly Vining and Jeremiah Dung, Oregon State University

The first quarter of 2021 finds us emerging from the pandemic-induced research slowdown and accelerating progress. We continue to explore the role of monoterpene biosynthesis in *Verticillium* wilt resistance. While mint oil is thought of as mostly produced in oil glands on mint leaf surfaces, terpene volatiles are also produced in stems and roots of mint plants. Our various data sets - gene expression and oil analysis - are pointing to root-borne volatiles as being potentially important for wilt resistance. In particular, a cluster of (-)-isopiperitenone-reductase-like genes on chromosome 11 of the mint genome looks very promising. One or more genes in this cluster appear to be "early responders" to attack by *Verticillium dahliae*, the causative agent of wilt disease. Molecular markers tagging this gene cluster have been developed and are now being tested in the Vining lab.

Meanwhile, mint breeding at OSU continues. We have now generated two populations derived from three-way crosses of mint ancestral species: *Mentha longifolia*, *M. suaveolens* and *M. aquatica*. Only wilt-resistant mint USDA accessions are being used in these crosses. The hybrid status of individual plants in the two populations is now being tested, because some are being suspected of having arisen from accidental self-pollinations. The testing is being done by Nahla Bassil's lab at the USDA National Clonal Germplasm Repository. Confirmed hybrid plants will be sent to the Lange lab for oil analysis and will be tested for wilt resistance at the Vining lab in the new growth chamber that is scheduled for installation in late April.

To test if mint oils have an inhibitory effect on *Verticillium* growth, *Verticillium*-infested soils were drenched with one of three mint oils (peppermint, scotch spearmint or native spearmint) or (+)-menthofuran at a rate of 1 gal/A. After two weeks, soil samples were collected and *V. dahliae* levels were quantified using qPCR. Although treatments with mint oils reduced *V. dahliae* DNA levels by over 80 percent, significant differences were not observed between infested soils regardless of treatment (Table 1). Subsequently, Black Mitcham peppermint cuttings were planted into the pots and placed in a growth chamber to evaluate plants for *Verticillium* wilt severity and yield. Wilt severity was significantly reduced in all of the treatments compared to the infested control; however, yields were not significantly different among the treatments (Table 1).

Table 1. Effect of peppermint oil, Scotch spearmint oil, native spearmint oil and menthofuran on *Verticillium dahliae* levels in soil, *Verticillium* wilt severity and yield.*

Treatment	DNA (fg)	Wilt severity	Yield ratio
Non-infested	60.8 a	0.25 b	1.00
Infested/non-treated	4,513.0 b	2.25 a	0.71
Peppermint oil	885.2 b	0.50 b	0.61
Scotch oil	585.0 b	1.00 b	0.76
Native oil	865.2 b	0.75 b	0.75
Menthofuran	594.6 b	1.00 b	0.79
***P*-value**	**< 0.01**	**0.01**	**0.06**

**Verticillium* levels are based on DNA quantification using qPCR. *Verticillium* wilt symptoms were assessed using a disease severity index ranging from 0 = no visible symptoms to 5 = dead/nearly dead plant. Yield ratios < 1 indicated reduced yields compared with the mean yield of the non-inoculated control treatment. Treatments followed by the same letters are not significantly different from each other at $P \leq 0.05$.

News from O.E.O.G.L.

Tim Butler, OEOGL Chairman, Aumsville, Oregon

Plans are beginning for the 2022 Annual Convention. Be sure to mark your calendars. The dates will be January 13 & 14 at the Salishan Resort, Gleneden Beach, Oregon.

If you are interested in advertising in the 2022 Meeting Program and Directory, a mailing will be made in August. If you do not receive the mailing or would like additional information on advertising, contact Shawn or Sue at the Association office at (503) 364-2944.

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