OREGON mint UPDATE

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

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Verticillium wilt, caused by *Verticillium dahliae*, is a major constraint to mint production in the United States. Initial inoculum of *V. dahliae* consists of soilborne microsclerotia, which form in senescing plants and can survive in soils for over ten years. Integrated pest management (IPM)-based strategies for *Verticillium* wilt of mint are needed to enable sustainable mint production in the United States. A fundamental concept of IPM is the concept of action (or treatment) thresholds. An action threshold is the point at which pest or pathogen populations require treatment to prevent economic loss. Several methods have been developed to sample and quantify *V. dahliae* from soils, including traditional plating and DNA-based molecular techniques. However, there are no clear guidelines on what constitutes an economic action threshold for soilborne inoculum of *V. dahliae* in mint and the inoculum levels required to cause *Verticillium* wilt may vary among different mint cultivars.

A greenhouse trial was conducted in 2022 to identify inoculum thresholds for *V. dahliae* in mint cultivars grown in the United States. Five peppermint (*Mentha* x *piperita*) varieties ('Black Mitcham', 'M-83-7', 'Redefined Murray Mitcham,' 'Todd's Mitcham' and 'B-90-9'), two Scotch spearmint (*M.* x *gracilis*) varieties ('Scotch', 'S770'), two native spearmint (*M. spicata*) varieties ('native' and 'N83-5') and two *M. arvensis* varieties ('Shivalik' and 'Paraguayan') were included in the trial. A soil:perlite (3:1) mix was infested with either 1, 5, 10, 20, 50 or 100 microsclerotia/cc field soil; a non-infested control was included. All treatments were replicated four times and arranged in a randomized complete block design in a greenhouse. *Verticillium* wilt symptoms were assessed three times using a disease severity index (DSI) ranging from 0=no visible symptoms to 6=dead/nearly dead plant.

Three disease evaluations and harvests were conducted among all 11 mint cultivars and seven inoculum levels that were tested (Table 1). Although overall disease severity was low, a significant effect of inoculum level was still observed for AUDPC values among peppermint cultivars, but not *M. arvensis*, Scotch spearmint or native spearmint cultivars. However, disease severity was still much lower among peppermint cultivars in 2021 than in 2020, but generally greater in *M. arvensis*, native spearmint and Scotch spearmint.

By the end of the trial, significant differences in yield were observed among *M. arvensis*, peppermint and Scotch spearmint cultivars; however, results differed from the previous year's study in many respects. For example, Black Mitcham peppermint exhibited the lowest final yield ratios among peppermint cultivars in 2020, but in 2021 it exhibited the second highest yield ratios at the end of the trial. Additionally, Scotch spearmint exhibited significantly higher final yield ratios than S770 spearmint, which was contrary to the 2021 results.

It was also noted that the overall growth of all mint plants throughout the season was reduced by up to 75 percent based on dry hay yields (data not shown). Although the greenhouse was climate controlled, the exceptional heat wave in late June and early July resulted in temperatures over 120°F, which may have affected disease development and overall plant growth and contributed to the differences observed between the two trials. A third trial is planned for 2022.

Table 1. Effect of *Verticillium dahliae* on area under disease progress curve (AUDPC) values and yield ratios of *Mentha* species and cultivars. Yield ratios < 1 indicate reduced yields compared with the mean yield of the control treatment.

Species	Cultivar	AUDPC	Final yield ratio
M. x piperita	**M-83-7**	46	1.06
	Todd's Mitcham	47	0.90
	Redefined Murray	23	1.19
	B-90-0	40	0.85
	Black Mitcham	60	1.10
M. x gracilis	**Scotch**	47	1.10
	S770	42	0.93
M. spicata	**Native**	23	0.99
	N83-5	29	0.98
M. arvensis	**Paraguayan**	18	0.99
	Shivalik	28	0.81

Developing New Uses for Herbicides in Oregon Peppermint

Andy Hulting, Caio Brunharo and John Spring, Oregon State University

During the 2021 growing season, trials were conducted in peppermint to identify best herbicide use patterns for weed management in Oregon mint and to develop supporting data for new herbicides with potential for registration in the mint industry.

The primary objective of these trials was to provide data in support of registration for herbicides that are not currently registered for use in peppermint in Oregon. Therefore, many of the herbicides or uses described in this article are not registered. For a current list of registered herbicides for use in Oregon peppermint, refer to the mint chapter in the Pacific Northwest Weed Management Handbook (https://pnwhandbooks.org/weed). We thank the many mint growers and agronomists that cooperated with us in conducting these trials and the Oregon Mint Commission and Mint Industry Research Council for funding.

Trials focused mainly on evaluation of the herbicides tiafenacil, saflufenacil, tolpyralate and fluroxypyr in single and double cut mint in the Willamette Valley, and in single cut mint in Central Oregon. Tiafenacil is a PPO-inhibitor (Group 14) herbicide with contact-only burndown activity on broadleaf weeds. Recent past research has demonstrated potential for tiafenacil as a partial replacement for paraquat, although without the grass activity that paraquat offers. It is currently registered for fallow and certain pre-plant burndown uses as Reviton (Helm Agro US). Saflufenacil (Sharpen, BASF) is another Group 14 herbicide with primarily broadleaf contact burndown activity, plus limited soil residual activity at higher rates. Tolpyralate (registered in corn as Shieldex, Summit Agro USA) is a HPPD-inhibiting herbicide (Group 27) with a weed efficacy profile roughly similar to the bleaching component of Huskie (pyrasulfotole, i.e. systemic bleaching of primarily broadleaf weeds). Fluroxypyr (e.g. Starane Ultra, Corteva Agriscience) is a synthetic auxin (Group 4) herbicide, with systemic activity on broadleaf weeds, and a history of promising experimental use in mint.

Field trials were conducted in: i. dormant season and early post-emergence in newly established, single cut mint in the Willamette Valley, near Marion, Oregon (Table 1); ii. after the first cutting in established, double cut mint near Independence, Oregon (Table 2); and iii. at dormant and early post-emergence in established, single-cut mint in Central Oregon near Madras, Oregon (Table 3). All trials included a non-treated check, as well as an 'industry standard' herbicide treatment (Gramoxone + Goal). Trials were conducted in a randomized complete block design with four replicates and individual plot size of 8'x35'

(Willamette Valley) or 10'x25' (Central Oregon). Herbicides were applied with $C0_2$ powered research spray booms and crop injury and weed control evaluated visually on a 0-100 percent scale (with no injury at 0 percent and complete plant death at 100 percent) at appropriate intervals through the season. At crop maturity (matching field harvest timing), peppermint was harvested for yield. In the Willamette Valley, $1m^2$ subsamples were hand-harvested from each plot, dried for 1-2 days, then distilled with the research scale stills located at the OSU Hyslop Research Farm. In Central Oregon, plots were swathed with a plot swather (6'x18' area), allowed to dry for 3 days, shredded with a branch chipper and distilled for oil yield with the experimental stills at the Hyslop Research Farm.

In Willamette Valley single-cut seedling mint (Table 1), herbicides were applied at either a late-dormant application timing (March 15, 2021) or an early post-emergent timing (May 26), and plots were harvested on August 4. In double-cut mint (Table 2), all herbicides were applied 10 days after first cutting (August 3, 2021) and harvested September 8. In Central Oregon (Table 3), late-dormant applications were made to true dormant mint (March 4, 2021) or early post-emergent (May 24), and plots swathed July 30.

In Willamette Valley single-cut seedling mint, dormant application of saflufenacil, tiafenacil and tolpyralate resulted in good crop safety, comparable to dormant application of the industry standard paraquat + oxyfluorfen (Table 1). Post-emergent applications of tiafenacil and tolpyralate, however, caused unacceptably high crop injury. These results corroborate previous year results indicating that tiafenacil and tolpyralate are likely safe for a late-dormant application, but applications made during active mint growth are unsafe.

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Table 1. Experimental herbicide treatments, crop injury and oil yield of newly established peppermint in the Willamette Valley.

					Peppermint Apr-21	Peppermint May-21	Peppermint Jun-21	Peppermint Jul-21	Peppermint Aug-21
Treatment		Timing	Rates		Injury (%)	Injury (%)	Injury (%)	Injury (%)	Yield (lb/A)
1	untreated	-			0 a	0 a	0 a	0 a	26
2	paraquat	March	0.5	lb ai/a	3.8 a	8.7 a	2.5 a	1.3 a	28
	oxyflurofen	(dormant)	0.75	lb ai/a					
3	tolpyralate	March	0.026	lb ai/a	5.0 a	7.5 a	2.5 a	5 a	20
	MSO		1	% v/v					
4	tolpyralate	March	0.035	lb ai/a	1.3 a	7.5 a	3.8 a	2.5 a	54
	MSO		1	% v/v					
5	tiafenacil	March	0.0438	lb ai/a	5.0 a	10 a	5a	2.5 a	29
	MSO		1	% v/v					
6	tiafenacil	March	0.0656	lb ai/a	7.5 a	7.5 a	0 a	0 a	42
	MSO		1	% v/v					
7	saflufenacil	March	0.0445	lb ai/a	3.8 a	5.0 a	2.5 a	3.8 a	33
	MSO		1	% v/v					
	AMS		1.67	lb ai/a					
8	saflufenacil	March	0.135	lb ai/a	2.5 a	10.8 a	6.3 a	1.3 a	24
	MSO		1	% v/v					
	AMS		1.67	lb ai/a					
9	saflufenacil	March	0.135	lb ai/a	1.3 a	1.3 a	3.8 a	2.5 a	27
	paraquat		0.5	lb ai/a					
	MSO		1	% v/v					
	AMS		1.67	lb ai/a					
10	tolpyralate	May	0.026	lb ai/a	*na*	*na*	45 a	45 a	11
	MSO	(4" regrowth)	1	% v/v					
11	tolpyralate	May	0.035	lb ai/a	*na*	*na*	42.5 a	52.5 a	29
	MSO		1	% v/v					
12	tiafenacil	May	0.0438	lb ai/a	*na*	*na*	44 a	45 a	21
	MSO		1	% v/v					
13	tiafenacil	May	0.0656	lb ai/a	*na*	*na*	42 a	45 a	27
	MSO		1	% v/v					

Within a column, means followed by the same letter are not significantly different from each other according to protected Student-Newman-Keuls test.

(continued from page 3)

Table 2. Experimental herbicide treatments, crop injury and oil yield in second cutting of established peppermint in the Willamette Valley.

				Horsetail 31-Aug-21	Redroot Pigweed 31-Aug-21	Peppermint 31-Aug-21	Peppermint 31-Aug-21
	Treatment	Rates		Control (%)	Control (%)	Injury (%)	Oil Yield (lb/A)
1	untreated	-	-	0 b	0 b	0	75 a
2	paraquat	0.5	lb ai/a	58 a	100 a	54 ab	13 c
	oxyflurofen	0.75	lb ai/a				
3	tolpyralate	0.026	lb ai/a	18 ab	99 a	44 b	17 c
	MSO	1	% v/v				
4	tolpyralate	0.035	lb ai/a	24 ab	100 a	46 b	17 c
	MSO	1	% v/v				
5	tiafenacil	0.0438	lb ai/a	54 a	80 a	60 a	7 c
	MSO	1	% v/v				
6	tiafenacil	0.0656	lb ai/a	51 a	100 a	63 a	3 c
	MSO	1	% v/v				
7	Starane Ultra	0.125	lb ae/a	34 ab	20 b	16 c	60 ab
	NIS	1	% v/v				
8	Starane Ultra	0.25	lb ae/a	40 a	35 b	16 c	48 b
	NIS	1	% v/v				

Within a column, means followed by the same letter are not significantly different from each other according to protected Student-Newman-Keuls test.

In double-cut mint (Table 2), tiafenacil and paraquat + oxyfluorfen provided similar levels of horsetail (*Equisetum* spp.) suppression, although nothing approaching commercially acceptable control. Tolpyralate and fluroxypyr provided low-level suppression of horsetail. In contrast, control of redroot pigweed was excellent with tolpyralate and the higher rate of tiafenacil. Fluroxypyr performed poorly on redroot pigweed in this trial. Peppermint injury was unacceptably high with paraquat + oxyfluorfen and both rates of tolpyralate and tiafenacil when applied 10 days after cutting. All three herbicides resulted in nearly complete crop loss at second cutting, which is consistently apparent in oil yield data as well. Visual injury with fluroxypyr was fairly low, although treatments reduced oil yields approximately 20 to 40 percent depending on rate. The lower rate may have utility as a salvage treatment for susceptible weeds in a double cut system, although neither weed species present in this trial was well controlled. Based on previous work, the utility of fluroxypyr will more likely be maximized with late-dormant or early post-emergent applications in single cut production systems.

In Central Oregon single cut established mint (Table 3), crop safety of pyroxasulfone (Zidua, recently registered in mint) was variable between similar treatments (3 and 4) for unknown reasons. Saflufenacil resulted in good crop safety and improved burndown performance on weeds relative to paraquat standards. When applied to dormant mint, tiafenacil offered impressive burndown and good crop safety, although post-emergent (May) applications caused unacceptably high crop injury and yield loss. Tolpyralate was not safe in Central Oregon at either timing, although it is possible that applications made earlier in the dormant season could offer better safety. Marestail control with tolpyralate was acceptable. Tumble mustard plants that were large at the time of treatment were able to bolt, but small rosettes were generally controlled. Fluroxypyr provided excellent weed control and caused little visual crop injury, but reduced oil yield at both application timings. A lower rate (0.125 lb ae/ac) might provide a better balance with crop safety as observed in Willamette Valley trials and will be evaluated in any future work with fluroxypyr in Central Oregon.

Trials are planned or in progress for the 2022 growing season in western and Central Oregon. One will continue work with tiafenacil to support potential registration across the country and improve post-emergence burndown broadleaf weed control options in mint. This will be a national effort in cooperation with the MIRC weed science project that has developed over the last several years. Trials will also continue to evaluate pyroxasulfone premix products (Anthem Flex and Fierce EZ), saflufenacil, tolpyralate and fluroxypyr to refine the application rates and timings as described above in support of potential future registration of these products in Oregon mint.

Table 3. Experimental herbicide treatments, weed control, crop injury and oil yield of peppermint in Central Oregon.

				Weeds 2 WAT †	Weeds 4 WAT*†	Peppermint 2WAT*†	Peppermint 4WAT*†	Peppermint Pre-Swath†	Peppermint Yield†
	Treatment	Timing	Rates	Control (%)	Control (%)	Injury (%)	Injury (%)	Injury (%)	Oil (lb/A)
1	nontreated	-	- -	0 a	0 a	0 a	0 a	0 a	74 a
2	paraquat	March	0.5 lb ai/A	49 b	31 abc	61 d	18 bc	0 a	64 a
	oxyflurofen	(dormant)	0.75 lb ai/A						
	MSO		1 % v/v						
	AMS		2.5 % v/v						
3	pyroxasulfone	March	0.09 lb ai/A	50 b	30 ab	49 cd	0	1 a	56 a
	paraquat		0.5 lb ai/A						
	MSO		1 % v/v						
	AMS		2.5 % v/v						
4	pyroxasulfone	March	0.09 lb ai/A	64 bc	38 ab	59 d	13 ab	0 a	82 a
	paraquat		0.5 lb ai/A						
	oxyflurofen		0.75 lb ai/A						
	MSO		1 % v/v						
	AMS		2.5 % v/v						
5	safluenacil	March	0.045 lb ai/A	79 cd	35 abc	81 e	35 bcd	1 a	85 a
	MSO		1 % v/v						
	AMS		2.5 % v/v						
6	saflufenacil	March	0.045 lb ai/A	85 de	66 bcd	86 ef	45 cd	6 a	77 a
	oxyflurofen		0.75 lb ai/A						
	MSO		1 % v/v						
	AMS		2.5 % v/v						
7	tiafenacil	March	0.066 lb ai/A	98 e	98 d	94 f	54 cd	4 a	72 a
	MSO		1 % v/v						
	AMS		2.5 % v/v						
8	tolpyralate	March	0.035 lb ai/A	63 bc	33 abc	40 c	24 bc	0 a	59 a
	MSO		1 % v/v						
	AMS		2.5 % v/v						
9	tiafenacil	March	0.066 lb ai/A	98 e	99 d	95 f	70 de	0 a	64 a
	tolpyralate		0.035 lb ai/A						
	MSO		1 % v/v						
	AMS		2.5 % v/v						
10	fluroxypyr	March	0.25 lb ae/A	90 de	99 d	0 a	13 abc	0 a	57 a
11	tiafenacil	May	0.066 lb ai/A	50 b	0 a	89 ef	74 de	22 b	65 a
	MSO	(4” regrowth)	1 % v/v						
12	tolpyralate	May	0.035 lb ai/A	92 de	83 cd	19 b	61 cde	20 b	60 a
	MSO		1 % v/v						
13	tiafenacil	May	0.066 lb ai/A	76 cd	34 a	90 ef	73 e	20 b	73 a
	tolpyralate		0.035 lb ai/A						
	MSO		1 % v/v						
14	fluroxypyr	May	0.25 lb ae/A	90 de	99 d	13 b	32 cd	4 a	65 a

** WAT = Weeds after treatment. Dormant applications made April 6, 2021 and later applications made May 26, 2021.*
Weed control ratings made on tumble mustard for April applications and marestail for May applications.
†Within a column, means followed by the same letter are not significantly different from each other according to Tukeys multiple comparison procedure (α=0.05).

Fungicide Screen in Mint for Rust Control

Kyle Roerig, Research Agronomist, Pratum Co-op

Introduction:

Rust, *Puccinia menthae*, is a significant fungal pathogen which reduces yield in mint; especially mint grown in western Oregon. Currently registered fungicides fall short of controlling the disease at registered rates. Additionally, reliance on a limited group of fungicide modes of action increases the risk of the pathogen developing resistance to the fungicide. Increasing fungicide options may improve rust control, preserving crop yield and reduce the risk of fungicide resistance. This study was designed to screen fungicides for rust control and mint crop safety to identify good candidates for additional evaluation in future research.

Methods:

Eleven fungicides not currently registered in mint were selected for evaluation. The products selected were based on the ability to control rust in other crops and an indication from the manufacturer of the possibility of supporting future registration. Each fungicide was applied as single and sequential applications based on the highest number of repeat applications allowed in other crops. These were compared to azoxystrobin-propiconazole (Quilt Xcel) as single and repeat applications and an untreated check. Fungicide applications were made on May 3, May 18, June 1 and June 16. Single applications occured June 1. Treatments were applied to first-year mint in a randomized complete block design with four replications as indicated in Table 1. The treatments (Table 2) were applied with a CO_2 backpack sprayer at 20 gallons of carrier per acre using Greenleaf AM11003 nozzles. Crop injury and rust control were evaluated May 18, June 16, July 15 and August 12.

Results:

At the May 18 evaluation (data not shown), very little rust pressure was observed. By June 16 rust was visible throughout the trial (Table 3). At the July 15 evaluation no rust was observed (data not shown), presumably in consequence of the late-June heat wave. At the August 12 evaluation rust control in all treatments had broken down and were no longer controlling rust (data not shown). Thus, only the June 16 evaluations will be discussed. Rust pressure was highly variable and appropriate statistical analysis was not possible; nonetheless, several treatments had little or no rust in each replication. Seven fungicides were identified for future evaluation. These were fluxapyroxad-pyraclostrobin (Priaxor), benzovindiflupyr-azoxystrobin-propiconazole (Trivapro), azoxystrobin-benzovindiflupyr (Elatus), inpyrfluxam (Excalia), mefentrifluconazole-pyraclostrobin-fluxapyroxad (Revytek), picoxystrobin-cyproconazol (Approach Prima) and penthiopyrad (Fontelis). The manufacturers of these products will be contacted to confirm continued support and the fungicides will be submitted to additional evaluations during the 2022 growing season.

Table 1. Site and application information

Site description	
Crop	Peppermint
Variety	Todd
Planting date	9/30/2020
Soil	Concord silt loam
Location	44.808445, -123.170884

Application	A	B	C	D
Date	5/3/2021	5/18/2021	6/1/2021	6/16/2021
Air temperature	66 F	57 F	89 F	56 F
Wind	3 MPH SW	3-7 MPH W	3 MPH E	4-5 MPH N
Wet leaves	No	No	No	Yes
Soil moisture	Moist	Damp	Dry	Wet
Cloud cover	10%	65%	0%	0%
Crop	0-6 in	2-12 in	6-16 in	6-22 in
Rust stage	Pre-infection	5% infection	25% infection	95% infection

Table 2. Fungicide applications for control of rust in peppermint.

	Formulation							
	Conc.	Unit	Type	Description	MOA[1]	Appl.	Rate	Other rate
untreated								
azoxystrobin-propiconazole	2.20	lb/gal	SE	Quilt Xcel	3, 11	C	0.240 lb ai/a	14.0 oz/a
azoxystrobin-propiconazole	2.20	lb/gal	SE	Quilt Xcel	3, 11	A	0.240 lb ai/a	14.0 oz/a
+ azoxystrobin-propiconazole	2.20	lb/gal	SE	Quilt Xcel	3, 11	B	0.240 lb ai/a	14.0 oz/a
+ azoxystrobin-propiconazole	2.20	lb/gal	SE	Quilt Xcel	3, 11	C	0.240 lb ai/a	14.0 oz/a
prothioconazole-tebuconazole	3.52	lb/gal	SC	Prosaro	3	C	0.226 lb ai/a	8.2 oz/a
prothioconazole-tebuconazole	3.52	lb/gal	SC	Prosaro	3	A	0.226 lb ai/a	8.2 oz/a
+ prothioconazole-tebuconazole	3.52	lb/gal	SC	Prosaro	3	C	0.226 lb ai/a	8.2 oz/a
fluxapyroxad-pyraclostrobin	4.17	lb/gal	SC	Priaxor	7, 11	C	0.260 lb ai/a	8.0 oz/a
fluxapyroxad-pyraclostrobin	4.17	lb/gal	SC	Priaxor	7,11	A	0.260 lb ai/a	8.0 oz/a
+ fluxapyroxad-pyraclostrobin	4.17	lb/gal	SC	Priaxor	7, 11	B	0.260 lb ai/a	8.0 oz/a
+ fluxapyroxad-pyraclostrobin	4.17	lb/gal	SC	Priaxor	7, 11	C	0.260 lb ai/a	8.0 oz/a
benzovindiflupyr-azoxystrobin-propiconazole	2.21	lb/gal	SE	Trivapro	3, 7, 11	C	0.237 lb ai/a	13.7 oz/a
benzovindiflupyr-azoxystrobin-propiconazole	2.21	lb/gal	SE	Trivapro	3, 7, 11	A	0.237 lb ai/a	13.7 oz/a
+ benzovindiflupyr-azoxystrobin-propiconazole	2.21	lb/gal	SE	Trivapro	3, 7, 11	B	0.237 lb ai/a	13.7 oz/a
+ benzovindiflupyr-azoxystrobin-propiconazole	2.21	lb/gal	SE	Trivapro	3, 7, 11	C	0.237 lb ai/a	13.7 oz/a
azoxystrobin-benzovindiflupyr	45	%	WDG	Elatus	11, 7	C	0.205 lb ai/a	7.3 oz/a
azoxystrobin-benzovindiflupyr	45	%	WDG	Elatus	11, 7	A	0.205 lb ai/a	7.3 oz/a
+ azoxystrobin-benzovindiflupyr	45	%	WDG	Elatus	11, 7	B	0.205 lb ai/a	7.3 oz/a
+ azoxystrobin-benzovindiflupyr	45	%	WDG	Elatus	11, 7	C	0.205 lb ai/a	7.3 oz/a
inpyrfluxam	2.84	lb/gal	SC	Excalia	7	C	0.044 lb ai/a	2.0 oz/a
inpyrfluxam	2.84	lb/gal	SC	Excalia	7	A	0.044 lb ai/a	2.0 oz/a
+ inpyrfluxam	2.84	lb/gal	SC	Excalia	7	B	0.044 lb ai/a	2.0 oz/a
+ inpyrfluxam	2.84	lb/gal	SC	Excalia	7	C	0.044 lb ai/a	2.0 oz/a
azoxystrobin-flutriafol	4.29	lb/gal	SC	TopGuard EQ	3, 11	C	0.268 lb ai/a	8.0 oz/a
azoxystrobin-flutriafol	4.29	lb/gal	SC	TopGuard EQ	3, 11	A	0.268 lb ai/a	8.0 oz/a
+ azoxystrobin-flutriafol	4.29	lb/gal	SC	TopGuard EQ	3, 11	B	0.268 lb ai/a	8.0 oz/a
+ azoxystrobin-flutriafol	4.29	lb/gal	SC	TopGuard EQ	3, 11	C	0.268 lb ai/a	8.0 oz/a
+ azoxystrobin-flutriafol	4.29	lb/gal	SC	TopGuard EQ	3, 11	D	0.268 lb ai/a	8.0 oz/a
swinglea extract	7.50	lb/gal	L	EcoSwing		C	1.880 lb ai/a	2.0 pt/a
swinglea extract	7.50	lb/gal	L	EcoSwing		A	1.880 lb ai/a	2.0 pt/a
+ swinglea extract	7.50	lb/gal	L	EcoSwing		B	1.880 lb ai/a	2.0 pt/a
+ swinglea extract	7.50	lb/gal	L	EcoSwing		C	1.880 lb ai/a	2.0 pt/a
+ swinglea extract	7.50	lb/gal	L	EcoSwing		D	1.880 lb ai/a	2.0 pt/a
mefentrifluconazole-pyraclostrobin-fluxapyroxad	3.33	lb/gal	SC	Revytek	3, 7, 11	C	0.390 lb ai/a	15.0 oz/a
mefentrifluconazole-pyraclostrobin-fluxapyroxad	3.33	lb/gal	SC	Revytek	3, 7, 11	A	0.390 lb ai/a	15.0 oz/a
+ mefentrifluconazole-pyraclostrobin-fluxapyroxad	3.33	lb/gal	SC	Revytek	3, 7, 11	B	0.390 lb ai/a	15.0 oz/a
+ mefentrifluconazole-pyraclostrobin-fluxapyroxad	3.33	lb/gal	SC	Revytek	3, 7, 11	C	0.390 lb ai/a	15.0 oz/a
myclobutanil	40	%	WS	Rally	3	C	0.125 lb ai/a	5.0 oz/a
myclobutanil	40	%	WS	Rally	3	A	0.125 lb ai/a	5.0 oz/a
+ myclobutanil	40	%	WS	Rally	3	B	0.125 lb ai/a	5.0 oz/a
+ myclobutanil	40	%	WS	Rally	3	C	0.125 lb ai/a	5.0 oz/a
picoxystrobin-cyproconazole	2.34	lb/gal	SC	Aproach Prima	3, 11	C	0.124 lb ai/a	6.8 oz/a
picoxystrobin-cyproconazole	2.34	lb/gal	SC	Aproach Prima	3, 11	A	0.124 lb ai/a	6.8 oz/a
+ picoxystrobin-cyproconazole	2.34	lb/gal	SC	Aproach Prima	3, 11	C	0.124 lb ai/a	6.8 oz/a
penthiopyrad	1.67	lb/gal	SC	Fontelis	7	C	0.313 lb ai/a	24.0 oz/a
penthiopyrad	1.67	lb/gal	SC	Fontelis	7	A	0.313 lb ai/a	24.0 oz/a
+ penthiopyrad	1.67	lb/gal	SC	Fontelis	7	B	0.313 lb ai/a	24.0 oz/a
+ penthiopyrad	1.67	lb/gal	SC	Fontelis	7	C	0.313 lb ai/a	24.0 oz/a

[1]*MOA = Mode of Action*

(continued on page 8)

(continued from page 7)

Table 3. Evaluation of experimental fungicides for control of rust and peppermint injury

	Rate	Appl.	Peppermint 6/16/2021 Injury	Rust 6/16/2021 Pressure
	lb ai/a		%	0-10
untreated			0	2.3
azoxystrobin-propiconazole	0.240	C	0	2.0
azoxystrobin-propiconazole	0.240	A	0	0.5
+ azoxystrobin-propiconazole	0.240	B		
+ azoxystrobin-propiconazole	0.240	C		
prothioconazole-tebuconazole	0.226	C	0	2.0
prothioconazole-tebuconazole	0.226	A	0	1.0
+ prothioconazole-tebuconazole	0.226	C		
fluxapyroxad-pyraclostrobin	0.260	C	0	0.3
fluxapyroxad-pyraclostrobin	0.260	A	0	0.0
+ fluxapyroxad-pyraclostrobin	0.260	B		
+ fluxapyroxad-pyraclostrobin	0.260	C		
benzovindiflupyr-azoxystrobin-propiconazole	0.237	C	0	1.8
benzovindiflupyr-azoxystrobin-propiconazole	0.237	A	0	0.0
+ benzovindiflupyr-azoxystrobin-propiconazole	0.237	B		
+ benzovindiflupyr-azoxystrobin-propiconazole	0.237	C		
azoxystrobin-benzovindiflupyr	0.205	C	0	1.0
azoxystrobin-benzovindiflupyr	0.205	A	0	0.0
+ azoxystrobin-benzovindiflupyr	0.205	B		
+ azoxystrobin-benzovindiflupyr	0.205	C		
inpyrfluxam	0.044	C	0	1.5
inpyrfluxam	0.044	A	0	0.0
+ inpyrfluxam	0.044	B		
+ inpyrfluxam	0.044	C		
azoxystrobin-flutriafol	0.268	C	0	2.0
azoxystrobin-flutriafol	0.268	A	0	1.5
+ azoxystrobin-flutriafol	0.268	B		
+ azoxystrobin-flutriafol	0.268	C		
+ azoxystrobin-flutriafol	0.268	D		
swinglea extract	1.880	C	0	1.8
swinglea extract	1.880	A	0	1.8
+ swinglea extract	1.880	B		
+ swinglea extract	1.880	C		
+ swinglea extract	1.880	D		
mefentrifluconazole-pyraclostrobin-fluxapyroxad	0.390	C	0	1.5
mefentrifluconazole-pyraclostrobin-fluxapyroxad	0.390	A	0	0.3
+ mefentrifluconazole-pyraclostrobin-fluxapyroxad	0.390	B		
+ mefentrifluconazole-pyraclostrobin-fluxapyroxad	0.390	C		
myclobutanil	0.125	C	0	1.3
myclobutanil	0.125	A	0	3.3
+ myclobutanil	0.125	B		
+ myclobutanil	0.125	C		
picoxystrobin-cyproconazole	0.124	C	0	1.3
picoxystrobin-cyproconazole	0.124	A	0	0.5
+ picoxystrobin-cyproconazole	0.124	C		
penthiopyrad	0.313	C	0	1.8
penthiopyrad	0.313	A	0	0.0
+ penthiopyrad	0.313	B		
+ penthiopyrad	0.313	C		

Means do not differ (at p-value 0.05)

Mint Industry Research & Regulatory Update

Steve Salisbury, Mint Industry Research Council Research and Regulatory Coordinator

At the risk of losing you within the first sentence of this update, there are some crop protection regulatory items worthy of bringing up here. Yes, it's not necessarily the most favorable topic and oftentimes is bad news for ag producers. Nonetheless, it is important that we are aware of what's going on and how certain actions or directions may impact crop production.

To begin, it goes without saying that the loss of chlorpyrifos has officially taken its place in crop protection history. We have fully discussed this action in past newsletter articles and MIRC presentations in state and regional industry meetings. In my recent presentations I shared a chart showing the labeled insecticide options that we have available. That chart shows that we have several options for some insect pests and few for some others, garden symphylan being one of concern without much for options.

As for garden symphylans, mint growers still have Mocap (ethoprop) labeled for use, but it is limited to a fall post-harvest application due to the lengthy pre-harvest interval. So, what about late fall or spring applications where Mocap can not be used? Are there other actives we have labeled on mint whose label could be expanded? Perhaps.

Looking at our existing labels and registrations is a convenient way to search for new options and answers to losing a tool like chlorpyrifos. Mint is fortunate to have a pretty good array of modes of action and pest spectrums to take a look at, and many of the actives labeled for use on mint are pretty effective compounds.

One option that has been discussed was thiamethoxam (Actara). This insecticide is labeled on mint for control of aphid, flea beetle, fleahopper, grasshopper and leafhopper. This label use is a foliar application to mint. However, we also know that thiamethoxam is labeled under a different trade name and on a different crop for control of garden symphylan. Our intuition would certainly lead us to ask the question, "Can we add garden symphylan to the Actara mint label or mint to the other thiamethoxam label?"

These questions were indeed asked to the registrant with hopes of a favorable response. Well, bad news, it's not that straightforward. The other product is registered for a specific use pattern different than our current labeled mint use. Therefore, if we want to add a soil application use pattern we would need to pursue additional regulatory approval. Further, the extra bad news on this thought is that thiamethoxam is a neonicotinoid, a significant roadblock.

This begs the question, what is the current status of neonics? Currently, the EPA is not accepting any neonics for consideration for new registrations and/or labeled uses. This is because the agency is still reviewing the current registrations of all neonics and their potential impacts, specifically on pollinators. The entire class of chemistry is being reviewed so that the EPA will be consistent throughout the class. Once the assessment is completed, then the agency will pursue risk mitigation. The review of thiamethoxam is scheduled to be complete later in 2022. What that means is that if we want to pursue expanding the thiamethoxam label to include symphylan, then we have to wait until that review is complete and that the risk mitigations implemented by the EPA will allow for our use requested.

Steve Salisbury

While we are discussing the EPA and their review of pesticide registrations it is worth mentioning another new development. It is no surprise that the agency is continually being sued over several pesticides that they have registered for use on US crops. However, the latest development revolved around the endangered species act (ESA). Interest groups have filed lawsuits against the EPA claiming the agency did not complete the required ESA assessment of active ingredients used for pest control.

What does this mean for pesticide registrations? Going forward, all new active ingredients will go through a complete evaluation of impact on endangered species. The EPA will consult with the US Fish and Wildlife on this evaluation. Furthermore, every active ingredient that the EPA is currently being sued on will go through an ESA evaluation. It should be no surprise that most of the actives being used in US agriculture production seems to be on this "ESA Litigation" list. Currently, the agency is booked out through 2027 to complete these reviews.

How does this ESA litigation affect potential new uses of registered actives? We are not sure exactly at this point. The EPA is developing a strategy to address the issue and will prioritize ESA evaluation in 2022. However, from what we hear in the previous comment above I'm left to believe that this will have a substantial impact on obtaining new uses of existing materials. I guess time will tell.

I do want to leave you on a positive note regarding the battles on the pesticide front. I'm pleased to report that the IR-4 project is slated to get its first budget increase from Congress in over a decade. Congressional leaders reached an agreement on a spending bill which includes additional funding for IR-4. Of course, they still need to officially vote and approve the bill, but indications are the vote will pass.

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The IR-4 project is a federally funded program responsible for developing the data and information needed to support specialty crop industries in obtaining pesticide registrations, labels and tolerances (MRLs). This program is critical to the mint industry, and the MIRC certainly remains engaged in the Commodity Liaison Committee which assists IR-4 in obtaining federal funding. This increase in IR-4's budget helps shore up the program that was facing substantial reductions which would directly impact US minor crops, including mint. Regardless of individual political views on the spending bill, this budget increase is a welcomed improvement to IR-4, mint and all US minor crops.

As always, please feel free to contact me if you have any questions or want to discuss any of these issues or other mint topics. Have a great spring!

Electronic Mint Pest Alert Newsletter Regarding Control of Mint Root Borer, Cutworm Complex and Loopers, Year 8.

K. Christy Tanner, Clare Sullivan and Darrin L. Walenta, Oregon State University

The Mint Pest Alert Newsletter was distributed to growers and fieldmen for the eighth growing season in 2021. The newsletter is designed to help growers and consultants track and predict key insect pest development and target sensitive life cycle stages for improved insecticide efficacy. The newsletter puts into action the well-established insect development models (R. Berry and L. Coop) in combination with insect population monitoring results from a network of on-farm traps and integrated pest management information.

The Pest Alert Newsletter was tailored to three mint production regions in Oregon: Willamette Valley, Central Oregon and Northeast Oregon. Mint root borer and variegated cutworm growing degree day (GDD) models were run using weather data from five AgriMet weather stations across Oregon, one in the Willamette Valley (Corvallis), two in Central Oregon (Powell Butte and Madras) and two in Northeastern Oregon (Baker Valley and Imbler) to ensure that growers were receiving locally relevant information. On-farm monitoring via pheromone traps, sweep net samples and visual scouting is done to help validate model accuracy in the respective production regions.

The newsletter was distributed to a total of 121 recipients in 2021 including Western Oregon (65), Central Oregon (37) and Northeast Oregon (19). Distribution lists are being updated for the 2022 season for increased distribution to the mint industry. In addition to the email version of the newsletter, an online blog is also utilized to provide predictive model updates, expand content related to mint pests and their management and observations from the field. (http://blogs.oregonstate.edu/mintpestalert/).

The 2021 Growing Season was Warm!

Accumulation of GDDs for 2021 was substantially ahead of the 30-year average in all growing regions. A heat wave in late June greatly increased early season GDD accumulation and warmer than average weather continued throughout the summer. Peak moth catch (910 GDDs) was predicted 15-21 days earlier than the 30 year average, and five percent hibernaculum formation (1,857 GDDs) was reached 26-50 days earlier than the 30-year average. These differences pushed the optimum timing of pest management events earlier than ususal (Figure 1). Without information from growing degree models, it would have been easy to miss the optimum spray window in 2021. Growers were aware that the year was warmer than average, but were often surprised to hear how much warmer. GDD model forecasts provided quantitative information about the magnitude of the difference and how management practices should be adjusted in response.

The alert system serves as a helpful decision-making tool for growers deciding whether to apply Coragen pre-harvest or apply traditional insecticide products or Coragen after mint harvest. The drought and heat wave of 2021 demonstrated additional utility of the alert system due to the concern for late season irrigation water availability in some areas. The alert system helped some growers to choose to chemigate Coragen pre-harvest for insect pest control as it requires only 0.2 inches irrigation water compared to post-harvest applications which need two inches irrigation water to move the product into the root zone.

Compared to the previous year, 2021 MRB capture rates were lower in the Willamette Valley, higher in Northeastern Oregon

2021 Spray Timing Was Earlier

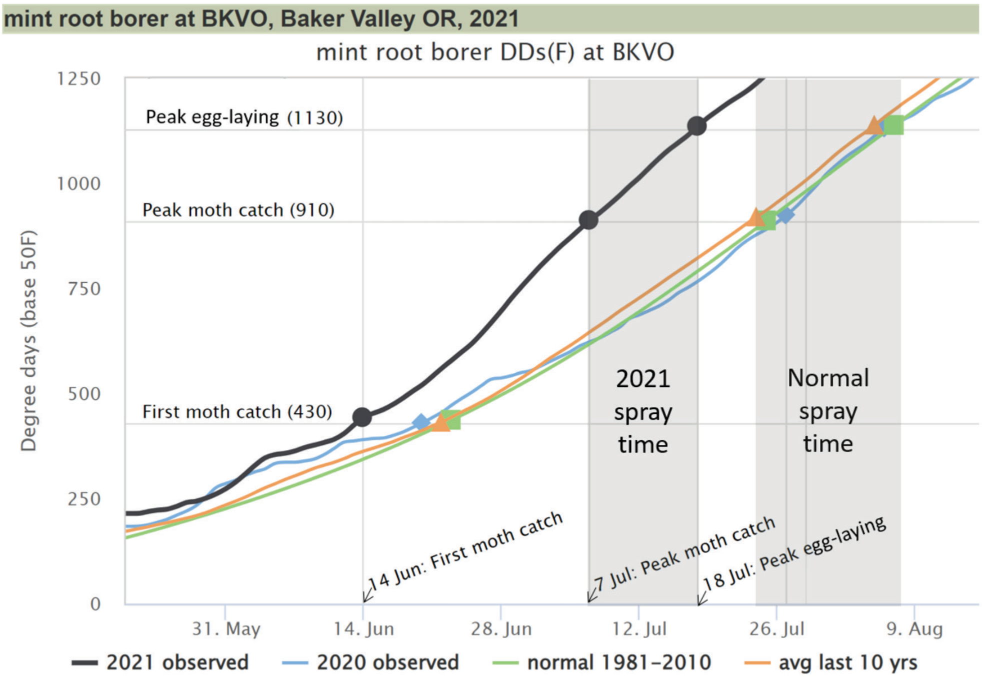

Figure 1. Growing degree accumulation in 2021 (black Line), in 2020 (blue line) and historial averages (orange and green lines) at the weather station BKVO in Baker Valley. Shading shows the optimal time to spray for 2021 and for past years. Arrows indicate model prediction dates for first and peak moth catch and peak egg laying events.

and similar in Central Oregon. Loopers, cutworms and other pests were observed in small numbers across field sites. No Ligurian leafhoppers (a newly identified invasive insect) were observed during sampling this year, nor were there signs of damage from this pest.

While peak moth catch was well predicted by the model in both Central Oregon and the Willamette Valley, elevated moth capture rates were observed in these regions 2-4 weeks after the initial peak flight (Figure 2). A similar observation was made in 2020 but the reason for such population dynamics is not known at this time. In the Baker Valley, the highest MRB moth capture rates occurred the first week of monitoring, which was approximately 7 days earlier than the model prediction for peak catch (13 days earlier than 2020). The adult moth capture rates remained low for the rest of the season and did not have a resurgence of activity as observed in the Willamette Valley or Central Oregon. Future monitoring efforts should watch for increased moth flights later in the season.

Survey results

A key component of the alert system is to conduct an annual survey of newsletter recipients in order to keep the system responsive to the needs of the industry. Results from the 2021 survey indicates strong support for continuation of the alert system. Eleven respondents participated in the survey and represented six mint growers, two crop consultants, one industry rep and an ex-mint grower. Responses were well distributed among growing regions with 4, 3 and 2 responses from the Willamette Valley, Central Oregon and Northeast Oregon, respectively, and one respondent answering "other." Compared to previous years, the survey response rate was lower than 2020, but higher than 2019. Despite a lower number of 2021 survey participants, 75 percent of the respondents represented the target audience of growers and crop consultants and also indicates a 10 percent increase compared to the 2020 (65 percent) survey effort.

Respondents were asked to rank the top two most problematic pests for mint production in their area. As seen in past years, mint root borer and cutworms were the most commonly selected pests (Figure 3). This indicates that the information in the newsletters is targeting the most important pests for Oregon mint growers.

When asked if the newsletter should continue, 90 percent of repondents answered "yes." The one "no" response came from someone who also noted that they are an "ex-mint grower." Survey responses also indicate the newsletter was successful at increasing recipients knowledge of both growing degree day models of insect

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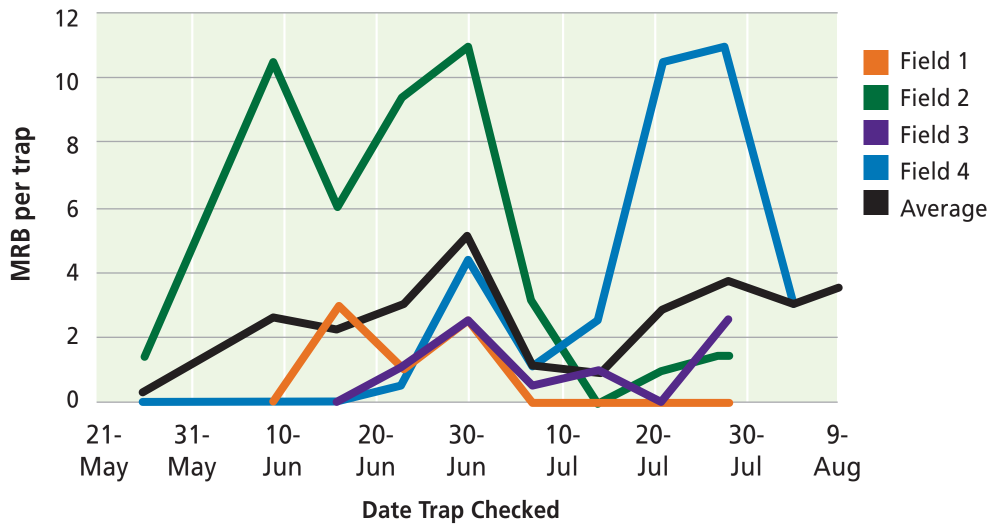
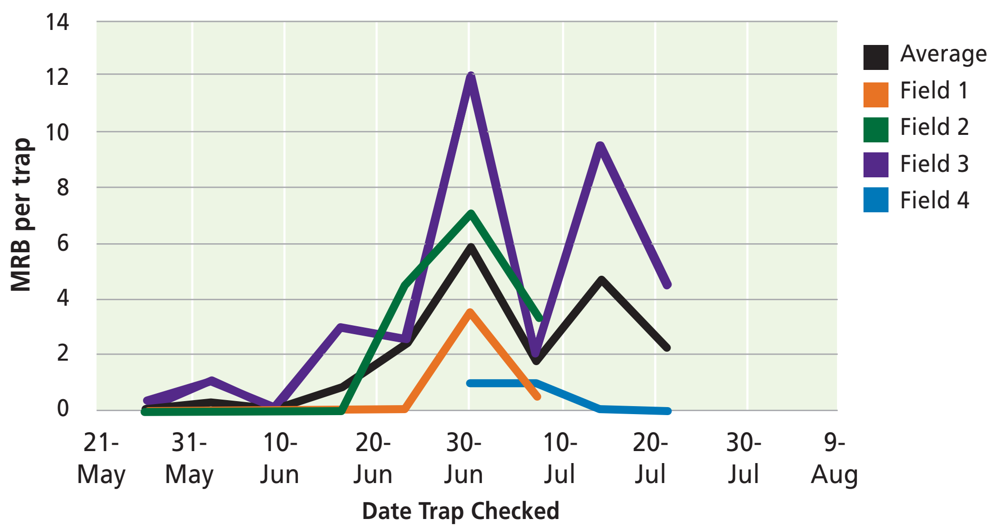
Figure 2. MRB trap capture rates for the Willamette Valley (top), Central OR (middle) and Northeast OR (bottom) in 2021.

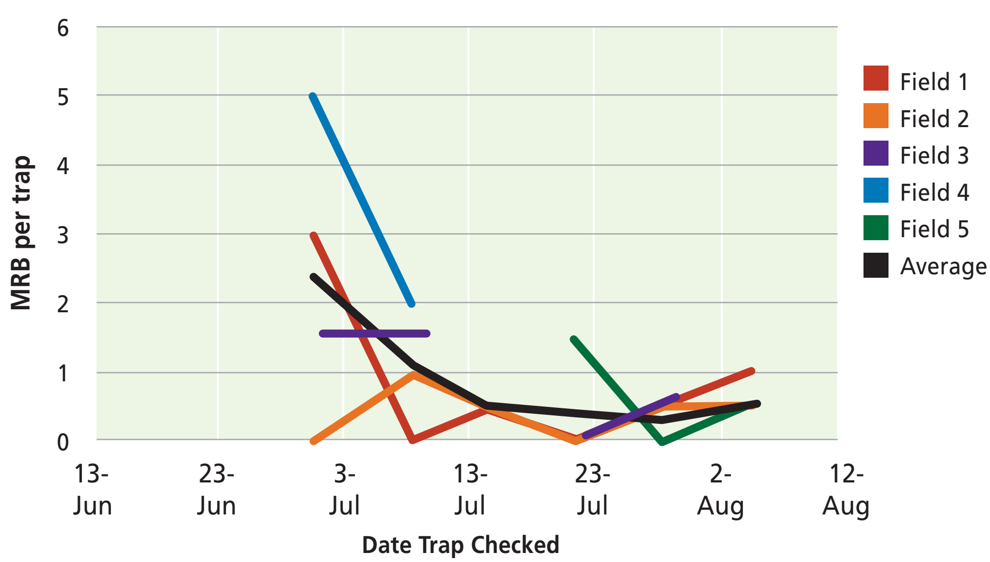
Willamette Valley



Central Oregon



Northeastern Oregon



pest development and the use of Coragen/Vantacor insecticides (Table 1). On a five point scale (1 = uninformed, 5 = fully informed), knowledge of insect development increased by 0.88 points, while knowledge of the use of Coragen/Vantacor increased 0.68 points.

The respondents reported that the information in the newsletter had some influence on their management decisions (Table 2). On a five point scale (1 = no influence, 5= heavy influence), survey respondents rated the influence of the newsletter on their insecticide application timing and product choice a 3 out of 5 for both questions. These results are similar to previous survey results and indicate the utility of the newsletter in helping to make insect pest management decisions.

Please let us know if you would like to receive the newsletter or if you have any suggestions for improvement of the mint pest alert system. Feel free to contact us anytime. Christy Tanner: christy.tanner@oregonstate.edu or Darrin Walenta: darrin.walenta@oregonstate.edu.

Figure 3. The number of 2021 survey respondents identifying each pest as their worst and second worst pest.

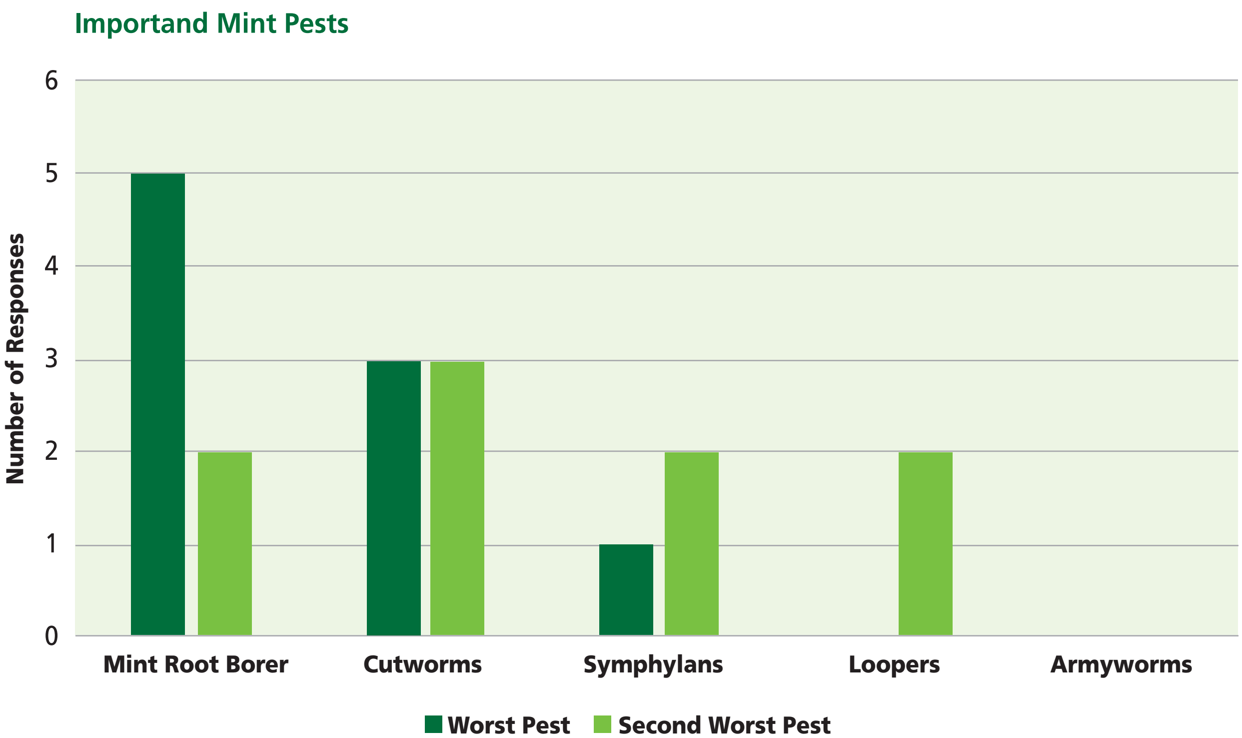


Table 1. Newsletter recipient knowledge level of insect development based on DD and the use of Coragen®, before and after reading the 2021 e-Newsletter (1=uninformed, 5=fully informed).

	Insect Development	Use of Vantacor/Coragen
Before	3	2.75
After	3.88	3.43

Table 2. Influence of e-Newsletter on insecticide application timing and insecticide product choice (1= no influence, 5= heavy influence), for 2019-2021.

	Insecticide Timing	Product Choice
2019	3.1	3.2
2020	2.9	2.9
2021	**3**	**3**

Mint Varietal Improvement Update

Kelly Vining, Oregon State University, Mark Lange, Washington State University, and Nahla Bassil, USDA-National Clonal Germplasm Repository

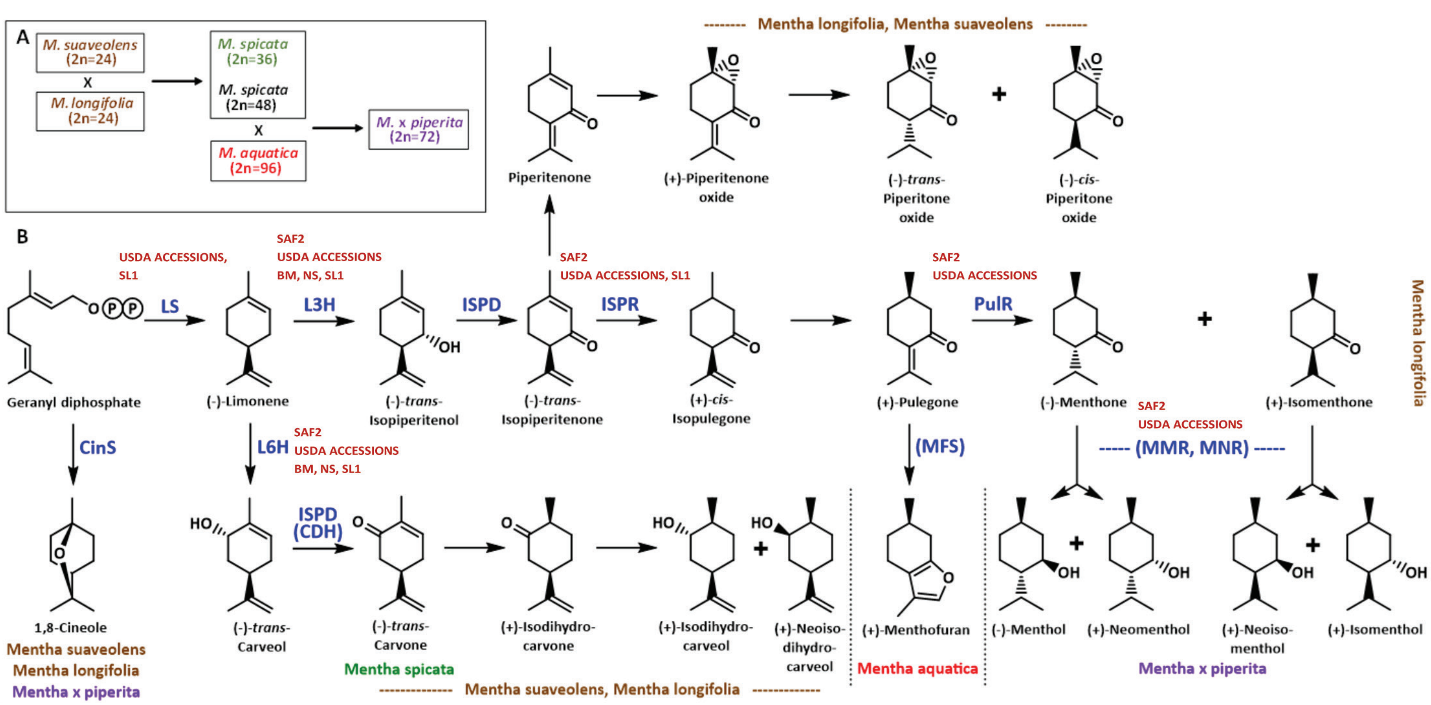
The purpose of this multi-institution collaborative project was to build foundational resources in the areas of genomics, biochemistry and plant breeding in order to support the development of new *Verticillium* wilt-resistant cultivars with desirable oil characteristics.

For the 2021 funding period, we proposed to identify interspecific hybrid using DNA-based tests, continue to validate molecular markers for *Verticillium* wilt resistance and essential oil composition as well as to assemble the complex polyploid genomes of Black Mitcham peppermint and native spearmint. These activities supported the long-term goal of developing improved mint cultivars.

The mint DNA fingerprinting set was improved to be more accurate and reliable. It is based on 11 regions of the genome that contain Simple Sequence Repeats (SSRs): repetitive patterns of DNA that tend to be highly variable between plants. DNA fingerprinting has been used to genotype parents and progeny of three populations. One population is the result of a cross between two *M. suaveolens* accessions, CMEN 9 x CMEN 13 (= 9x13, 147 individuals). The other two populations have 'SLA' designations, indicating contributions from *M. suaveolens*, *M. longifolia* and *M. aquatica*. The 43 member 'SLA1' population is the result of an interspecific cross between SL1-18-6 (an *M. suaveolens* x *M. longifolia* hybrid) and CMEN 115, an *M. aquatica* accession. The 30 member SLA2 population is the reciprocal cross, using CMEN 115 as the female parent. Progeny resulting from the intended crosses were identified based on presence of both male parent-specific DNA markers and female parent-specific markers. Out of the 147 progeny in the 9x13 population, 48 appear to have resulted from the cross based on DNA marker patterns at one to four SSRs. Out of 40 progeny in the SLA1 population, 14 appear to have resulted from the cross based on marker patterns at one to eight SSRs. Out of 30 progeny in the SLA2 population, 26 appear to have resulted from the cross based on marker patterns at two to eight SSRs.

Molecular markers targeting six genes in the mint monoterpene biosynthesis pathway were tested in USDA *Mentha* accessions and the *M. longifolia* SAF2 population (Fig 1). A subset of markers has also been tested in *M. suaveolens* × *M. longifolia* hybrids, Black Mitcham peppermint and native spearmint. Now that 14 SLA1 and 26 SLA2 hybrids have been confirmed with DNA fingerprinting, these plants have undergone initial testing with markers targeting three of these genes: (-)-limonene-3-hydroxylase, (-)limonene-6-hydroxylase and (-)-isopiperitenone reductase (Fig. 2). The purpose of these tests is to be able to discern the parental contributions from the two parents: the *M. suaveolens-M. longifolia* hybrid and the *M. aquatica* accession. The SLA hybrids are now in the process of being phenotyped for

Figure 1. Current status of molecular marker testing for monoterpene biosynthesis genes. BM=Black Mitcham; NS=Native spearmint.



relative wilt resistance (Fig. 3) and have been sent to the Lange lab at WSU for monoterpene profiling.

Mint genome resources were being expanded with newly-obtained Black Mitcham peppermint (BM) and native spearmint (NS) genome assemblies. Black Mitcham's large genome size and complexity meant that whole-genome sequencing was not even considered until recently. DNA lengths are measured in 'basepair' (bp) units, and the BM genome has been estimated using flow cytometry to be 1.4 billion bp = 1.4 Gigabases (Gb). However, long-read sequencing data quality and data yield per run have increased rapidly. The new data for BM provided the equivalent of >350x coverage of the BM genome and >570x coverage of the NS genome. A recently-developed genome assembly tool, Hifi-asm, was applied with default parameters to the sequence data from each genome and the results were surprisingly good: instead of a highly-fragmented set of thousands of small DNA sequence scaffolds, 610 long scaffolds were obtained for BM, and 206 long scaffolds were obtained for NS. The longest scaffolds from each genome were of comparable size to the *M. longifolia* reference genome's chromosomes. This degree of early success was surprising and very encouraging. Further, the BM scaffolds were compared to the 12 chromosomes in the *M. longifolia* reference genome. Highly homologous BM scaffolds were identified for seven of the 12 chromosomes. This is a positive indication that we may be one step closer to our objective: to identify the contributions of the three ancestral species – *M. longifolia*, *M. suaveolens* and *M. aquatica* – to the complex genome of peppermint.

Figure 2. Molecular markers targeting a limonene-3-hydroxylase gene in a subset of SLA1 and SLA2 plants. *M. aquatica* parent CMEN115 and *M. suaveolens-M. longifolia* hybrid SL1 18-6 are shown next to two SLA1 plants and 15 SLA2 plants.

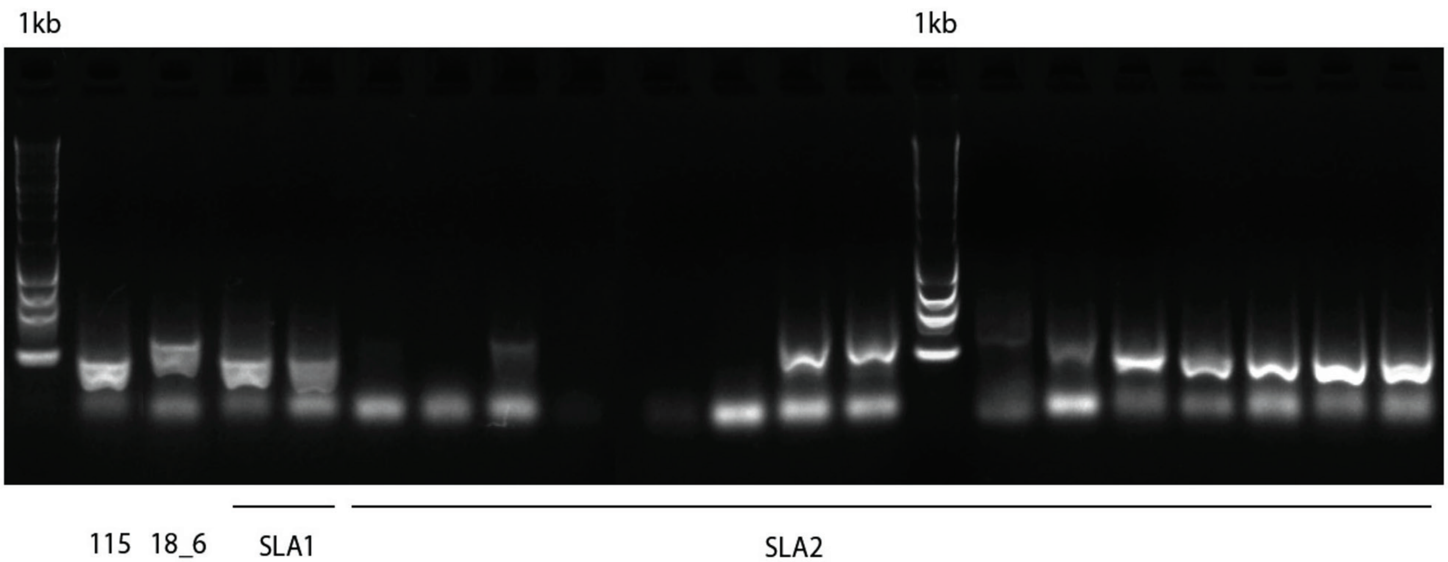
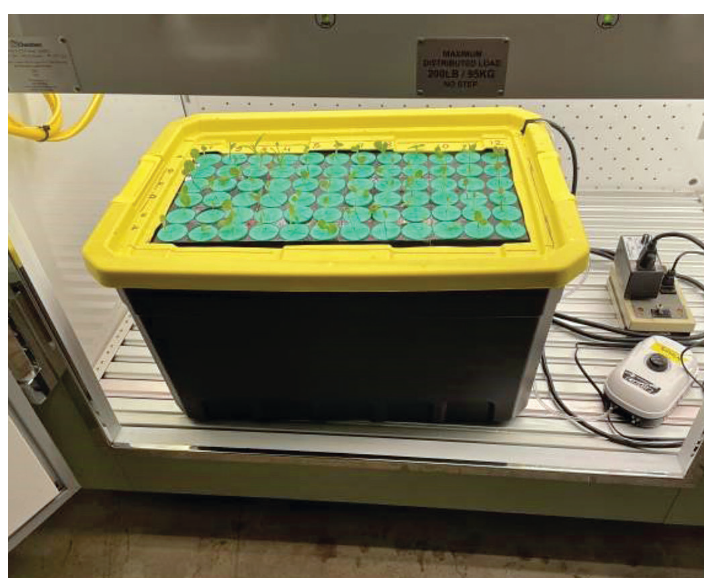


Figure 3. *Verticillium* wilt resistance screening is initiated with the SLA1 population. Mint cuttings are being rooted in an aeroponic unit in the new growth chamber at OSU. Rooting in the aeroponic system takes half the time of rooting in soil, speeding the time to *Verticillium dahliae* inoculation.



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

Scott Setniker, O.E.O.G.L. Chairman, Independence, Oregon

Plans are beginning for the 2023 Annual Convention. Be sure to mark your calendars. The dates will be January 12 & 13 at the Salishan Resort, Gleneden Beach, Oregon.

If you are interested in advertising in the 2023 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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