Spring 2017

OREGON mint UPDATE

NEWSLETTER OF THE OREGON MINT COMMISSION

Weed Control in Western Oregon

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During the 2016 growing season three crop safety and herbicide efficacy trials were conducted in commercially grown mint fields in Polk, Benton and Lane counties in western Oregon. The primary objectives of these trials were to provide data in support of the registration of linuron (Lorox) and to evaluate the use of several protoporphyrinogen oxidase (PPO) inhibitor herbicides - carfentrazone (Aim), flumioxazin (Chateau) and saflufenacil (Sharpen) - at various application timings. Pyroxasulfone treatments were also included to continue our on-going evaluation of this herbicide for use in mint. Many of the herbicides and use patterns discussed in this report are not registered for use in mint. For a current list of registered herbicides refer to the Pacific Northwest Weed Management Handbook (https://pnwhandbooks.org/weed).

Evaluation of PPO Inhibitor Timings in Peppermint

PPO inhibitors (Group 14) have been successfully utilized in a number of perennial crops to control small annual weeds. Three PPO inhibitor herbicides, carfentrazone, flumioxazin and saflufenacil, were applied to an established peppermint field in Polk County at three timings. Pyroxasulfone-carfentrazone (Anthem Flex), pyroxasulfone-flumioxazin (Fierce) and paraquat (Gramoxone) were included. Weed control in this trial varied greatly by herbicide and application timing. Common groundsel control with paraquat or saflufenacil was 90 percent or greater (Table 1). None of the other herbicides provided satisfactory control of common groundsel. Flumioxazin and pyroxasulfone-flumioxazin provided 99 percent or greater control of purslane speedwell when applied March 29 or earlier. Injury ratings indicate that mid to late April applications of saflufenacil and flumioxazin are too injurious. These results indicate that these PPO inhibitor herbicides can be safely used in mint, but that attention to matching the correct herbicide to the weed spectrum present will be important.

Linuron Treatments in Support of IR-4 Program

Linuron was applied to established peppermint in Benton County at two timings and three rates to provide crop safety data in support of registration through the IR-4 process. Applications were made on February 8 to dormant peppermint, March 29 to peppermint with 2-3 inches of regrowth and April 29 to peppermint with 2-8 inches of regrowth. Immediately following application chlorosis was observed, however, these symptoms were transient and did not result in a reduction in yield (Table 2). No weed control evaluations were made due to a lack of weeds present in the trial area. These results indicate

Table 1. Evaluation of PPO Inhibitor Application Timing in Peppermint.

	Rate lb ai/a	Application date	Prickly lettuce Count[A]	Common groundsel Control[B]	Purslane speedwell Control[B]	Peppermint Injury[A]	Peppermint Oil yield[C] lb/a
			#/plot	%	%	%	
untreated			3.2 a	0 f	0 f	0 f	51 cd
pyroxasulfone-carfentrazone	0.14	2/9/16	0.5 cd	0 f	88 ab	3 ef	56 bc
pyroxasulfone-flumioxazin	0.214	2/9/16	0.0 d	50 cd	100 a	0 f	62 ab
paraquat	0.75	2/9/16	0.5 cd	97 a	8 f	3 ef	61 ab
saflufenacil	0.0445	2/9/16	0.3 cd	99 a	49 de	0 f	67 a
carfentrazone	0.0156	2/9/16	0.5 cd	22 ef	78 abc	0 f	56 bc
flumioxazin	0.08	2/9/16	0.0 d	8 f	99 a	2 f	58 bc
saflufenacil	0.0445	3/29/16	0.2 d	100 a	43 e	25 c	61 ab
carfentrazone	0.0156	3/29/16	1.3 bcd	35 de	35 e	2 f	58 bc
flumioxazin	0.08	3/29/16	1.3 bcd	32 de	99 a	13 de	56 bc
saflufenacil	0.0445	4/21/16	0.0 d	90 ab	85 ab	53 a	53 cd
carfentrazone	0.0156	4/21/16	2.7 ab	18 ef	58 cde	15 cd	52 cd
flumioxazin	0.08	4/21/16	2.0 abc	68 bc	70 bcd	42 b	47 d
LSD P=0.05			1.8	23	24	11	8
CV			164.7	42	33	75	12

[A]Evaluated 6/1/16, [B]Evaluated 5/5/16, [C]Harvested 6/22/16

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that linuron rates of 0.5-2.0 pounds of active ingredient per acre are safe on dormant or actively growing peppermint.

Oregon Contribution to MIRC Multi-State Collaborative Linuron Project

This trial was conducted in an established field of peppermint in Lane County as part of a multi-state effort to evaluate linuron for use in peppermint. The field was treated with paraquat and oxyfluorfen by the grower on January 25. The first treatments were applied February 23. At this timing, there was very little peppermint regrowth visible. The second treatments were applied April 14 when peppermint had 2-8 inches of regrowth. Plots were assessed visually for crop injury and crop biomass was harvested and weighed. No weed control evaluations were made due to a lack of weeds present in the trial area. No injury was observed when linuron was applied to dormant peppermint, except when applied with sulfentrazone which temporary slowed regrowth (Table 3). Some injury was observed when linuron was applied to mint with 2-8 inches of regrowth. Peppermint injury increased with application rate, but by June the injury was no longer visible. Injury observed when linuron was applied with the addition of crop oil concentrate or with crop oil concentrate and terbacil did not differ significantly (p-value 0.05) from the same rate of linuron applied alone. Fresh biomass yield did not differ significantly (p-value 0.05) among the treatments.

Trials Planned for 2017

Three trials are planned or in progress for the 2017 growing season. One is a continuation of our work with PPO inhibitor timings and will build on data to support registration and improve the use of these products. Another trial is being conducted to demonstrate possible tank mixes that could be used with pyroxasulfone (Zidua) should it become available for use in mint. The third trial will focus on providing efficacy data in support of the registration of pyridate.

Table 2. Evaluation of Linuron Rates and Application Timing in Peppermint.

Name	Rate lb ai/a	Application date	3/14/2016	Peppermint injury 5/20/2016	6/29/2016	Peppermint Oil Yield[A]
			---------------------------------	%	---------------------------------	lb/acre
untreated			0 b	0 c	0 b	53
linuron	0.5	2/8/16	9 a	0 c	0 b	53
linuron	1.0	2/8/16	11 a	0 c	0 b	45
linuron	2.0	2/8/16	11 a	0 c	0 b	52
linuron	0.5	4/29/16		1 c	0 b	49
linuron	1.0	4/29/16		6 b	0 b	52
linuron	2.0	4/29/16		14 a	7 a	56
LSD P=0.05			2	4	5	NS
CV			19	102	410	16

[A]Harvested 8/9/16

Table 3. Evaluation of Linuron Rates and Tank Mixes in Peppermint.

	Rate lb ai/a	date	Peppermint Injury[A]	Injury[B]	Fresh wt.[C]
			-------------------- %	-------------------	lb/plot
untreated			0 d	0	66
linuron	0.50	2/23/16	0 d	0	58
linuron	1.00	2/23/16	0 d	0	63
linuron	2.00	2/23/16	0 d	0	68
linuron	1.00	2/23/16	0 d	0	63
+ terbacil	0.50	2/23/16			
linuron	1.00	2/23/16	0 d	0	63
+ sulfentrazone	0.19	2/23/16			
terbacil	0.50	2/23/16	0 d	0	64
linuron	0.50	4/15/16	2 d	0	62
linuron	1.00	4/15/16	13 b	0	62
linuron	2.00	4/15/16	21 a	0	65
linuron	0.50	4/15/16	2 d	0	58
+ COC	1.00	4/15/16			
linuron	1.00	4/15/16	8 bc	0	64
+ COC	1.00	4/15/16			
linuron	0.50	4/15/16	3 d	0	63
+ terbacil	0.50	4/15/16			
+ COC	1.00	4/15/16			
terbacil	0.50	4/15/16	0 d	0	65
+ COC	1.00	4/15/16			
LSD P=0.05			5	NS	NS
CV			139	0	14

[A]Evaluated 5/9/16, [B]Evaluated 6/29/16, [C]Harvested 8/16/16

Late Season Fungicide Applications to Control Rust and Powdery Mildew and Increase Oil Yields in Northeast Oregon

Bryon Quebbeman, Quebbeman's Crop Monitoring, La Grande, Oregon

Past fungicide research I've done tested Headline fungicide (Pyraclostrobin) mostly on established mint.

Powdery mildew is often present on baby mint in June but it is not considered a problem because the mildew disappears in July. However, powdery mildew often reappears in late August or early September. By the time the mildew is observed in late August there is usually not enough time before harvest to apply a fungicide.

It would be useful to determine if a preventative fungicide application would increase oil yields in baby mint. Any fungicide applied this late in the season would need to have a relative short Pre-Harvest Interval (PHI). For this experiment the three short PHI fungicides that were chosen to test were Headline, Aframe (generic Quadris) and Tilt.

Aframe and Tilt both have a 7-day PHI while Headline has a 14-day PHI. Rally fungicide was not considered because it has a 30-day PHI.

It would also be useful to determine if there were any differences in effectiveness between these three fungicides. If all three fungicides performed equally well, then growers could use the least expensive fungicide. If one or more performed better, growers would know which one to choose in this situation.

Objectives

1. Determine if a mid-August application of fungicide will increase oil yields of baby mint grown in the La Grande area.

2. Determine if there are any differences in oil yields between Headline (Pyraclostrobin), Aframe, generic Quadris (azoxystrobin) and Tilt (Propiconazole) fungicides.

Materials and Methods

Two experiments were established in production Black Mitcham baby mint fields in the La Grande area.

Plots were 18' x 20' and were replicated ten times in a randomized block design.

To determine oil yields, 50 square feet of mint hay was cut from the center of each plot and air-dried.

Due to the large size of mint hay samples, the dry mint hay was cut into small pieces using a hedge trimmer so as to reduce the size of the sample. These cut up mint hay samples had the oil extracted from them within 90 minutes of being cut up. The oil extraction was done at the mini mint still located at the Parma Experiment Station near Parma, Idaho.

Yields were determined by converting the extracted milliliters of oil into lbs. of oil and then converting the total square feet harvested from each plot into acres. The final results are presented in lbs. of oil/acre.

Results and Discussion

The 2016 growing season was unusually early. Mint matured early so most mint was harvested early. On August 5, Experiment One had a low to moderate level of powdery mildew while Experiment Two had a low level of powdery mildew present.

When the experiments were harvested on August 22 and 23, both experiments had low levels of powdery mildew in the untreated plots.

Both experiments had about equal trace amounts of powdery mildew on the oldest leaves of all the fungicide treated plots. All the fungicides appeared to reduce the powdery mildew levels equally in both trials.

No rust was ever observed at any time in either trial.

The 2016 season was unusual in that the baby mint had some powdery mildew in early August. Most years the baby mint is free of powder mildew in early August. It was also unusual in that the mint fields were harvested by August 23. With this early harvest date, no new powdery mildew developed as it usually does in late August.

None of the oil yields from the fungicide treatments were significantly different than the untreated check, or each other, in either experiment. (Table 1)

Table 1. Treatments and oil yields of baby peppermint treated late season with different fungicides in the La Grande, OR area (2016)

All Treatments applied August 5. Exp.1 & 2 harvested August 22 & 23, respectively.

		Exp. 1 (835)	**Exp. 2** (1100.1)
Treatment	**Rate (ai/a)**	**Mean oil yields (lb/ac)**	
1. UTC		91.2	79.8
2. Headline 12 oz/a	0.2	92.3	80.3
3. Aframe* 15.5 oz/a	0.25	95.0	81.7
4. Tilt 4 oz/a	0.11	95.1	77.7
LSD		NS	NS
%CV		10.7%	12.1%

LSD Sample means were compared with Fisher's Protected LSD (p=0.05).

* Generic Quadris (Azoxystrobin)

Conclusions

The three fungicides of Headline, Aframe (generic Quadris) and Tilt did slightly reduce the level of Powdery Mildew equally, but none of them statistically increased the oil yields.

Mint Varietal Improvement Project

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

Objective: Cross ancestral peppermint species *Mentha longifolia* and *Mentha suaveolens* to regenerate interspecific hybrids (*Mentha spicata*)

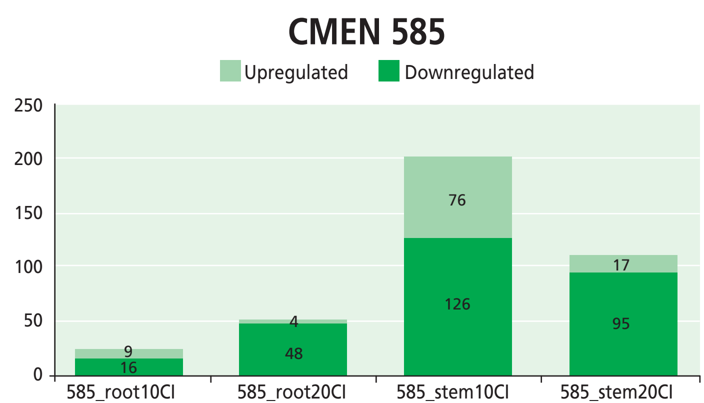
Our long-term breeding goal is to generate *Verticillium* wilt resistant peppermint cultivars by hybridization between ancestral mint species. Nature originally took this route, giving rise to Black Mitcham peppermint. The two-step hybridization process involves first crossing *M. longifolia* with *M. suaveolens*, then crossing the resulting *M. spicata* type with *M. aquatica*. We initiated work on this objective by testing USDA accessions of each species for relative wilt susceptibility and then chose four resistant accessions from each species for crossing as previously reported. After encountering pest problems in the greenhouse, we moved into a growth chamber in fall 2016 to keep plants under a long-day lighting regime in order to force continued flowering. However, while the *M. longifolia* accessions continued flowering as expected, all of the *M. suaveolens* accessions reverted to vegetative growth. In January 2017, the plants were moved into a greenhouse section with stronger lighting than that of the growth chamber. With no apparent disease or pest problems, the *M. suaveolens* accessions are now flowering and crosses are proceeding (Fig. 1). Some of the pollinated flowers' ovules are already expanding, which is an early indication of successful fertilization. After onset of ovule expansion, mature seeds can be expected in approximately three weeks.

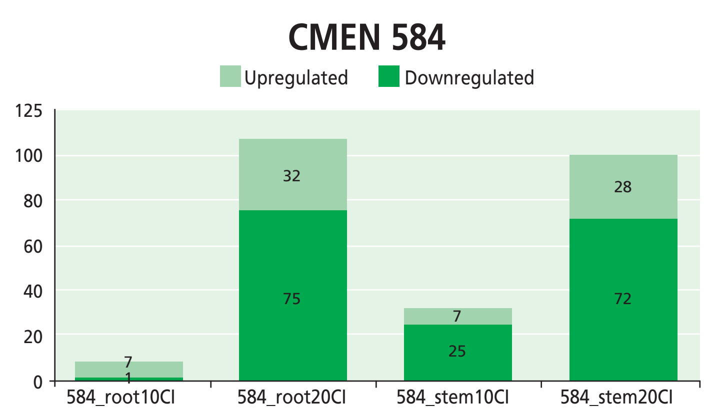
Figure 1. *Mentha suaveolens* accession CMEN 28 flowering under lights at the OSU greenhouse. Crossing tags mark flowers that have been pollinated with pollen from *M. longifolia* accessions.

Objective: Compare gene expression in resistant and susceptible mints in order to identify genes conferring wilt resistance.

This work focused initially on two *M. longifolia* accessions: wilt-resistant CMEN 585 and wilt-susceptible CMEN 584. These are the two grandparents of the *M. longifolia* SAF2 population, which is segregating for wilt resistance, oil constituents and other traits. A genome assembled for CMEN 585 provides the reference point from which we can compare sets of genes that are switched on or off, or turned up or down, in response to fungal invasion. These profiles of gene expression changes have enabled identification of candidate genes for wilt resistance. We started with *M. longifolia* because, with just two genome copies, it is genetically simpler than Black Mitcham peppermint (six genome copies) and Native spearmint (four genome copies), for which gene expression data was also collected. We previously reported that, when plants were inoculated with *Verticillium dahliae*, a range of 50-150 genes changed expression level in roots of the different mints, and a range of 200-1,100 genes changed expression level in stems. We have now categorized these genes into different functional categories, prioritizing those with relevance to plant defense against pathogens. We have determined that there is early, increased expression in resistant CMEN 585 stems of genes in two key categories: plant defense signaling (Figure 2), and secondary metabolite biosynthesis. We are now comparing the variants of these genes in CMEN 585 and CMEN 584. Each *M. longifolia* accession has two copies of every gene: The two copies may be the same or may have small differences. We will also look at these genes in Black Mitcham (six copies of each gene), in Native spearmint (four copies of each gene) and in the USDA accessions we are using in crosses. We

Figure 2. Plant defense genes switched on earlier in stems of resistant mint. Numbers of genes upregulated or downregulated in response to *Verticillium dahliae* inoculation in resistant *M. longifolia* CMEN 585 (top) and susceptible *M. longifolia* CMEN 584 (bottom). Results are shown for 10 and 20 days post-inoculation (DPI).





can exploit these small differences to develop molecular markers for these genes that can be employed in the breeding program.

Objective: Compare *Verticillium dahliae* isolates to assess genetic diversity and potential for pathogenicity.

This work focuses on a collection of mint *V. dahliae* isolates that were mainly collected from mint-growing sites in Washington and Oregon. We previously showed that, although nearly all of the mint isolates belong to the same vegetative compatibility group (2B), they have underlying genetic differences that define four distinct groups. We have chosen representative isolates from each of the four groups for further testing of two types: 1) DNA tests of specific mating type and pathogenicity-related genes; and 2) Inoculation tests to determine relative pathogenicity on known resistant and susceptible mints. For the DNA tests, the Vining lab obtained cultures of the representative isolates from the Dung lab and isolated DNA. Whole-genome DNA sequence information that we had previously generated was then searched to determine whether there were any single-point DNA differences in any of the genes listed in Table 1. Tests are currently underway to determine the mating type of these isolates.

Table 1. Examples of *Verticillium dahliae* pathogenicity-related genes showing evidence of DNA sequence differences among surveyed isolates. Gene name, expected function, chromosome site and number of DNA sequence differences are listed.

Gene Name	Function	Chromosome	Start Position	Stop Position	Number SNPs
MAT1-2	Mating type associated gene - pathogenicity related	3	1,655,533	1,647,040	1
VdRasGTPase	Ras GTPase Activator Protein - pathogenicity related	3	3,707,621	3,698,265	2
VMK1	MAP Kinase - pathogenicity related	1	5,080,214	5,082,141	1

Mint Industry Research & Regulatory Update

Steve Salisbury, Mint Industry Research Council Research and Regulatory Coordinator

MIRC Research

The MIRC's Scientific Affairs Committee (SAC) had a full slate of proposals to discuss during their January annual meeting. It is encouraging to have more interest in mint research by several researchers, agencies and associations, and it creates a healthy competitive grant situation. This is a good thing for the mint industry. However, the unfortunate reality is that the MIRC can only fund so many proposed projects each year. That said, the SAC maintained its primary focus on agronomic research and varietal improvement.

In the area of agronomy, several projects were funded in the areas of weed science, *Verticillium* wilt, nematodes and entomology. Weed management continues to be an on-going effort to pursue new active ingredients that are usable and effective in mint. This year's multi-regional weed research trials will focus on pyridate (Tough) post-emergence treatments to control difficult weeds and new developing weeds in each region. A few of the weeds on the hit list include Russian thistle, field violet, sulfur cinquefoil, common groundsel, waterhemp, white cockle and Palmer amaranth. This work goes hand-in-hand with the current regulatory efforts on Tough for mint.

The SAC continued its support of *Verticillium* wilt (VW) research developing a quick bioassay test to detect and quantify the mint strain of VW in field via soil samples. Researchers are refining quantitative Polymerase Chain Reaction (qPCR) techniques to make this determination. qPCR is essentially the technical way to say they are looking for genetic/DNA differences between VW strains present to differentiate between the mint strain and others not affecting mint. If developed, this technique could be a tool used by commercial agriculture labs to assist growers in making field planting decisions.


Steve Salisbury

In addition to the qPCR *Verticillium* efforts, a new project to the MIRC this year is studying the genome of the pathogen (VW) itself. This project fits nicely with the genome work going on with the varietal improvement project. As with any disease, there is an interaction between the pathogen and the host. The better we can understand both the pathogen and host, the better we should be able to manage the disease. In our case, the better we understand the genome of VW along with the genome of mint, the better chance we have to develop VW resistant mint and/or developing VW management strategies. This project was initiated by the Oregon Mint Commission last year, but due to the fact that this project can potentially have industry-wide impact the MIRC considered and supported it this year.

Nematodes continue to be a challenge in several production areas and there are still many unanswered questions regarding this pest. The MIRC's priority at this time is to find effective products to control nematodes that we can get registered for use on mint. There are a few materials that are being evaluated in trials and recently there have been more candidate materials proposed for use on mint. In addition

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to finding effective options, it is also a challenge to determine the best application strategies to optimize the material's effectiveness while maintaining acceptable crop safety. At the end of the day, the mint industry needs options outside of Vydate, which is still not available, and Mocap. These research efforts are key to developing those options.

With regards to entomology, the SAC supported the continued efforts to research the use of pyrethroid insecticides on mint and they supported a new project to study acaricide resistance in spider mites infesting peppermint. The pyrethroid research will bring to light which material has the best fit for use on mint while evaluating pest control performance as well as what impacts the treatments may have on beneficial and predatory mites. It is the MIRC's intention to review this data and consider pursuing a new registration of a pyrethroid for mint.

As for the acaricide resistance, this research will not only evaluate the efficacy of miticides on mites, but will also develop and expand molecular diagnostics to predict miticide resistance in the field. Clearly a benefit to the grower to be able to identify if populations of pest mites are resistant to specific acaricides.

As for the MIRC's continued efforts in varietal improvement, the SAC remains focused and supportive of the non-transgenic (traditional breeding) efforts. This research continues to develop key genomic knowledge that will lead to selections for possible crosses and improved lines. The goal remains to improve mint cultivars by integrating *Verticillium* wilt resistance, preferred oil characteristics and yield.

Overall, the MIRC's research efforts remain busy and focused on pest management topics and varietal improvement. However, there are two key pieces missing from our program at this time; those being irrigation and distillation. Efforts are being made to initiate studies in both arenas as both have great potential of benefiting the industry by improving production efficiencies and reducing energy consumption.

Thank you to our SAC members who dedicate a significant amount of time to review reports and proposals as well as discuss the proposed projects. There is a lot of time invested to make the recommendations as to which research projects to fund each year. The industry appreciates your time and interest.

Pesticides

A brief update on pesticide news. If you had not heard, Aim herbicide is now registered for use on mint as tolerance was established by EPA through the IR-4 program. Recently, FMC published their new label including mint. However, by the time this update is published the window of application will have passed for most or all of you. The labeled use is only for application to dormant mint. An e-announcement was sent out via the Mint Insider from the MIRC office. If you did not get that, then please let us know your email address so that you will get important announcements in the future.

We continue to work on obtaining a Section 18 request for Tough herbicide (pyridate) through the states and EPA. As excited as we are to actually have a possible solution for our urgent post-emergent weed control situation, it is still a significant challenge to navigate through this process. In other words, if we get an emergency exemption then that is fantastic, but you should not make plans expecting it to happen. The best news on the Tough front is that the registrant has applied for a full federal Section 3 label. That application was submitted at the first of the year and is now under review at the EPA. Keep in mind this process takes approximately 18 months and has to withstand the rigors of the review. We are hopeful that there will be an approval in time for the 2018 crop.

If you have not heard, Vydate remains unavailable to the US market. DuPont has commented that they are targeting the fourth quarter of 2017 for having material available again. Let's keep an eye on that and hopefully there is relief in the foreseeable future.

As always, I welcome your questions, comments and thoughts. Your support of the MIRC efforts is always appreciated. I wish you all a safe and productive year.

Update on Green Manure Trials for *Verticillium* Wilt Management

Jeremiah Dung and Darrin Walenta, Oregon State University

Verticillium wilt caused by the fungus *Verticillium dahliae* is the most important disease of commercial mint production. Rotation to non-hosts is difficult since inoculum of *V. dahliae* can survive in field soils for ten years or more and the pathogen has a wide host range. Certain green manure crops can reduce *Verticillium* wilt severity but these crops must fit into existing mint production systems. Fast-growing short-term cover crops would be desired in Central Oregon since the optimum time period for a green manure cover crop is a 2-3 month period in late summer and early fall. The objective of this project was to evaluate green manure crops for their potential to reduce *Verticillium* populations in the soil in Central Oregon cropping systems.

Greater Hay Yields and Reduced *Verticillium* Counts Following Certain Green Manures

A microplot experiment was established at COARC to determine if selected green manure crops can produce sufficient biomass if planted in late summer in Central Oregon. Round (24" diameter x 18" tall),

Table 1. Effect of green manure and allyl isothiocyanate (AITC) treatments on *V. dahliae* colony forming units (CFU), *Verticillium* wilt area under disease progress curves (AUDPC), and dry mint hay yields in microplots grown under Central Oregon conditions.

Treatment	Green manure yield (tons/acre)	CFU/ g soil[a]	AUDPC	Yield ratio (compared to control)[b]
Non-infested/non-treated	N/A[c]	0.0 a	0.0	1.00
Infested/non-treated	N/A	12.6 c	43.1	1.01
Brassica juncea 'Pacific Gold'	15.0	2.4 ab	32.5	1.01
B. juncea 'Kodiak'	19.7	2.4 ab	15.0	1.45
Sinapis alba 'Ida Gold'	13.0	1.1 a	42.5	1.38
Caliente 199 mustard blend	14.9	1.8 ab	52.5	1.37
Caliente Nemat arugula	6.8	2.3 ab	4.4	1.25
95% AITC (10 gal/acre)	N/A	9.5 bc	0.8	1.12
95% AITC (40 gal/acre)	N/A	5.1 bc	1.9	1.05
Non-infested/95% AITC (40 gal/acre)	N/A	1.1 a	3.8	0.96
P-value	0.1396	< 0.0001	0.0591	0.1425

[a] Values followed by different letters are significantly different at $P \leq 0.05$

[b] A yield ratio greater than 1.00 indicates increased yield compared to the control.

[c] N/A = not applicable.

bottomless nursery pots were placed in the ground so that the tops were approximately 2" above soil level. Each microplot was infested with a VCG 2B mint isolate of *V. dahliae* (approximately 3 CFU/cm^3 soil). Green manure crops were broadcast planted at recommended rates in August 2015 and grown using overhead irrigation. Other treatments consisted of allyl isothiocyanate (AITC) at 10- and 40 gal/acre, a non-treated/non-infested control, and a non-treated/infested control. A non-infested AITC treatment (40 gal/acre) was also included to determine if AITC can cause phytotoxicity in peppermint. Green manure biomass was measured in October 2015, after which green manures were chopped and incorporated by hand into each microplot. Microplots were planted with greenhouse-grown rhizomes of Black Mitcham peppermint in November 2015.

Soils from each microplot were sampled in March 2016 and assayed for *V. dahliae* using NP-10 semi-selective media. *Verticillium* wilt incidence (the number of infected stems) and severity (based on a scale of 0=no symptoms to 6=dead plant) were recorded at the onset of symptoms (June 2016) and prior to harvest (July 2016). Disease severity index (DSI) values were calculated (incidence x severity) and area under disease progress curves (AUDPC) were calculated using DSI values from both disease readings. Mint hay was harvested from each microplot in July 2016, dried for one week and weighed. Hay yields were converted to yield ratios by dividing the total yield for each treatment by the total yield of the control treatment. A yield ratio greater than 1.00 indicated increased yield compared to the control.

Significant differences in aboveground biomass were not observed among the five green manure treatments, but aboveground biomass of the four mustard treatments (Ida Gold, Pacific Gold, Kodiak and Caliente 199) were greater than expected, ranging between 13.0 and 19.7 tons/acre; Nemat arugula produced 6.8 tons/acre of biomass (Table 1). The broccoli green manure failed to grow in the microplots and did not produce any biomass during the trial period.

Significant effects of green manure or AITC treatments on *Verticillium* wilt AUDPC were not observed (P = 0.059) (Fig. 1); however, *B. juncea* 'Kodiak' and arugula reduced AUDPC by 65 and 90 percent, respectively, compared to the non-treated/infested control (Table 1). Microplots treated with AITC at 10- or 40 gal/acre rates also exhibited reduced AUDPC values but the differences were not significant. All four mustard treatments and arugula significantly reduced *V. dahliae* CFUs compared to the infested/non-treated control (Table 1). Both AITC treatments (10 and 40 gal/acre) reduced *V. dahliae* CFU levels but the reduction was not significant. A small number of *V. dahliae* CFUs were recovered from the non-infested/AITC treatment and mild wilt symptoms were observed, indicating the presence of a background level of inoculum at the trial site. Mint hay yields were not significantly different, but it was notable that hay yields were 1.25 to 1.45 times greater in some green manure treatments (Table 1). These results indicate that certain green manures can be used in mint cropping system rotations to reduce *Verticillium* wilt in fields already infested with the pathogen.

Fig. 1. Mint microplots (left) and plants exhibiting a range of symptoms from apical chlorosis and reddening (top right) to chlorosis, necrosis and wilting (bottom).

Crop Tolerance and Efficacy of Zidua (Pyroxasulfone) and Lorox DF (Linuron) on Dormant Mint in Northeast Oregon

Bryon Quebbeman, Quebbeman's Crop Monitoring, La Grande, Oregon

Zidua herbicide (pyroxasulfone) has the potential to be another useful herbicide for use in peppermint. It may be labeled for use in mint within the next few years. Zidua was tested in 2015 in Northeast Oregon for crop tolerance and weed control. The weather was unusually dry after the Zidua treatment was applied in February. The grower's irrigation that occurred in April was the first significant amount of water that was applied to the experiment plots. The annual weeds had begun to grow by the time irrigation was applied.

Lorox DF (linuron) herbicide is an older herbicide that was also tested because it is also being looked at for possible labeling on mint.

Objectives

1. Compare weed control effectiveness of Zidua and Lorox DF at different rates and application times to a standard, dormant herbicide tank mix.

2. Determine if there was any visual crop injury to dormant, established mint from the highest rate and a 2x rate of Zidua, Lorox and Chateau when compared to a standard treatment and an untreated check. Test the tolerance of the highest standard rate of Zidua and Lorox when applied in mid-March, when the mint was not completely dormant.

Results

Zidua alone provided little control of the weeds in both trials. The best results from Zidua came from the 2x rate applied in January on kochia (See Tables 1 and 2).

Lorox DF alone at the low and maximum rate provide poor control of all the weeds in both trials, however, at the 2x rate it provided significant control of yellow mustard and groundsel. When Paraquat was added to the Lorox at the maximum rate of 1 lb. ai/a, the weed control of prickly lettuce and downy brome increased significantly.

Paraquat by itself also produced significant control of downy brome and yellow mustard.

In Experiment Two, a 2x rate of Chateau was applied with Sinbar and Paraquat. This treatment provided the best and most lasting control of the groundsel of any treatment. The groundsel population

Table 1. Effectiveness and crop tolerance of Zidua (pyroxasulfone), Lorox and Sharpen on established mint in the La Grande, OR area. 2016 (Experiment One, 5th year field #1057)

Treatments	Rate lb ai/a	App. Date	Prickly lettuce[1]	Prickly lettuce[2]	Downy brome [1]	Downy brome [2]	Yellow Mustard [2]	Groundsel [2]	Crop injury[1]	Crop injury[2]
			----------% Control					----------% Control	-----% Injury-----	
UTC			0 a	0 a	0 a	0 a	0 a	0 a	0	0
Zidua	0.16	1/29	0 a	0 a	10 ab	0 a	0 a	41 bc	0	0
Zidua	0.32(2x)	1/29	26 ab	0 a	35 ab	0 a	0 a	78 de	0	0
Zidua	0.16	3/23	0 a	0 a	15 ab	0 a	0 a	0 a	0	0
Lorox 50 DF	1.0	1/29	20 ab	0 a	25 ab	0 a	70 b	14 ab	0	0
Lorox 50 DF	2.0(2x)	1/29	30 ab	0 a	50 bc	15 ab	95 c	91 e	0	0
Lorox 50 DF +COC	0.5 1.65	3/23	0 a	0 a	40 ab	0 a	100 c	25 abc	0	0
Lorox 50 DF +COC	1.0 1.65	3/23	41 b	40 c	0 a	0 a	100 c	38 bc	0	0
Lorox 50 DF + Paraquat MSO	1.0 0.56 0.8	1/29	95 c	33 bc	90 cd	100 c	100 c	48 cd	0	0
Sinbar + Chateau + Paraquat MSO	0.4 0.128 0.56 0.8	1/29	95 c	80 d	100 d	100 c	100 c	100 e	0	0
Sharpen (2 oz)	0.0445	1/29	36 b	10 ab	45 b	30 b	90 bc	25 abc	0	0
Paraquat MSO	0.56 0.8	1/29	44 b	0 a	100 d	100 c	90 bc	0 a	0	0
LSD			35	29	42	21	20	32		

LSD Sample means were compared with Fisher's Protected LSD (p=0.05).

1 Evaluated 4-8-2016. On this date there was spider mite damage to the mint that could have masked any crop injury.

2 Evaluated 4-28-2016

was very heavy in Experiment Two. Table 2 shows that the 2x rate of Chateau did not provide significantly better control of the groundsel than did the maximum rate of Chateau, however, visually the 2x rate had noticeably less groundsel than the standard maximum rate.

In Experiment Two, the 2x rate of Chateau treatment did have significantly more crop injury on the April 7 date but by May 28 there was no crop injury in this or any other treatment of Experiment Two.

In Experiment One, Sharpen at 2 oz./ac 0.04 lb ai/a was compared to the low rate of Paraquat (0.56 lb ai/a). Both products preformed statistically similar on prickly lettuce, yellow mustard and groundsel, but Sharpen did not control the downy brome while the Paraquat provided 100 percent control.

The treatments that contained standard herbicides of Sinbar + Chateau + Paraquat provided the best control of prickly lettuce, groundsel and kochia in both experiments.

There was no crop injury in either experiment for any of the Zidua treatments at either treatment date.

Lorox DF did not cause any crop injury except when crop oil concentrate was added and the treatments were applied on March 23. The standard treatments that included Sinbar, Chateau and Paraquat also caused some crop injury in Experiment Two. The mint damage outgrew all crop injury by late May.

Conclusions

At the recommended rates Zidua by itself did not provide adequate control of prickly lettuce, downy brome, yellow mustard, salsify, green foxtail, kochia or groundsel. Zidua did appear safe on the mint even when applied shortly after the mint had broken dormancy in March, but weed control was reduced when the Zidua was applied late.

Lorox at the recommended rates did not provide any significant weed control except on yellow mustard. Lorox at the 1 lb. ai/a rate provided 70 percent control of the yellow mustard (Table 1).

When Paraquat was tank mixed with Lorox, prickly lettuce control was good. In addition, this tank mix also provided some groundsel control.

When the 2x rate (2 lb. ai/a) of Lorox was applied, the control of yellow mustard and groundsel was significantly improved.

Sharpen may have a fit to replace Paraquat in dormant applications if there are no grasses to control.

A January application of a 2x rate of Chateau with Sinbar and Paraquat provided good groundsel control when the pressure from groundsel was extreme. This 2x rate of Chateau did cause more crop injury than the standard 1x rate of Chateau, but by late May the crop had outgrown the damage.

Table 2. Effectiveness and crop tolerance of Zidua (pyroxasulfone) and Lorox (Linuron) on established mint in the La Grande, OR area (Experiment Two, 4th year field# 1530)

	Rate lb ai/a	App. date	Prickly Lettuce[1]	Groundsel[1]	Groundsel[2]	Salsify[1]	Green Foxtail[2]	Kochia[2]	Crop Injury[1]	Crop injury[2]
			--------% Control					--------	-------% Injury	-------
UTC			0 a	0 a	0 a	0	0	0 a	0 a	0
Zidua	0.16	1/29	25 ab	15 ab	5 a	13	90	37 ab	0 a	0
Zidua	0.32(2x)	1/29	25 ab	13 ab	65 c	0	70	67 bc	0 a	0
Zidua	0.16	3/23	0 a	13 ab	5 a	25	45	8 a	0 a	0
Lorox 50 DF	1.0	1/29	25 ab	38 ab	35 b	13	0	0 a	0 a	0
Lorox 50 DF	2.0(2x)	1/29	63 bc	90 ef	88 d	50	5	0 a	0 a	0
Lorox 50 DF +COC	0.5 1.65	3/23	63 bc	65 de	19 ab	38	0	0 a	5 bc	0
Lorox 50 DF + COC	1.0 1.65	3/23	50 bc	58 cd	33 b	63	13	7 a	8 cd	0
Sinbar + Chateau + Paraquat + MSO	0.4 0.26 (2x) 0.56 0.8	1/29	75 c	100 f	98 d	25	38	100 c	10 d	0
Sinbar + Chateau + Paraquat + MSO	0.4 0.128 0.56 0.8	1/29	75 c	100 f	97 d	40	70	100 c	3 ab	0
LSD			44	26	22	NS	NS	42	4	NS

LSD Sample means were compared with Fisher's Protected LSD (p=0.05).

1 Evaluated 4-7-2016

2 Evaluated 5-28-2016

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

Clare Sullivan and Marvin Butler, Central Oregon Agricultural Research Center
Darrin L. Walenta and Ralph Berry, Oregon State University

In 2016 an electronic newsletter was developed for the peppermint production regions in Oregon to assist growers and fieldmen with the control of mint root borers, cutworms, armyworms and loopers during the growing season prior to crop damage. This was the third year of distributing an electronic Mint Pest Alert Newsletter that included information on larval insect development and control recommendations. The e-Newsletter was created and distributed with three objectives in mind:

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.
3. In addition, to provide degree-day information that will benefit those using traditional products like Orthene® and Lorsban Advance®.

Recommendations of optimal insecticide application timing were based on the insect development models and were provided through weekly e-Newsletters in each region from mid-June until the end of July. Extension Agents from the Willamette Valley, Central Oregon and Union County provided scouting services to confirm insect development model accuracy.

Average MRB moth numbers were highest in the Willamette Valley. The MRB moth population first peaked during the June 29-July 6 trapping period, which lined up with the peak moth catch predicted by the model (July 2). The population then dropped, as the model predicted, but peaked again from July 20-28. Mint root borer moth numbers in Central Oregon were moderate. Culver trap numbers for MRB moths peaked July 7-14 and Prineville July 14-21; both of these times lined up with the peak moth catch predicted by the models. The MRB moth counts remained very low all season in Baker Valley. Moth catch peaked July 16-22 in Baker Valley, which was in line with the model's predicted peak moth catch of July 17.

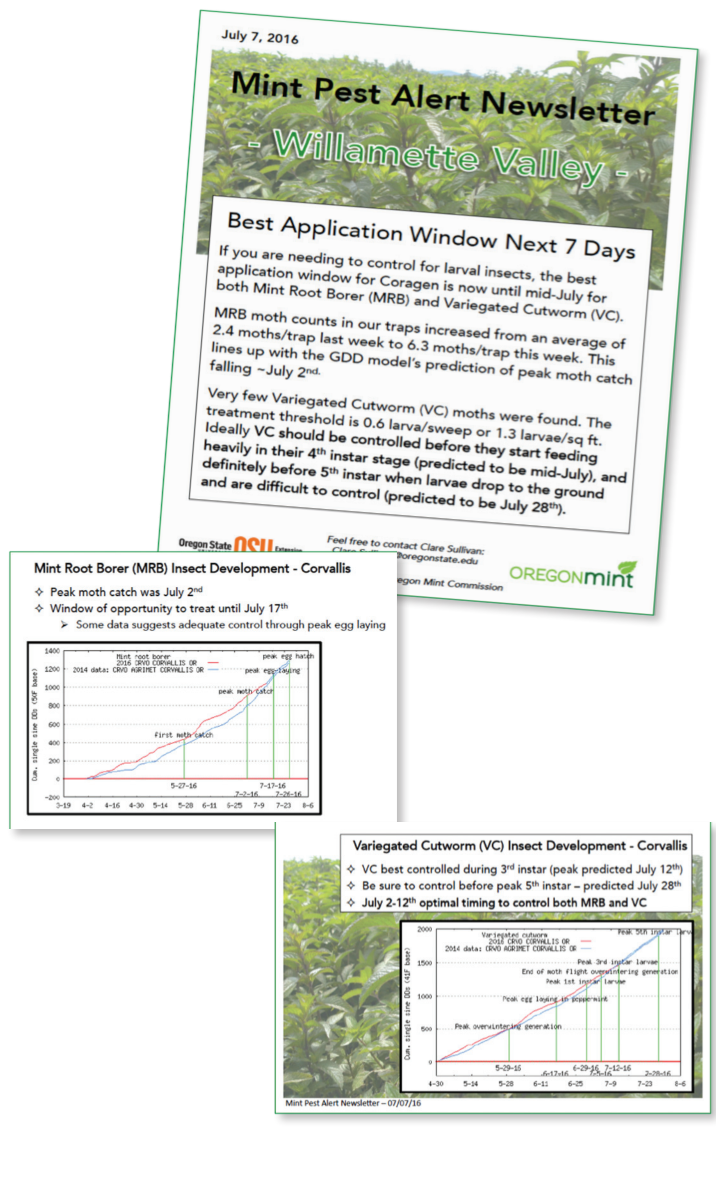
Cutworm moth and larvae numbers remained fairly low in all regions throughout the 2016 growing season. There were also no MRB larvae found in any of the soil samples taken in early September.

A formal survey of those receiving the newsletter indicated that the newsletter was well received.

Respondents rated the newsletter effectiveness in assisting grower/crop consultants in using degree-day models and specifically targeting use of Coragen for mint root borer control of eggs and first instar as 3.5 on a scale of 1 (not effective) to 5 (very effective). When asked if the Mint Pest Alert Newsletter should continue as an ongoing project, the unanimous response was "Yes."

We also asked respondents how they planned to manage mint larval pests without chlorpyrifos if the EPA proposal to revoke all chlorpyrifos tolerances is enacted. The majority of respondents (53 percent) said they would use Coragen.

In answering how the Mint Pest Alert Newsletter could be improved in the future, the suggestions were more focus on life cycles, degree day models and identifying characteristics of the different larval pests.



Comparison of Fungicides to Increase Peppermint Oil Yields in Northeast Oregon

Bryon Quebbeman, Quebbeman's Crop Monitoring, La Grande Oregon

Many growers in the La Grande area have been applying Headline fungicide (pyraclostrobin) to increase yields. Recently, some growers in the La Grande area have switched to using a generic formulation of Quadris (Azoxystrobin) instead of Headline. This is due to the increased cost of Headline and the decreased cost of azoxystrobin. There is currently no lower cost generic form of Headline available.

There is limited research in the La Grande area to prove that Azoxystrobin produces the same yield increase as Headline.

Research Objectives

1.Determine if any yield increase is realized by Headline or Aframe (generic Quadris) compared to an untreated check.

2. Determine if there is a yield difference between the maximum and minimum rates of Headline and Aframe (generic Quadris).

3. Determine if there is a yield difference between Headline and Aframe fungicides.

Materials and Methods

Two experiments were placed in established production peppermint fields in the La Grande area.

At the time of the applications, the mint in Experiment One was lodged and 16-22 inches tall, with the mint starting to send out flower buds. There was a lot of mint growth on this second year virgin soil field.

The mint in Experiment Two was 10-14 inches tall and slightly lodged, and there were no flower buds present at the application date.

Experiment One was harvested on August 4, or 20 days after the fungicides were applied. Experiment Two was harvested on August 15, or 31 days after the fungicides were applied.

To determine oil yields, 50 square feet of mint hay was cut from the center of each plot and air-dried.

Table 1. Treatments and oil yields of established peppermint treated with fungicides in the La Grande, OR area (2016)

Treatment	Application date	Rate (ai/a)	Exp. 1** Mean oil yields (lb/ac)	Exp. 2*** Mean oil yields (lb/ac)
1. UTC			93.2	84.0
2. Headline 9 oz/a	7/15	0.014	94.4	82.7
3. Headline 12 oz/a	7/15	0.2	94.4	77.1
4. Aframe* 6 oz/a	7/15	0.097	95.2	78.2
5. Aframe* 15.5 oz/a	7/15	0.25	92.9	79.1
LSD			NS	NS
%CV			11.6%	10.3%

LSD Sample means were compared with Fisher's Protected LSD (p=0.05).
*Generic Quadris (Azoxystrobin) • **Harvested Aug. 4 • ***Harvested Aug. 15

Due to the large size of mint hay samples, the dry mint hay was cut into small pieces using a hedge trimmer so as to reduce the size of the sample. These cut up mint hay samples had the oil extracted from them within 90 minutes of being cut up. The oil extraction was done at the mini mint still located at the Parma Experiment Station near Parma, Idaho. Yields were determined by converting the extracted milliliters of oil into lbs. of oil, and then converting the total square feet harvested from each plot into acres. The final results are presented in lbs. of oil/acre.

Experience in using this mini still has found that not all the mint oil is recovered from the mini collectors. Antidotal evidence shows that 20 to 40 percent of the mint oil is lost when using a mini still. This gives a low oil yield compared to what a grower would get using a commercial still. No multiplier factor was used in this experiment. The yields shown are the actual yields that were obtained from this experiment. The purpose of this experiment is to measure the oil yields against the untreated check.

Results and Discussion

At the time the fungicides were applied, there was no noticeable powdery mildew present.

On August 4 in Experiment One there was a light amount of powdery mildew in the untreated plots. There was a trace of powdery mildew found in all the fungicide treated plots. It did not appear that it made any difference which fungicide was used; all fungicide treatments had a trace of powdery mildew. It appeared that some of the mint that had powdery mildew in the fungicide treated plots may have been covered by foliage at the time the fungicides were applied. Any plant material that was treated with a fungicide was free of powdery mildew.

On August 13, in the Experiment Two, there was a very light amount of powdery mildew found only in the untreated plots. No powdery mildew was found in any of the fungicide treated plots.

The fungicide treatments clearly reduced the level of powdery mildew in both trials but did not completely eliminate it in Experiment One. The overall mildew level was low over the entire season.

It is common that in August established mint does not have any visible powder mildew, but this year it was common for established mint to have powdery mildew in early August.

There were no significant oil yield differences between any of the treatments and the untreated check for either experiment.

The 2016 season was unusual in for the mint started growing earlier than usual and continued to grow well throughout the season.

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Experiment One was harvested earlier than was expected due to the grower harvesting the field early.

Experiment Two was harvested in mid-August as was expected.

This data is different than the data that was obtained in 2008 and 2009 in the La Grande area.

It is not understood why Headline generally increased oil yields in 2008 and 2009 in the La Grande area but did not in 2016.

In 2016, La Grande area growers applied Headline or the generic equivalent of Quadris to most of the peppermint fields.

It appears that the oil yield increases from Headline is sporadic or no longer provides oil yield increases. Continued research would be useful to determine if there is any benefit from using Headline or Quadris in Northeast Oregon.

Conclusions

All of the fungicide treatments did equally reduce the amount of visible powdery mildew at harvest time compared to the untreated check.

Applying Headline or generic Quadris (Aframe) did not increase the oil yields in either experiment.

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

Tim Butler, OEOGL Chairman, Aumsville, Oregon

Plans are beginning for the 2018 Annual Convention. Be sure to mark your calendars. The dates will be January 11 & 12 at the Salishan Lodge and Golf Resort, Gleneden Beach, Oregon.

If you are interested in advertising in the 2018 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 Kari or Sue at the Association office at (503) 364-2944.