Spring 2018

OREGONmint UPDATE

NEWSLETTER OF THE OREGON MINT COMMISSION

Weed Control in Western Oregon

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During the 2017 growing season three crop safety and herbicide efficacy trials were conducted in commercially grown peppermint fields in western Oregon. The primary objectives of these trials were to provide data in support of the registration of pyroxasulfone (Zidua) and associated tank mixes and to evaluate the use of several protoporphyrinogen oxidase (PPO) inhibitor herbicides; carfentrazone (Aim), flumioxazin (Chateau) and saflufenacil (Sharpen) at various application timings. Pyridate (Tough) treatments were also included in one study to continue our on-going evaluation of this herbicide for use in peppermint. Many of the herbicides and use patterns discussed in this report are not registered for use in peppermint. 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. Saflufenacil, carfentrazone and flumioxazin were applied to an established peppermint field in Linn County to assess crop safety at two spring timings. Saflufenacil was applied with MSO at 1 percent v/v and AMS at 1 percent w/v. All other treatments were applied with 0.025 percent v/v NIS. No weeds were present in the plot area. Evaluation June 5 showed injury in all treatments (Table 1). The plots were evaluated again on July 7, but wilt symptoms had developed making it difficult to know whether stunting was a result of the disease or herbicide treatments. Plots were harvested to calculate biomass yield, but due to the wilt were variable. The yield results were inconclusive and will not be published here. However, these results appear to indicate that these PPO inhibitor herbicides can be safely used in peppermint, but that initial peppermint injury following application should be expected.

Table 1. PPO inhibitors applied to established peppermint.

	Rate	Applied	Peppermint injury 6/5/2017	Peppermint injury 7/17/2017
	lb ai/a	Date	----------%----------	
Untreated			0	0
Saflufenacil	0.045	3/31	33	0
Saflufenacil	0.089	3/31	35	0
Carfentrazone	0.016	3/31	8	0
Flumioxazin	0.080	3/31	23	0
Saflufenacil	0.045	4/28	58	0
Saflufenacil	0.089	4/28	70	0
Carfentrazone	0.016	4/28	30	0
Flumioxazin	0.080	4/28	60	0
LSD P=0.05			13	*NS*

Pyroxasulfone (Zidua) Tank Mixes Study

To assess possible tank mix partners for pyroxasulfone, a trial was conducted in an established peppermint field in Polk County. Pyroxasulfone was applied with other herbicides frequently used during peppermint dormancy. Two pyroxasulfone-containing premixes were also included. All treatments were applied February 14 in 20 gallons per acre of water. In this study acceptable control of common groundsel and annual bluegrass was only achieved when paraquat was added to the tank mix (Table 2). Treatments containing paraquat or flumioxazin provided 100 percent control of prickly lettuce (data not shown). Some injury was visible April 4, nearly two months after the treatment, but by June 12 injury was no longer visible. Biomass was harvested on June 27. There were no differences in biomass yield at p-value 0.05. These results indicate that pyroxasulfone can successfully be used as a dormant treatment and in combination with other herbicides for use in peppermint.

Pyridate (Tough) use for Pigweed Management

A trial was conducted in a spring-planted peppermint field in Polk County. The trial area had a dense infestation of redroot pigweed ranging from seedling to 24 inches in height and peppermint size ranged from 2-10 inches. The herbicide treatments were applied using a bicycle wheeled sprayer in 20 gallons per acre on July 12, 2017. At the evaluation five days following the application, redroot pigweed in all plots showed promising injury symptoms (Table 3). However, by August 10, 2017 significant regrowth had occurred. Pyridate and saflufenacil appear likely to provide control of small redroot pigweed, but due to plant size and weed density, control was not adequate at this site. With the exception of the saflufenacil treatment, injury to peppermint was minimal and transient. Future projects with pyridate and saflufenacil will focus on smaller weeds and appropriate tank mix combinations.

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Trials Planned for 2018

Trials are planned or in progress for the 2018 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. This trial will focus on providing application timing, rate and efficacy data in support of the registration of saflufenacil for use in peppermint. Another trial is being conducted to refine and demonstrate possible tank mixes that could be used with pyroxasulfone (Zidua) should it become available for use in mint.

Table 2. Pyroxasulfone tank mixes in established peppermint.

	Common	Annual Groundsel Control[1]	Bluegrass Control[1]	Injury[1]	Peppermint Injury[2]	Biomass[3]
	lb ai/a	----------%----------				lb/plot
Untreated		0	0	0	0	18.4
Pyroxasulfone + terbacil + paraquat	0.090 1.200 0.500	95	100	10	0	19.3
Pyroxasulfone + oxyfluorfen + paraquat	0.090 0.500 0.500	99	100	28	0	18.6
Pyroxasulfone + terbacil + paraquat	0.190 1.200 0.500	83	100	8	0	18.5
Pyroxasulfone + oxyfluorfen + paraquat	0.190 0.500 0.500	100	100	31	0	20.4
Pyroxasulfone + sulfentrazone	0.090 0.313	25	50	23	0	19.9
Pyroxasulfone + pendimethalin	0.090 1.900	0	19	0	0	18.0
pyroxasulfone-flumioxazin	0.339	41	60	34	0	18.8
pyroxasulfone-carfentrazone	0.204	0	38	5	0	17.8
LSD P=0.05		16	33	7	*NS*	2.1

[1]Evaluated 4/4/2017 [2]Evaluated 6/12/2017 [3]Harvested 6/27/2017

Table 3. Redroot pigweed control in newly planted peppermint.

Name	Rate	Peppermint Injury 7/17/2017	Peppermint Injury 8/10/2017	Redroot pigweed Control 7/17/2017	Redroot pigweed Control 8/10/2017
	lb ai/a*	----------%----------			
untreated		0	0	0	0
pyridate + COC	0.940 1.000	0	0	50	48
pyridate + bentazon + COC	0.940 1.000 1.000	0	10	55	35
pyridate + bromoxynil + COC	0.940 0.375 1.000	20	10	5	50
saflufenacil + COC	0.045 1.000	50	23	90	63
bentazon + COC	1.000 1.000	0	0	29	13
bromoxynil + NIS	0.375 0.250	13	0	38	23
MCPB + NIS	0.500 0.250	0	10	21	43
LSD P=0.05		5	17	8	25

*Except adjuvants, which are expressed in %V/V

Integrated Disease Management of *Verticillium* Wilt

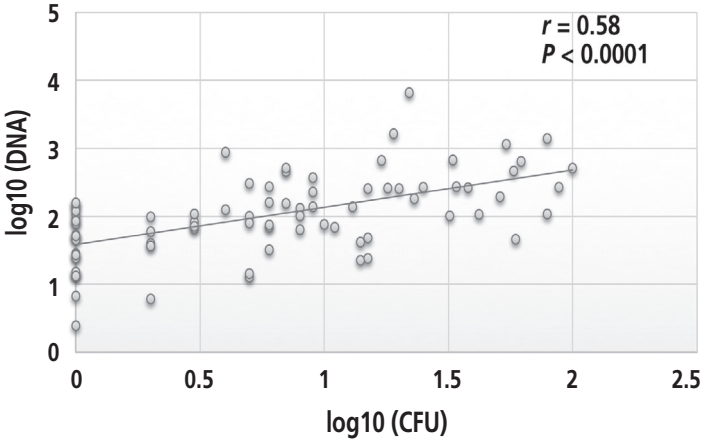
Jeremiah Dung and Darrin Walenta, Oregon State University
David Wheeler and Dennis Johnson, Washington State University

Verticillium wilt, caused by the fungus *Verticillium dahliae*, is the most important disease of commercial mint production. Control options are limited once *V. dahliae* is introduced to a field because inoculum of the fungus can survive in field soils for ten years or more and the pathogen has a wide host range. Fumigation, green manures and flaming can reduce pathogen levels, but more tools are needed to help growers assess *Verticillium* wilt risk prior to planting and guide IPM practices. Collaborative research by Oregon State University and Washington State University was conducted to develop *Verticillium* wilt risk assessment tools for mint growers. The objectives of this research were to: 1) develop and validate a DNA-based method to detect and quantify *Verticillium* inoculum in field soils; 2) identify risk factors associated with *Verticillium* wilt in mint; and 3) determine inoculum thresholds for *Verticillium* wilt in mint.

Developing and Validating a DNA-based Method to Detect and Quantify *Verticillium* Inoculum in Field Soils

A quantitative PCR (qPCR)-based assay was developed for *Verticillium* that exhibited increased sensitivity, improved reproducibility and faster turn-around time for results compared to conventional plating methods. The utility of this assay was demonstrated using soil samples that were collected from 96 study sites representing 22 commercial mint fields in Central Oregon (Madras area), northeastern Oregon (La Grande area) and the Columbia Basin of Central Washington. *Verticillium* colony forming units (CFUs) were quantified using conventional plating methods and DNA was extracted from soil samples. Results from the qPCR assay were correlated with and obtained faster than results from conventional plating (r = 0.58; P <0.0001) which were obtained in two weeks compared to three days for the qPCR assay (Fig. 1).

Fig. 1. Correlation between *Verticillium dahliae* colony forming units (CFU) as determined by conventional plating and *V. dahliae* DNA as determined using the quantitative PCR assay.



Identifying Risk Factors Associated with *Verticillium* Wilt in Mint

A preliminary model was developed to determine risk factors associated with *Verticillium* wilt in mint. In addition to *V. dahliae* levels, nematode populations, (root lesion, pin, ring and others), crop age and mint cultivar were also considered as predictor variables for the model. The number of wilted stems at each study site was best predicted by the amount of *V. dahliae* DNA, the number of root lesion nematodes (*Pratylenchus penetrans*), the cultivar of mint being grown and the age of the stand (Table 1).

Table 1. *Verticillium* wilt risk in mint modeled as a function of *Verticillium dahliae* inoculum levels, root lesion nematode (*Pratylenchus penetrans*) counts, mint cultivar and field age.

Parameter	Parameteric model Partial slope	Parameteric model P-value	Non-parametric model P-value
V. dahliae DNA (fg)[a]	0.17	0.03	0.002
P. penetrans (per 250 g of soil)[a]	0.44	<0.0001	<0.0001
Mint cultivar			<0.0001
Peppermint	2.41	0.007	
Spearmint	1.60	0.13	
Native spearmint	ND[b]	ND	
Field age			0.002
1 year	ND	ND	
2 years	0.36	0.32	
3 years	1.08	0.004	
4 years	0.14	0.83	
Multiple R^2	0.53		0.58
Predicted square error	25.71		3.46

[a] Data were log10-transformed.

[b] ND: not determined due to low sample size.

Determining Inoculum Thresholds for *Verticillium* Wilt in Mint

Currently, there are no clear guidelines on the economic thresholds for *Verticillium* wilt risk in mint or the inoculum levels required that cause disease. An initial study was performed to quantify *Verticillium* levels from soils collected internal and external to wilt foci. A total of five foci in each of two peppermint fields were sampled and *Verticillium* levels were quantified using the qPCR assay. Preliminary, DNA-based inoculum thresholds were identified (Fig. 2), but further research is needed to further define and refine economic thresholds for different mint species and cultivars.

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Conclusions

The qPCR assay provided estimates of *V. dahliae* from commercial field soils that correlated with the conventional plating method but required less time and was more sensitive. Estimates of *V. dahliae* inoculum from the qPCR assay were related to wilt in commercial mint fields. Variation in wilt that is not explained by *V. dahliae* inoculum may be explained by differences in root lesion nematode populations, mint species and cultivar and the field age. Research on economic thresholds for *Verticillium* wilt is also underway. Together, this work will provide growers with risk-based IPM tools to help inform pre-planting management decisions for *Verticillium* wilt of mint.

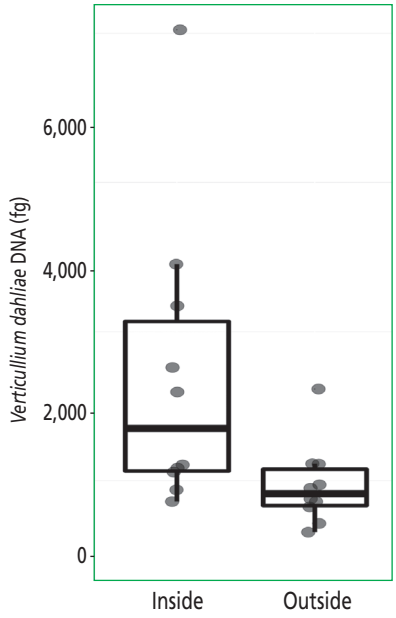


Fig. 2. Box and whisker diagrams of *Verticillium dahliae* DNA levels in soil samples collected from inside and outside *Verticillium* wilt foci in two commercial peppermint fields.

Comparison of Headline and Generic Quadris 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 even when no diseases are present. 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.

Objectives

1. Determine if any yield increase is realized by Headline or Aframe (generic azoxystrobin) 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 at either rate.

Results and Discussion

At the time the fungicides were applied, there was no noticeable Powdery Mildew present, likewise there was no noticeable Powdery Mildew present at harvest in either experiments. Powdery Mildew is not commonly found in early to mid-August in established mint.

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

In 2016 these same treatments were tested with the same results.

This 2017 data is different than the data that was obtained in 2008/09 in the La Grande area.

Table 1. Treatments and oil yields of established peppermint treated with fungicides in the La Grande, OR area (2017)

Treatment	Application date	Rate (ai/a)	Exp. 1** Mean oil yields (lb/ac)	Exp. 2*** Mean oil yields (lb/ac)
1. UTC			84	91
2. Headline 9 oz/a	7-15	0.014	79	94
3. Headline 12 oz/a	7-15	0.2	81	90
4. Aframe* 6 oz/a	7-15	0.097	83	89
5. Aframe* 15.5 oz/a	7-15	0.25	79	91
LSD			NS	NS

LSD Sample means were compared with Fisher's Protected LSD (p=0.05).
*Generic Quadris (Azoxystrobin)
**Harvested Aug. 14 ***Harvested Aug. 8

It is not understood why Headline generally increased oil yields in 2008/09 in the La Grande area, but did not in 2016 and 2017.

Conclusions

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

The past effect of increasing oil yields by applying Headline fungicide must be a sporadic effect.

From this research, there is no reason to apply Headline or Quadris on mint unless there is a need to control a foliar disease.

Mint Varietal Improvement Project

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

Mint Reference Genome Improvement

In 2017, we made a substantial improvement of the *Mentha* reference genome. This was achieved with "long-read sequencing" technology using the PacBio Sequel instrument at the OSU Center for Genome Research and Biocomputing. The assembled reference genome, derived from *Verticillium* wilt-resistant *M. longifolia* accession CMEN 585, now consists 2,256 strings of DNA letters (A,T,G,C) with a median length of >517,000. This means that we are closing in on our ultimate goal of achieving whole chromosome representations. This is important for accurate gene identification for wilt resistance-related and oil biosynthesis-related genes. We can already see that there are multiple copies of most of the oil biosynthesis genes, and they occur in several clusters. For example, there are five different copies of a gene that encodes pulegone reductase (PR), a key enzyme in the menthol biosynthesis pathway. The relative genome positions of two PR gene copies, PR_4 and PR_5, are shown in Figure 1. The PR gene copies, as well as the copies of other oil biosynthesis genes, have small differences in DNA sequence that make them distinct from each other. In some cases, gene copies have sequence patterns that are unlikely to encode functional proteins. In other cases, multiple gene copies appear to encode functional proteins. This is allowing us to target specific gene copies with a PCR assay, which makes millions of copies of the specific DNA target that can be visualized. Using this assay, we can see which plants have particular DNA differences that identify variants of wilt resistance and oil biosynthesis genes. These DNA differences are termed "markers" for particular genes of interest. Markers allow us to screen plants for sets of particular variants at the seedling stage, instead of having to wait until plants are mature. For example, marker-assisted selection will allow us to accurately predict which oil constituents will be present in mature plants long before those plants are actually producing that oil. This will greatly accelerate breeding of new, wilt-resistant mint cultivars with desirable oil types.

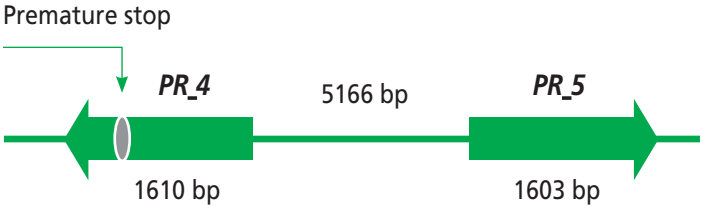


Figure 1. Genome context of two mint oil biosynthesis genes. Two copies of pulegone reductase, PR_4 and PR_5, occur near each other in the mint reference genome. The direction of their protein-coding DNA sequences is indicated by arrows. The PR_4 gene has a premature stop signal in its coding sequence, indicating that it likely encodes a nonfunctional protein.

Using the improved reference genome, we have recently made progress on markers for two traits: oil type and floral male fertility. Figure 2 shows PCR results from markers for the pulegone reductase PR_4 and PR_5 genes. These two gene copies have different variants in mint accessions that can be distinguished from each other by DNA banding patterns. These differences can be tracked in progeny plants when the accessions are used as parents in crosses. By targeting variants of all genes in the carvone and menthol biosynthesis pathways, we can start to predict the oil types mint plants will possess when the plants are at an early growth stage. This is the beginning of marker-assisted selection for oil type.

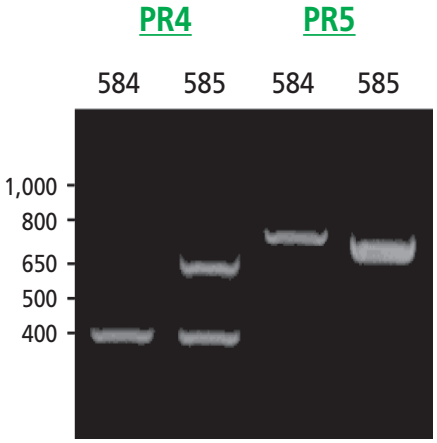


Figure 2. DNA markers distinguish two pulegone reductase genes. PCR results are shown for two *Mentha longifolia* accessions, CMEN 584 and CMEN 585. Light-colored bands represent DNA fragments of different sizes. Different DNA banding patterns distinguish variants of the PR genes in the two mint plants.

Mint Industry Research & Regulatory Update

Steve Salisbury, Mint Industry Research Council Research and Regulatory Coordinator

The annual MIRC meeting in New Orleans was a great success. The meeting was well attended and possibly one of the best turnouts to the annual meeting. The program included research reports, invited guests who sparked new ideas and thoughts for our industry as well as raised our awareness of important issues affecting us, and we acknowledged and celebrated some key people who have made significant contributions to the MIRC. The committee and board meetings were highly productive. A new executive committee was ushered in, new members were welcomed and introduced and new council initiatives were presented. And to cap it off at the reception, we all enjoyed the specialty mint-drink bar sponsored by our friends at Belchim Crop Protection, the registrant for Tough herbicide! It truly was a successful annual meeting and reflected the positive momentum of the MIRC.

One of the goals within the MIRC each year is to grow our membership. We are pleased to announce our newest members to the MIRC, welcome back to Essex Laboratories and welcome to Young Living. Both have jumped right in and began providing excellent input to committee and board discussions. We look forward to hearing more of their fresh ideas moving forward. In 2018, we will continue our efforts in sharing the values and achievements of the MIRC with other prospective members.

In 2018, we also welcomed in a new Executive Committee including the new MIRC Chairman, Greg Biza with Callisons. Greg will serve as the chairman for the next two years and we are eager to see the MIRC continue to grow under his leadership. Dana Wendel, RCB International, is serving as vice-chairman after holding the secretary-treasurer position for the past two years. And, we welcome Karla Farina with Labbeemint into the executive committee as the new secretary-treasurer. This new slate of officers will provide great leadership for the next couple of years. A big "Thank you" to Jason Stromme, Norwest Ingredients, our past chairman as he did a terrific job leading the council for the past two years. We appreciate his leadership and we thank Norwest for allowing Jason the time to serve the MIRC as chair.

As mentioned earlier, there were some new ideas presented and discussed at the board meeting. One of those ideas was the need for the MIRC to expand its engagement in regulatory affairs to include matters beyond pesticide regulations. This concept is still under development at this time, but the gist is to improve our involvement with regulatory matters that are pertinent to and may threaten the mint industry. Council members would collaborate to collect and disseminate information on these matters which will lead to industry-wide strategies to mitigate the risks to the industry. As with all agriculture, the mint industry will continue to be under more regulatory scrutiny which impacts all of our members, growers, dealers and end-users. The MIRC can play a vital role in coordinating industry strategies to manage these challenges.

Steve Salisbury

The Council is still serving its purpose of funding mint research. The Scientific Affairs Committee (SAC) recommended a strong slate of funding proposals to the board, which were funded for 2018. Our proposal submissions continue to be competitive and increasingly difficult for SAC members to make funding decisions due to the high quality of projects presented. We appreciate the interest in mint from the research communities and we continue the effort to expand interest in mint to new potential scientists who may be able to contribute to the mint knowledgebase.

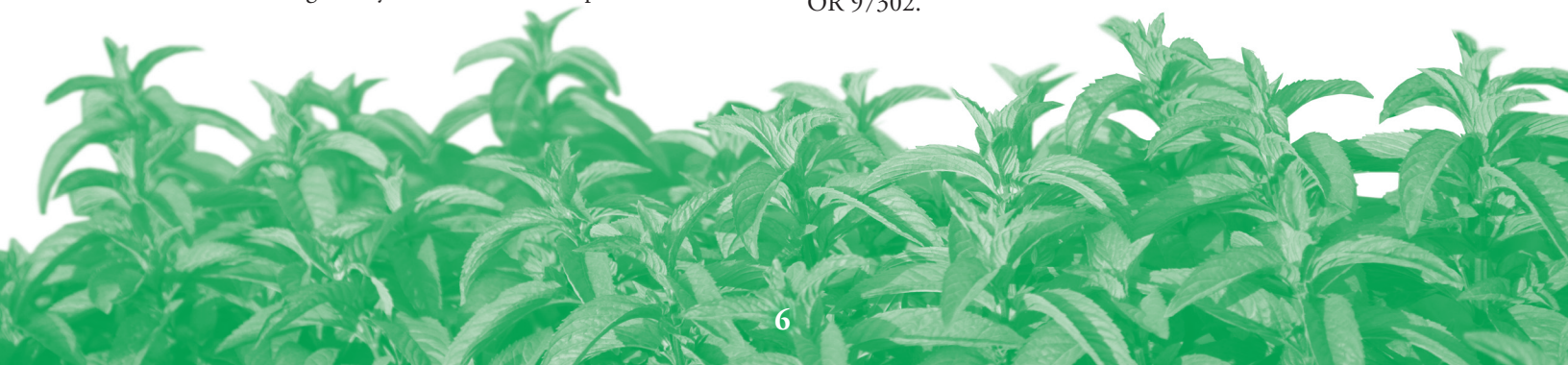
Overall, the MIRC has a lot of good momentum right now. The Council has a lot of productive collaboration happening amongst members that is very positive for the industry. The Council will continue to coordinate its members' efforts to keep improving the momentum, which in turn will provide great benefit and value back to the industry and its members.

As always, this is your industry's council. Your input is important so please contact me if you have any questions or comments. Thank you for being involved.

Tough Herbicide Update

The 2018 Section 18 registration has been approved for Oregon, Washington and Idaho. This authorization is for double-cut mint acres. Please adhere to the label application dates.

It is required that you complete and submit the waiver agreement at the time of purchase. Please be sure you complete the form and send it to the MIRC admininistrative office. You can email a scanned copy to info@mircnews.org or fax it to (503) 581-6819 or mail it to Mint Industry Research Council, PO Box 4059, Salem, OR 97302.



Crop Tolerance and Efficacy of Various Herbicides on Dormant Mint in Northeast Oregon

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

New herbicides may soon be registered for use in mint. These new products are welcomed as new tools are needed to combat herbicide resistance, deal with crop rotation issues and ways to cut production costs. This research seeks to test the efficacy and crop tolerance of the newly registered herbicide Aim (carfentrazone) by itself and in tank mixes with other herbicides.

In addition, the newer herbicide Sharpen (saflufenacil) was also tested by itself and in combinations with other herbicides. The older, but unregistered herbicide Linuron was also tested, however, the testing of Linuron will be discontinued in my trials after this year due to the high price of the product.

Objectives

1. Compare weed control effectiveness of Linuron, Sharpen, Aim and Gramoxone(paraquat) herbicide rates to a standard herbicide tank mix.
2. Determine the crop tolerance of dormant and non-dormant herbicide applications to established mint of Linuron, Sharpen and Gramoxone(paraquat), compared to a standard herbicide tank mix.

Results

Objective One

Experiment One - Herbicide Efficacy

Aim provided little to no control of the winter annual weeds by itself. When it was combined with Sinbar, and/or Chateau, it added no significant weed control. (Table 1).

Gramoxone by itself provided little control of established groundsel and almost no control of seedling groundsel, salsify and prickly lettuce. The seedling groundsel was not fully emerged at the time of the herbicide application.

Linuron, at 1 lb ai/a, added no significant increase in weed control of established groundsel, salsify and prickly lettuce. Linuron did increase seedling groundsel control slightly when added with Aim, Sharpen or Gramoxone, but the amount of control would not be considered adequate.

Sharpen, at the 2 oz/a rate, controlled established groundsel very well but provided poor control of salsify and prickly lettuce. Combinations of Sharpen and Chateau and Sinbar did significantly improve the control of prickly lettuce but did not help much with controlling salsify.

The standard treatment of Sinbar, Chateau and Gramoxone provided poor control of the established groundsel and salsify with moderate control of prickly lettuce. It did provide excellent control of the seedling groundsel.

When 2 oz/a Sharpen was added to the previous standard treatment of Sinbar, Chateau and Gramoxone, the weed control increased significantly and provided excellent control of established groundsel, seedling groundsel and prickly lettuce. Control of salsify was moderate but control of salsify was better than any of the other treatments.

It appears that mixing Gramoxone and Sharpen could greatly widen the spectrum and amount of weed control in dormant mint.

Table 1. Experiment One. Efficacy of weed control of dormant applied herbicides on established mint in the La Grande area. (Treatments applied 2-17-17) (Fld. 1531)

			Established Groundsel	Seedling Groundsel	Salsify	Prickly Lettuce
			5-18	5-18	5-18	5-18
#	Treatment	lb ai/a	----------% Control ----------			
1	UTC		0 c	0 e	0 c	0 g
2	Aim (1 oz/a)	0.015	0 c	0 e	11 c	3 f
3	Aim (1 oz) Sinbar (9.6 oz)	0.015 0.5	0 c	5 de	12 c	28 ef
4	Aim (1 oz) Chateau (4 oz)	0.015 0.125	0 c	100 a	5 c	13 f
5	Aim (1 oz) +Chateau (4 oz) +Sinbar 9.6 oz	0.015 0.125 0.5	0 c	100 a	5 c	5 f
6	Aim (1 oz) + Linuron	0.015 1.0	0 c	22 cd	0 c	0 f
7	Sharpen (2 oz)	0.044	100 a	30 bc	10 c	62 cd
8	Sharpen (4 oz)	0.089	100 a	40 bc	7 c	88 abc
9	Aim (2 oz)	0.03	0 c	0 e	0 c	0 f
10	Sharpen (2 oz) +Sinbar	0.044 0.5	100 a	22 cd	10 c	45 de
11	Sharpen (2 oz) +Chateau	0.044 0.128	100 a	100 a	27 bc	95 ab
12	Sharpen (2 oz) +Sinbar +Chateau	0.044 0.5 0.128	100 a	100 a	47 ab	91 ab
13	Sharpen +Linuron	0.044 1.0	100 a	50 b	12 c	76 abc
14	Gramoxone	0.56	30 b	2 de	5 c	25 ef
15	Linuron +Gramoxone	1.0 0.56	40 b	35 bc	10 c	18 ef
16	Sinbar +Chateau +Gramoxone	0.5 0.128 0.56	36 b	100 a	24 bc	70 bcd
17	Sharpen (2 oz) +Sinbar +Chateau +Gramoxone	0.044 0.5 0.128 0.56	100 a	100 a	68 a	100 a
	LSD		27	21	29	28

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

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Any treatment that included Chateau provided excellent control of seedling groundsel.

Experiment One - Crop Injury

The mint stand in Experiment One was very thin. Some evaluations of crop injury were difficult due to the mint being so thin.

Aim did not cause any significant damage to the mint.

Although Linuron was not applied by itself, it did not appear to cause any additional damage to the mint.

Gramoxone caused slight damage to the mint early on, but did not cause any lasting damage.

Sharpen by itself and when added to other herbicides caused the most visible crop injury. The injury from Sharpen alone decreased quickly. When Sharpen was added to Chateau, the mint took longer to recover from the damage.

Sharpen at the rate of 2 oz/a and 4 oz/a initially caused some of the highest injury ratings to the mint. Doubling the Sharpen rate to 4 oz/a did not significantly increase the amount of crop injury. The mint did outgrow the crop injury from both rates of Sharpen.

When Sharpen was added to the standard mix of Sinbar, Chateau and Gramoxone, the initial amount of crop injury was significantly more. However, the actual crop injury was not much different than crop injury caused by Sharpen alone at the 2 oz/a rate. By May 18 this treatment still had the most visible crop injury. No further visual evaluations were made due to the weeds canopying in some plots and interfering with mint growth and evaluation of the mint.

Experiment Two - Crop Injury and Herbicide Efficacy.

In Northeast Oregon, catchweed bedstraw is a troublesome weed. Standard herbicide mixes do not usually control this weed. This small trial was done to determine if Sharpen and Aim were effective in controlling this weed when it was established.

The mint stand was very poor in this plot area but crop injury evaluations were made. The bedstraw was very thick and well established and was approximately one to two inches tall at the time the herbicides were applied on March 1, 2017.

The initial damage caused by Sharpen is similar to Gramoxone although Sharpen did continue to damage the mint longer than Gramoxone (Table 2).

Aim caused minor visible crop injury which was similar to Gramoxone. Even at the 4 oz/a rate the crop injury was not significantly different than at the 2 oz/a rate.

Sharpen and Aim appear to have some activity on bedstraw but are not effective enough to provide adequate control. It is puzzling that the amount of bedstraw control appeared to decrease when Sinbar was added to the Sharpen.

Objective Two

Experiment Three - Crop Tolerance

This trial was to determine the crop tolerance of dormant and non-dormant applications on established mint to Linuron, Sharpen and Gramoxone compared to a standard herbicide tank mix.

The previous two experiments were located in fields that had high levels of weeds. The site for Experiment Three was chosen because it had low weed pressure. Any weeds that appeared in this plot area were hand weeded. Although the mint stand was mostly consistent, the mint was very weak due to being eight years old in 2017. This weak mint was considered to be a good test for crop safety of these new herbicides.

The early or dormant set of treatments were supposed to be applied in February, but the snow was so deep that March 1 was the first day that the snow melted and the treatments could be applied.

The second set of treatments were applied on March 28. The mint buds had grown approximately ¼ inch by the time the March 28 applications were made and the mint was not dormant. Due to the cold wet spring, the mint had less growth on March 28 than it would have in a more normal year.

Fifty square feet of mint hay was harvested from each plot on July 20, 2017. This harvest date was a little earlier than normal for the La Grande area. By July, some areas of the plot area had died out due to weak stands. In some cases, more than one mint hay sample had to be taken from a single plot due to crop injury from die-back and irrigation wind skips. The die-back areas did not have anything to do with the herbicide applications, as they occurred in the untreated check plots as frequently as in the treated plots.

The amount of mint hay was light compared to other mint fields. This was due to the crop being harvested early and the mint growing slowly, due to age.

Sharpen applied at the high rate of 2 oz/a or the 2x rate of 4 oz/a caused visual crop injury similar to the standard treatment that included Sinbar, Chateau and Gramoxone at the early application date. At the late application date, Sharpen at both rates did cause

Table 2. Crop injury and weed control efficacy of dormant applied herbicides on established mint in the La Grande area. (Treatments applied 2-17-2017) (Fld. 893)

#	Treatment (Product)	lb ai/a	---------- % Crop Injury ----------			% Bedstraw Control
			3-27	4-24	5-26	5-26
1	UTC		0 c	0 c	0 b	0 e
2	Aim (1 oz/a)	0.015	4 bc	2 bc	0 b	60 bc
3	Sharpen (2 oz/a)	0.044	10 ab	10 a	1 b	42 cd
4	Aim (4 oz/a)	0.06	3 c	6 ab	1 b	77 ab
5	Gramoxone	0.56	5 bc	0 c	0 b	0 e
6	Sinbar (0.6 lb/a) +Chateau (4oz/a) +Gramoxone	0.5 0.128 0.56	14 a	10 a	4 a	98 a
7	Sinbar (0.6 lb/a) +Gramoxone	0.5 0.56	2 c	3 bc	0 b	7 e
8	Aim (1 oz/a) Sinbar (0.6 lb/a)	0.015 0.5	0 c 13 a	2 bc 2 bc	0 b 0 b	73 abc 25 e
9	Sharpen (2 oz) +Sinbar	0.044 0.5	13 a	2 bc	0 b	25 e
	LSD		5	5	2	31

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

significantly more damage than Linuron and Gramoxone but it caused less damage than the standard treatment. The damage from both rates of Sharpen decreased faster than the standard treatment.

Linuron did not cause any significant visual damage compared to the untreated check at the early or late application time.

The standard treatment (Sinbar + Chateau + Gramoxone) caused the most damage when applied on the late application date. Some visible damage was still present on the last observation date of June 13. There were no visible differences in the mint growth at the time of sampling the mint hay on July 20.

The application date of March 28 was clearly too late to be applied safely on the mint crop, however for research purposes this application was made to test a worst-case scenario. In addition, the early harvest should have shown any crop injury to be more apparent because the mint would have had less time to outgrow the injury. Visually the mint was able to outgrow the damage from all treatments even on this weak eight-year-old field. However, it would be unwise to apply any of these applications this late in the season.

There were little differences in the dry hay weight of the different treatments. Only the late application of Gramoxone was significantly different than the untreated check (Table 3). It is odd that the late application of Gramoxone had a greater dry weight than the UTC. This same treatment also had numerically the highest oil yield of any treatment, but it was not significantly different than the UTC. It is unlikely that there was any beneficial effect of the late applied Gramoxone. It is most likely that some random variation in the plots caused this increase in dry hay weight and oil yield.

Overall, there was no significant difference in the oil yields between any of the treatments compared to the UTC.

This is positive information showing that there was no significant yield loss on this old weak field, even when the treatments were applied after the mint had slightly broke dormancy.

These products appear be safe to use on mint in Northeast Oregon if used according to the label and applied to dormant mint.

It is speculated that the crop safety would be greatly reduced if these treatments were applied anywhere other than Northeast Oregon.

Although this experiment showed no significant differences in oil yields, there is still a trend for some of the treatments to reduce yield when applied late, especially when observing crop injury.

This research does not support using herbicides in ways that are not listed on the herbicide label. The late applications were clearly too late to be used even if Sharpen and Linuron were labeled for use in mint.

Conclusions

Aim herbicide appears safe on the mint even at a 2 oz/a rate.

Aim, when applied at 1 oz/a, by itself or when mixed with other herbicides, does not appear to provide any significant weed control except on catchweed bedstraw. The control of catchweed bedstraw with Aim is mediocre at best.

Table 3. Effects on dry hay weights and oil yields of dormant and non-dormant applied herbicides on established mint in the La Grande area. (Harvested 7-20)

#	Treatment (Product)	lb ai/a	App. date	Dry hay wt./sample (lbs)	Oil yield lbs/a
1	UTC			5.7 bc	65 ab
2	Sharpen (2 oz/a)	0.044	3-1	5.8 bc	63 ab
3	Sharpen (4 oz/a)	0.089	3-1	5.8 bc	64 ab
4	Linuron (2 lb/a)	1.0	3-1	5.9 abc	64 ab
5	Gramoxone	0.56	3-1	5.9 ab	64 ab
6	Sinbar (0.6 lb/a) +Chateau (4oz/a) +Gramoxone	0.5 0.128 0.56	3-1	5.7 bc	65 ab
7	Sharpen (2 oz/a)	0.044	3-28	5.6 bc	64 ab
8	Sharpen (4 oz/a)	0.089	3-28	5.4 c	61 b
9	Linuron (2 lb/a)	1.0	3-28	5.6 bc	63 b
10	Gramoxone	0.56	3-28	6.4 a	71 a
11	Sinbar (0.6 lb/a) +Chateau (4oz/a) +Gramoxone	0.5 0.128 0.56	3-28	5.6 ab	65 ab
	LSD			0.5	8

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

Linuron when applied at 1 lb ai/a appears safe on dormant mint.

Linuron at 1 lb ai/a has some activity on seedling groundsel but does not provide effective control by itself. It increased the control of prickly lettuce when it was mixed with Sharpen, but control was still inadequate. The cost of Linuron at approximately $45/lb. of product makes it nearly cost prohibitive when 2 lb/a of this 50 percent active product is needed.

Sharpen can be damaging to dormant mint even more than Gramoxone. Although the damage from Sharpen lasts longer than damage from Gramoxone, the mint still seems to outgrow the damage. Crop injury from a 2x rate (4 oz/a) of Sharpen does not appear significantly greater than the high rate of 2 oz/a.

Sharpen appears to have adequate crop safety if used when the crop is clearly dormant. It appears that Sharpen has more potential to cause crop injury than Gramoxone.

Sharpen was very effective on established groundsel in Experiment One and seems to have some slight activity on newly emerging groundsel seedlings but will not provide adequate control by itself.

Sharpen appears weak on controlling salsify and prickly lettuce. It has some activity on catchweed bedstraw but cannot adequately control it.

Sharpen does appear to be a good product to mix with Gramoxone as that Sharpen can control some weeds that Gramoxone can miss. The best treatment for weed control was the mix of Gramoxone + Chateau + Sinbar + Sharpen. This four-way mix also appeared to cause significantly more visible crop injury compared to the standard mix of Gramoxone + Chateau + Sinbar. This four-way mix was not tested for its effect on mint oil yields.

Electronic Mint Pest Alert Newsletter Regarding Control of Mint Root Borer, Cutworm Complex and Loopers (Year 4)

Clare Sullivan, Deschutes County Extension and Darrin Walenta, Union County Extension

The 2017 growing season marked the fourth year of distributing the Mint Pest Alert e-Newsletter to the mint industry across Oregon. This newsletter included information on larval insect development based on growing degree day (GDD) models and was created to assist growers and fieldmen as they considered control of mint root borers (MRB), cutworms and other loopers during the growing season. As in past years, region-specific e-Newsletters were sent out weekly from mid-June until the end of July to participants in the Willamette Valley, Central Oregon and Eastern Oregon. The e-Newsletter was developed 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 growing degree-day (GDD) information that will benefit those using traditional products like Orthene® and Lorsban Advance®.

Forecasting of MRB and variegated cutworm insect development was achieved using GDD models from the "IPM Pest and Plant Disease Models and Forecasting" software provided through OSU (http://uspest.org/dd/model). This information was used to alert growers and fieldmen about the timing of predicted life stages when control practices would be optimal (eg. Peak moth flight optimal control timing for MRB with Coragen®). Extension cooperators provided onsite confirmation of model accuracy in the Willamette Valley and Central Oregon using pheromone traps to monitor MRB adults and sweeps to scout for cutworm and other larval pests. Field monitoring activities were not conducted in the Grande Ronde Valley nor Baker Valley due to the lack of available technical support.

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

	Insect Development - average rating -		Use of Coragen® - average rating -	
Respondents	**Before**	**After**	**Before**	**After**
Mint grower	3	4.6	4	4.6
Crop consultant/scout	3.4	4.4	3.8	4.6
Total	**3.3***	**4.5**	**3.9****	**4.6**

* Knowledge level rating of insect development in 2016: Before=2.8, After=3.8

** Knowledge level rating of Coragen® use in 2016: Before=2.7, After=3.6

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

Respondents	Application timing	Product choice
Mint grower	3.8	4.3
Crop consultant/scout	3.4	2.7
Total*	**3.6**	**3.4**

* Influence rating in 2016: Application timing=3.3, Product choice=3.2

Based on moth trapping in the Willamette Valley, peak moth flight in single-cut fields (July 11-19) was slightly later than the predicted peak moth catch of the GDD model (July 10), and quite a bit later than the predicted peak moth catch in double-cut fields (July 25-August 3). The difference was likely because the double-cut field was first harvested near the end of June and it took some time for the insect population to build up after harvest. This suggests the current GDD model may not

be appropriate for double-cut fields. The timing of peak moth catch numbers in the Culver area matched quite closely with what the model predicted.

As in past years, a Qualtrics® survey was distributed to newsletter recipients in fall 2017 in the continued effort to gather feedback from the industry. Respondents rated the overall effectiveness of the 2017 e-Newsletter as 4.2 on a scale of 1 (not effective) to 5 (very effective) in achieving its educational goal (assisting grower/crop consultants in using degree-day models and specifically targeting use of Coragen® for MRB control of eggs and first instar). Growers rated the e-Newsletter effectiveness at 4.6 and fieldmen rated it at 3.9. The overall rating of 4.2 in 2017 was an increase from the rating of 3.5 in both 2015 and 2016.

When asked if the Mint Pest Alert e-Newsletter should continue as an ongoing project, 15 of 16 (94 percent) of respondents said "Yes," including 100 percent of the growers. Although the number of survey responses have been low, there has been extremely high support of the e-Newsletter continuing from all respondents since it started in 2014. Based on four years (2014-2017) of survey responses from the local mint industry, MRB remains one of the most serious insect pests of commercial peppermint in Oregon. In some growing regions, cutworms are considered an equally important pest, with the variegated cutworm being the most common and damaging species of the cutworm complex. Additional state-wide pests include loopers and armyworms.

We will continue to provide the Mint Pest Alert e-Newsletter in 2018 and will incorporate the recommendations from 2017 survey respondents where practical. We will make every effort to keep the information as concise as possible and will clearly indicate which insecticides are used for which pests. For the 2018 growing season, field monitoring will be conducted by Extension cooperators in Central Oregon and the Baker Valley of northeastern Oregon. It is unlikely that field monitoring will be possible in the Willamette Valley but the e-Newsletter will be distributed to Willamette Valley recipients.

If you have not been receiving the e-Newsletter and would like to sign up or you have any suggested improvements for the e-Newsletter, please contact Clare Sullivan: clare.sullivan@oregonstate.edu.

Sample Mint Pest Alert e-Newsletter

July 8, 2017

Mint Pest Alert Newsletter

- Willamette Valley -

Best Application Window Approaching

According to the degree day model, best application window for Coragen to control mint root borer (MRB) and variegated cutworm (VC) is ~July 10-15th.

MRB trap counts decreased from an average of 4 moths/trap on June 28 to 1.8 moths/trap on July 5. This was not expected as the **model's predicted peak moth catch is July 10th.** This highlights the importance of using the model in conjunction with your own scouting results.

While optimal application of **Coragen** is at peak moth catch, **adequate control should continue through peak egg laying.**

No VC larvae have been found in our sweeps. VC should be in the early instar stages and very difficult to see. Ideally **VC should be controlled before they start feeding heavily in their 4th instar stage (predicted to be mid-July).**

Oregon State University OSU Extension Service

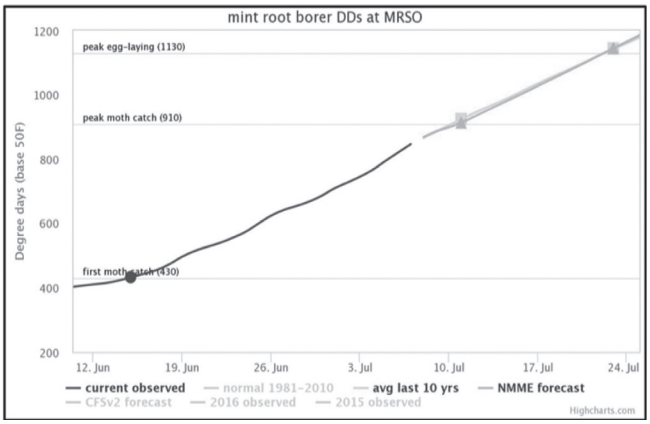
Feel free to contact Clare Sullivan: Clare.Sullivan@oregonstate.edu

OREGONmint

Sponsored by the Oregon Mint Commission

Mint Root Borer (MRB) Development – Culver & Madras

- Peak moth predicted to be July 11th - optimal application timing
- Window of opportunity to treat until July 23rd
  - Some data suggests adequate control through peak egg laying



OREGONmint COMMISSION

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

Tim Butler, OEOGL Chairman, Aumsville, Oregon

Plans are beginning for the 2019 Annual Convention. Be sure to mark your calendars. The dates will be January 10 & 11 at the Salishan Lodge and Golf Resort, Gleneden Beach, Oregon.

If you are interested in advertising in the 2019 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.

MARK YOUR CALENDARS

Make your plans to attend the
Oregon Mint Growers 2019 Annual Meeting.

JANUARY 10 & 11, 2019

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You'll hear the latest on the industry and receive pesticide recertification credit hours.

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