OREGON mint

UPDATE

Spring 2015

Effect of Biofumigation with AITC to Reduce *Verticillium* Wilt

Jeremiah Dung, Darrin Walenta and Jeness Scott, Oregon State University

Existing practices to reduce and manage *Verticillium* wilt in mint include the use of certified, disease-free planting materials, long rotations, propane flaming and pre-plant soil fumigation. Alternatives to pre-plant soil fumigation are needed due to increasing regulatory mandates and restrictions associated with fumigant use, their high economic cost, unforeseen availability in the future and potential environmental and human health risks. Green manure crops with biofumigant properties, specifically those which produce glucosinolate-derived compounds such as isothiocyanates, can suppress the growth of a broad range of weeds, bacteria, nematodes and fungi, including *Verticillium dahliae*. However, removing a field from production in order to grow a green manure crop is not always economically feasible. A broad-spectrum biopesticide containing 96.3 percent allyl isothiocyanate (AITC) was recently approved by the U.S. Environmental Protection Agency and offers the potential benefits of green manure crops without taking fields out of production. In addition, the product is expected to be approved for both conventional and organic farm systems. The objective of this research project is to determine the efficacy of different rates of AITC to reduce *V. dahliae* inoculum and *Verticillium* wilt symptoms in peppermint in the greenhouse. Two experiments, a growth chamber soil tube assay and a greenhouse bioassay, were conducted to address this objective.

Reducing Soilborne Inoculum with Allyl Isothiocyanate

A growth chamber assay was conducted to quantify the potential for AITC to reduce *V. dahliae* inoculum in field soils. Test tubes were filled with field soil collected from Central Oregon and autoclaved. Soils were then artificially infested with *V. dahliae* at rates of 10, 50 and 100 CFU/g or left non-infested. Infested soils were treated with 95 percent AITC at a rate of 0, 10, 20, 30 or 40 gal/acre. Test tubes were capped to simulate tarping and incubated in a growth chamber at 79°F day/50°F night. The number of *V. dahliae* CFU was determined for each soil tube after two weeks of incubation. Soil from each tube was then dried for two weeks and plated onto semi-selective medium.

Results from the soil tube assay experiment indicated that AITC was effective at reducing *V. dahliae* populations in field soils under laboratory conditions. *Verticillium dahliae* was not recovered from any soils treated with AITC at 10, 20, 30 and 40 gal/acre, but the pathogen was recovered from soils that were not treated with AITC (data not shown).

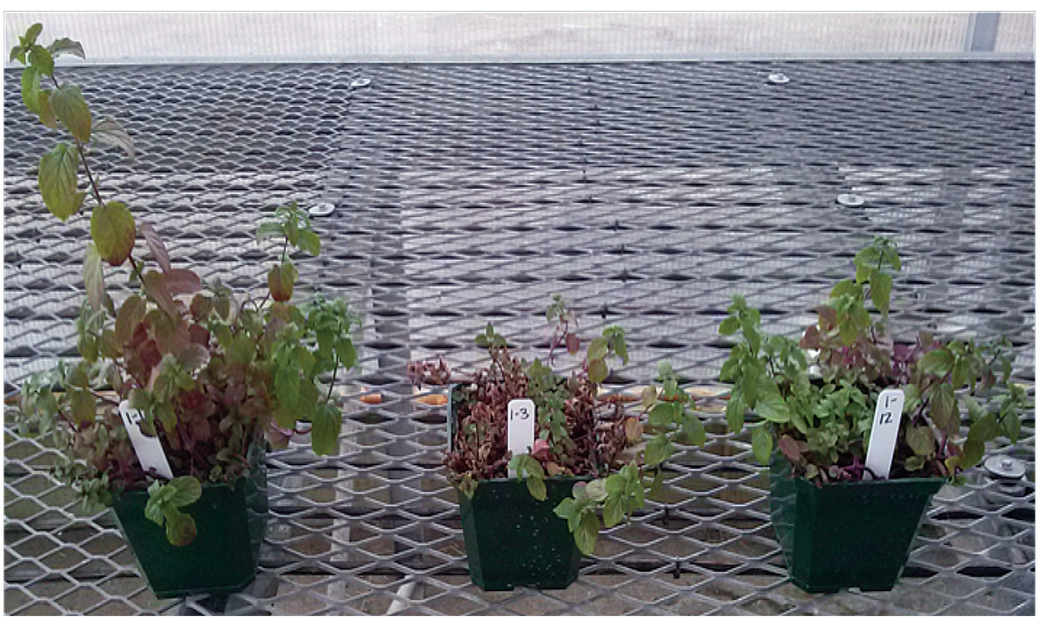

Figure 1. Black Mitcham peppermint plants planted in non-infested soil (left), soil infested with 20 CFU/cm^3 (middle) and soil infested with 20 CFU/cm^3 and treated with allyl isothiocyanate at 40 gal/acre (right).

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Table 1. Area under disease progress curve (AUDPC) and yield ratio values of Black Mitcham and M-83-7 peppermint after treatment with allyl isothiocyanate (AITC) in soils infested with *V. dahliae* at 0, 10 and 20 CFU/g soil

		Black Mitcham		M-83-7	
V. dahliae (CFU/g)	AITC (gal/acre)	AUDPC	Yield ratio	AUDPC	Yield ratio
0	**0**	0.0	1.00	0.0	1.00
0	**10**	0.0	0.92	0.0	1.07
0	**20**	0.0	0.96	0.0	1.23
0	**40**	0.0	0.91	0.0	1.16
10	**0**	71.8	0.79	6.1	0.88
10	**10**	20.1	0.89	17.5	1.19
10	**20**	22.8	1.08	30.6	0.90
10	**40**	34.1	0.91	13.1	1.08
20	**0**	82.3	0.78	17.5	0.87
20	**10**	44.6	0.83	6.1	1.23
20	**20**	28.0	0.86	12.3	1.00
20	**40**	30.6	0.92	8.8	1.09

Using Allyl Isothiocyanate to Reduce *Verticillium* Wilt Symptoms

A greenhouse bioassay was used to determine the impact of AITC treatment to reduce *Verticillium* wilt symptoms. Pots were filled with potting mix and infested with sand inoculated with *V. dahliae* isolate MT-96-1-4, which was shown to be aggressive on mint in a previous study. Pots were infested with *V. dahliae* at rates of 10 or 20 CFU/cm^3 of potting mix or were left as non-infested controls. Biofumigant treatments (AITC at 10, 20 and 40 gal/acre) or sterile distilled water controls were then applied as a drench. Pots were kept slightly moist and incubated in the greenhouse. After three weeks tissue-cultured plantlets of *Mentha* x *piperita* "Black Mitcham" (susceptible to *V. dahliae*) and *M.* x *piperita* M-83-7 (moderately resistant to *V. dahliae*) were transplanted to pots and maintained in the greenhouse. *Verticillium* wilt was evaluated at the onset of symptoms and approximately weekly thereafter using a disease severity index (DSI) where 0 = no symptoms and 6 = dead/nearly dead plant. Weekly DSI ratings were converted to area under disease progress curve (AUDPC) values. Dried aboveground plant mass was measured at the completion of the trial and yield ratios were calculated by dividing the dry aboveground plant mass by the mean of the non-inoculated and non-treated control treatment. A yield ratio < 1 indicated reduced yield relative to the control treatment.

Verticillium wilt symptoms were first observed between four and five weeks after transplanting peppermint into infested and treated soils (Fig. 1). Overall, symptoms were relatively mild and variable within treatments, with some plants exhibiting more severe symptoms than others. Black Mitcham peppermint exhibited significantly greater AUDPC values than the moderately resistant M-83-7 variety (Table 1). Although significant effects or interactions of *V. dahliae* inoculum level and AITC treatment on *Verticillium* wilt symptoms were not observed, non-treated Black Mitcham peppermint plants exposed to *V. dahliae* at either 10 or 20 CFU/cm^3 exhibited greater AUDPC values than all other treatment combinations (Table 1). *Verticillium* was not recovered from the stem sap of any plants, indicating low disease pressure overall. Yield ratios were only significantly different among cultivars but significant effects of AITC treatments and *V. dahliae* inoculum levels on yield were not observed.

Future Studies

Based on the promising results obtained in the soil tube assay but low disease pressure in the initial bioassay, additional greenhouse bioassays are currently underway using higher rates of *V. dahliae* inoculum and AITC at rates of 0, 10 and 40 gal/acre. Non-infested and non-treated controls are included for comparison. These studies are currently in progress.

Weed Control in Oregon Peppermint

Andrew Hulting, Kyle Roerig, Carol Mallory-Smith and Daniel Curtis
Department of Crop and Soil Science, Oregon State University

During the 2014 growing season three trials were conducted in Linn, Polk and Marion counties of western Oregon. All three of these studies were conducted with the cooperation of local mint growers on commercial mint fields. These trials focused on the use of pyroxasulfone (Zidua), pyroxasulfone + flumioxazin (Fierce) and saflufenacil (Sharpen). Many treatments discussed in this report are not registered for use in peppermint. For a current list of registered treatments refer to the Pacific Northwest Weed Management Handbook (http://pnwhandbooks.org/weed/).

Evaluation of Pyroxasulfone (Zidua-BASF) and Pyroxasulfone + Flumioxazin (Fierce-Valent) for Crop Safety and Weed Control in Peppermint.

A trial was established in Linn County to assess pyroxasulfone with possible tank mix partners at two timings as well as asulam (Asulox) in dormant, established mint (Table 1). At the first timing pyroxasulfone was applied with either paraquat (Gramoxone) or flumioxazin (Chateau). The second timing included treatments of pyroxasulfone with flumioxazin, carfentrazone (Aim) or saflufenacil (Sharpen). Both timings included one asulam treatment. Visual evaluations of weed control and crop injury were taken. Both timings of asulam were safe on the peppermint and resulted in poor to average control of the weed species present at the location. Treatments consisting of pyroxasulfone with flumioxazin and pyroxasulfone with saflufenacil resulted in the most crop injury, some of which was still evident when visual evaluations were made in late July. However, the addition of flumioxazin to the treatments improved prickly lettuce control compared to pyroxasulfone applied with paraquat. Pyroxasulfone applied with paraquat in mid-January resulted in no crop injury.

A second trial was conducted in Polk County to assess the use of pyroxasulfone in newly planted mint (Table 2). Pyroxasulfone was applied alone and with carfentrazone or saflufenacil in February and in April. Flumioxazin was not included in this trial because past research indicated that it is too injurious to newly planted peppermint. In

Table 1. Weed Control Efficacy and Peppermint Injury Resulting from Pyroxasulfone and Asulam Treatments in Dormant, Established Peppermint in 2014.

			Annual bluegrass[A]	Purslane speedwell[B]	Rough-stalk bluegrass[B]	Prickly lettuce[C]	Peppermint	
			Control				Injury[A]	Injury[C]
	lb ai/a	Appl.	%					
check			0	0	0	0	0	0
pyroxasulfone + paraquat	0.09 0.75	1/15/14 1/15/14	100	82.5	100	50	0	0
pyroxasulfone + flumioxazin	0.08 0.064	1/15/14 1/15/14	75	100	87.5	75	0	0
asulam	1.5	1/15/14	30.9	47.5	75	25	0	0
pyroxasulfone + flumioxazin	0.1 0.08	1/15/14 1/15/14	37.1	100	75	93.8	18.8	0
pyroxasulfone + flumioxazin	0.16 0.128	1/15/14 1/15/14	50	100	100	87.5	6.3	0
pyroxasulfone + flumioxazin	0.1 0.08	3/18/14 3/18/14	10.3	100	0	75	50	0
pyroxasulfone + flumioxazin	0.16 0.128	3/18/14 3/18/14	62.9	100	25	75	68.8	25
pyroxasulfone + carfentrazone	0.09 0.0156	3/18/14 3/18/14	38.5	87.5	37.5	75	62.5	0
pyroxasulfone + saflufenacil	0.09 0.0445	3/18/14 3/18/14	26.3	100	25	100	75	0
pyroxasulfone + saflufenacil	0.09 0.0223	3/18/14 3/18/14	85.4	70	25	87.5	75	12.5
asulam	1.5	3/18/14	3.8	22.5	25	87.5	0	0
LSD (P=.05)			35.58t	32.24	44.88	38.49	19.89	15.5

[A]Evaluated 4/11/14
[B]Evaluated 5/7/14
[C]Evaluated 7/22/14

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Table 2. Weed Control Efficacy and Peppermint Injury Resulting from Pyroxasulfone and Pyroxasulfone Tankmixes in Newly Planted Peppermint in 2014.

			Annual bluegrass[A]	Tall fescue[B]	Purslane speedwell[B]	Red sorrel[B]	Willowherb[B]	St.Johnswort[C]	Peppermint		
			---Control---						Injury[B]	Injury[C]	Fresh Yield[D]
	lb ai/a	Appl.	---%---								lb/a
check			0	0	0	0	0	0	0	0	17,026
pyroxasulfone	0.09	2/27[E]	96	94	100	90	100	100	0	0	18,496
pyroxasulfone + carfentrazone	0.09 0.0156	2/27 2/27	96	96	100	100	100	94	5	0	17,891
pyroxasulfone + saflufenacil	0.09 0.0223	2/27 2/27	98	95	100	100	100	100	34	0	15,644
pyroxasulfone + saflufenacil	0.09 0.0445	2/27 2/27	99	96	100	100	100	100	46	0	15,125
pyroxasulfone	0.09	4/14[F]	0	41	35	38	25	50	0	0	15,816
pyroxasulfone + carfentrazone	0.09 0.0156	4/14 4/14	10	45	100	75	50	44	0	0	13,829
pyroxasulfone + saflufenacil	0.09 0.0223	4/14 4/14	20	48	100	100	88	100	31	0	15,903
pyroxasulfone + saflufenacil	0.09 0.0445	4/14 4/14	15	48	100	100	100	81	41	0	16,767
LSD (P=.05)			6	7	12	27	27	35	15	0	3,736

[A]Evaluated 4/29/14
[B]Evaluated 6/5/14
[C]Evaluated 7/24/14
[D]Harvested 8/14/14
[E]Applied to 0-1″ mint
[F]Applied to 0.5-3″ mint

general, the earlier application timing resulted in better weed control than the later timing. Pyroxasulfone applied alone and pyroxasulfone applied with carfentrazone resulted in little or no peppermint injury. Pyroxasulfone applied with saflufenacil resulted in 30-40 percent injury to the peppermint when evaluated in June but this injury was not noted at the July evaluation. Pyroxasulfone appears to be a useful tool for weed control in newly-planted mint.

Evaluation of Herbicides for Crop Safety and Weed Control in Double Cut Peppermint.

A trial to evaluate potential herbicides for use in double cut peppermint was established immediately following harvest of a second year field in Marion County (Table 3). Pyroxasulfone, pyroxasulfone + flumioxazin, sulfentrazone, flumioxazin, terbacil (Sinbar), saflufenacil and pendimethalin (Prowl H_2O) were applied July 1. Plots treated with flumioxazin showed signs of injury two weeks after application, but one month later this injury was no longer visible. No injury was visible in any treatment at the September evaluation. The plots were harvested in mid-September and oil yields quantified. All treatments, except for flumioxazin applied alone, resulted in significantly higher oil yields compared to the untreated check.

Table 3. Peppermint Injury and Oil Yield Resulting from Herbicides Applied Following Initial Harvest in Double Cut Peppermint in 2014.

		Peppermint		
		Injury[A]	Injury[B]	Oil Yeild[C]
	lb ai/a	---%---		lb/a
check		0	0	45.5
pyroxasulfone	0.09	0	0	65.23
pyroxasulfone	0.18	0	0	62.0
pyroxasulfone + flumioxazin	0.08 0.064	12.5	0	60.63
pyroxasulfone + flumioxazin	0.1 0.08	16.3	0	61.93
sulfentrazone	0.188	0	0	59.93
flumioxazin	0.128	6.3	0	53.4
terbacil	1.2	0	0	60.75
saflufenacil	0.0445	0	0	59.58
pendamethalin	1.5	2.5	0	55.18
LSD (P=.05)		5.58	0	8.828

[A]Evaluated 7/15/14
[B]Evaluated 9/4/14
[C]Harvested 9/12/14

Next Steps for Biological Control of Field Bindweed in Peppermint

Jessica Green, Carol Mallory-Smith, Ed Peachey, Oregon State University and Rick Boydston, USDA-ARS, Prosser, WA

Tyta luctuosa is a known defoliator of field bindweed and readily consumes foliage in laboratory settings. Larvae are highly host specific and will complete development only on field bindweed, *Convolvulus arvensis*. Since 1980 the moth was field released as a biological control agent (BCA) in western states including Washington and Oregon. However, the lack of data regarding efficacy and establishment success continues to hinder adoption of this biological weed control program. Traditional sampling techniques (visual scouting, light traps) are time consuming and ineffective due to the cryptic, diurnal nature of larvae and adults. Therefore, a field-based pheromone trapping program was implemented throughout Oregon and in eastern Washington to assess the current range and status of the field bindweed moth. Paper wing traps, baited with a semiochemical lure, were placed at 22 locations where larvae had been released by our research team in prior years. With the exception of a wildlife refuge, most releases were made in or near cropland. Specifically, we focused efforts on perennial crops such as mint and small fruits. Trapping began in late May and continued throughout September and traps were checked bi-weekly. A few additional sites were monitored as control points, where no intentional release of the BCA had been made. Very few moths have been detected east of the Cascades, but in the Willamette Valley adult male moths were recovered from 80 percent of locations where larvae had been previously released, indicating successful establishment. Detection of the bindweed moth in this region is one of less than five published accounts of establishment in the U.S.

Now that we are sure the moth can overwinter in the Pacific Northwest, the next challenge is to explore ways to focus feeding by the moth where it is needed most (Figure 1). In other words, to mitigate crop loss we need the insect to be active within mint fields where bindweed interferes with production and reduces oil yield and quality.

In 2014, we released larvae of the bindweed moth near mint fields. At each site 200 larvae were distributed on patches of field bindweed growing next to or near the crop. This season we will return to each site to see if adult moths are present. Additionally, we will use pheromone traps to try to attract adults into mint fields in mint. Although the individual components of the pheromone lure are common, the ratio is highly specific and, therefore, will not attract other insects. Within the crop patches of bindweed will be flagged and evaluated for signs of feeding, egg laying, etc. We also will be conducting laboratory research to determine how and why the moth is attracted to field bindweed. Over the next year we will continue to learn more about the potential and efficacy of the moth for field bindweed control in a variety of crops.

Figure 1. Field bindweed is a common and persistent problem in mint. Releases of a defoliating moth larvae in perimeter patches such as the one shown here may help reduce weed pressure within the crop. For more information or to have larvae released at your field, contact Jessica.Green@oregonstate.edu.

Managing Mint Pests with eCommunication Tools

Marvin Butler, Central Oregon Agricultural Research Center (COARC)

Pest Control Prior to Damage

Mint root borer is one of the more serious insect pests of commercial peppermint in the Pacific Northwest. In some regions cutworms are considered an equally important pest, with the variegated cutworm being the most common species causing the most crop and economic damage. Additional pests include loopers and armyworms.

Coragen® provides a new approach to control these insect pests prior to crop damage in an environmentally friendly manner. The traditional approach for mint root borer control has been to apply Lorsban Advance® in the fall which requires irrigation to move the product into the soil for larval control. In contrast, Coragen® provides control of eggs and first instar larvae feeding on foliage prior to dropping to the ground to enter the rhizomes. The life cycles of these pests, based on developmental models, offer a window of opportunity to provide control of more than one target pest with a single application of the new insecticide.

Thinking Differently

This new application timing strategy timed earlier in the growing season, for mint root borer in particular, provides an opportunity for growers and industry representatives to consider application timing for control of mint root borers, cutworms and loopers before the pests cause damage during the growing season. The objective of this project was to provide an electronic Pest Alert Newsletter to assist growers, fieldmen and industry representatives in maximizing effectiveness of Coragen® application for control of mint root borer eggs and larvae, cutworms and loopers in peppermint production areas throughout Oregon.

eCommunication Tool

Similar, but separate, electronic Mint Pest Alert Newsletters were developed for the three regions; Willamette Valley, northeastern Oregon and Central Oregon. An email contact list was created that included recent Oregon mint growers who paid the mint assessment for whom we had email addresses and fieldmen for each region. Weather stations were identified to represent each production region and we utilized temperature data from those stations to generate insect pest degree day development models. These included: Corvallis (Willamette Valley), Imbler and Baker Valley (N.E. OR), Madras and Powell Butte (Central Oregon). Cooperators on the project were Darrin Walenta (Union Co.), Nicole Anderson (N. Willamette Valley), Clare Sullivan (S. Willamette Valley) and Katie Ralls (COARC) in addition to the involvement of Ralph Berry, Entomology Professor Emeritus.

eNewsletter Implementation

Degree day development models for mint root borer and variegated cutworm were run weekly from June 27 through July 25 and August 29 through September 5, with results provided through the week to growers and industry representatives. Representative cooperators provided onsite scouting activity to confirm model accuracy for each region. There was a general consensus from data across regions that the insect development models are reliable. A newsletter user survey was developed to assess how the Pest Alert Newsletter affected grower and fieldmen knowledge and pest management decisions, as well as to identify areas of newsletter strengths and obtain recommendations for improvement.

Positive Grower & Industry Response

The newsletter was sent to 88 people throughout the season and 30 responded to the survey, either by phone or via online. Ninety-one percent rated the newsletter as useful, with 43 percent saying "very useful" and 48 percent "somewhat useful." The preferred way for growers to get information was through field representatives (57 percent) compared to relying on themselves (24 percent). The vast majority of respondents appreciated receiving the newsletter and indicated their knowledge of the subject matter increased as a result. In general, comments by respondents indicated that they liked receiving information via the electronic newsletter in addition to relying on their fieldmen for onsite recommendations.

Sign Up for Mint Pest Alert Newsletter

To add your name to the newsletter list, provide your email to Katie Ralls at: Katie.ralls@oregonstate.edu, call 541-475-7107 (COARC) or send to COARC, 850 NW Dogwood Lane, Madras, OR 97741.

The Mint Varietal Improvement Project

Mark Lange, Washington State University, Kelly Vining, Oregon State University
Brian Dilkes, Purdue University

Background

The U.S. mint industry has faced a rolling challenge by *Verticillium* wilt, compounded by foreign production of lower-cost, lower-quality oils. Because peppermint is a clonally propagated species, no plant breeding has been possible and the only response to *Verticillium* spore buildup has been the migration of the site of production to the west and an alteration to the regional context of mint production. The mint varietal improvement project seeks to generate plant materials and genetic data that will allow continual improvement of mint crops for disease resistance as well as high oil yield and quality. The ultimate goal of this work is a sexually reproducing mint that permits the application of both molecular and classical plant breeding techniques for the sustainable and continuous improvement of mint varieties.

Generation of the Mint Genetic Blueprint

An understanding of the genome structure and gene content of cultivated mint is required for directed and successful genetic improvement of the crop. Peppermint (*Mentha* x *piperita*) is partially derived from water mint (*M. aquatica*), horse mint (*M. longifolia*) and apple mint (*M. suaveolens*), the latter of which are shared with spearmint (*M. spicata*). The Dilkes laboratory determined the genome copy numbers of more than 70 mint accessions and demonstrated that it is possible to produce hybrids at one copy number and then double the size of the genomes, thereby restoring fertility. These are the ingredients necessary to begin reconstructing the appropriate alleles in sexual mint species and to manipulate mint genomes to produce new high oil yielding hybrids.

To accurately identify all genetic loci with potential relevance for *Verticillium* resistance and oil quality, we need to obtain the sequences of each of the subgenomes present in peppermint. The Vining and Lange laboratories collaborated to obtain a draft genome sequence of horse mint, assembled short stretches of DNA into longer, contiguous stretches of DNA ("contigs"), determined the location and structure of genes and linked these genes with putative functions ("annotation"). The gold standard for ordering the contigs in a draft genome is accomplished by creating a genetic map. Such a map greatly increases the efficiency with which we can select valuable traits and utilize molecular markers for selective breeding. The Vining lab generated a segregating population (called SAF2), which is now being subjected to genetic mapping (Vining), gene expression profiling of the specialized cells that synthesize the essential oil (Dilkes) and comprehensive oil analyses (Lange). From these data we then determine which parts of the genome are linked, and in what order. The mint genetic map can then be used to improve the assembly of the draft genome as well as to determine gene orders. In addition, any data we have about the phenotypes of each of the plants in the SAF2 population, which is segregating for *Verticillium* wilt resistance, oil quality and plant growth, can be combined with the genetic marker data to determine the locations

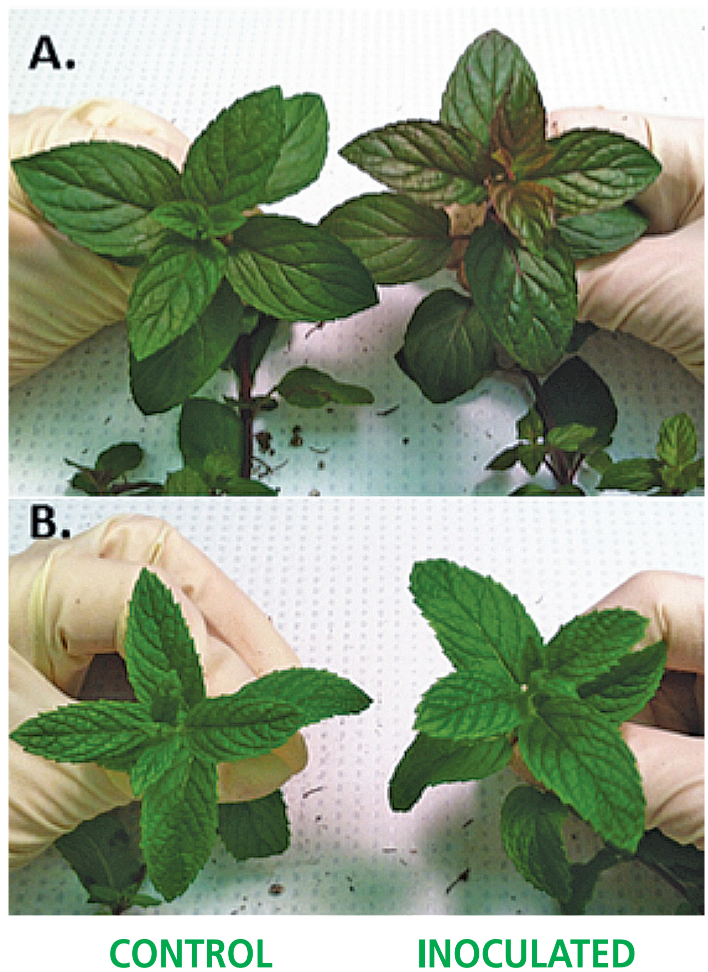

Figure 1. Control (left) and *Verticillium*-challenged (right) mints 20 days post-inoculation. Gene expression samples were taken at the 10-day and 20-day time points. A. Black Mitcham peppermint. B. Native spearmint.

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in the genome that alter each of these phenotypes. This will provide the first set of molecular markers linked to agronomic, disease resistance and oil quality traits in mint.

Gene expression profiling of the wilt-resistant and wilt-susceptible *M. longifolia* parents of the SAF2 population, as well as wilt-susceptible Black Mitcham peppermint and wilt-resistant Native spearmint (Figure 1), are underway in the Vining lab. Gene expression comparisons between samples with and without *Verticillium* inoculation will provide further insights into how many genes are activated in response to *Verticillium* challenge.

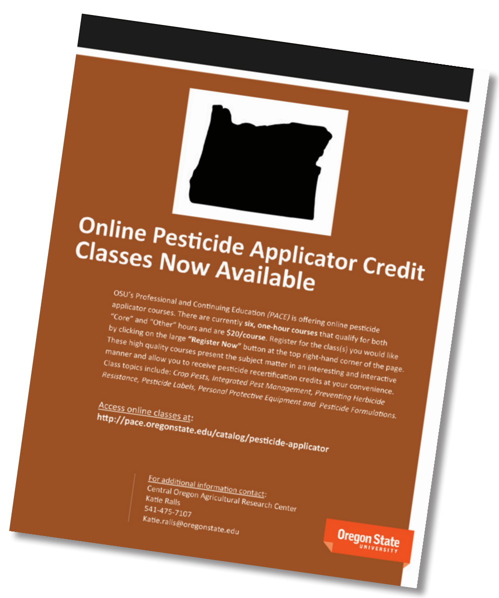
Surveying Genetic Diversity of Mint and Generating a New Hybrid Generation

The Dilkes laboratory is currently sequencing all genes expressed in the essential oil-synthesizing cells of 48 sexually reproducing mint accessions. The same accessions are assessed for their essential oil composition by the Lange laboratory. The variation in DNA sequences for each gene (single nucleotide polymorphisms and insertions/deletions) is being catalogued for each gene and accession. We are also testing whether the expression level of a particular gene (and thus the essential oil composition) is predictable by the sequence differences contained within the mint accessions. This information will be used to prioritize which crosses to make the first round of hybrids and which crosses to make to begin to collect the best set of alleles into a limited number of initial accessions. The most important goal of this will be to identify the sexually reproducing species that have the same alleles of the critical mint oil biosynthetic enzymes that are also found in the Black Mitcham cultivar of peppermint.

Crosses between mint species are known to work efficiently only when genome copy numbers are at correct levels. To prepare for this objective, the Dilkes laboratory determined the genome copy numbers of over 70 mint accessions. We are now inducing flowering in, and determining the fertility of, mint accessions of known genome copy numbers to provide a sexually-fertile germplasm collection. As new hybrids are generated they can be screened for genetic polymorphisms associated with the mint oil biosynthetic. Crosses will be made between species as well as within species in an effort to shuffle genotypes between existing USDA accessions. Novel hybrids will be measured for morphological phenotypes, *Verticillium* resistance and essential oil yield/composition. Plants with desirable properties will then be prepared for future field testing.

Online Pesticide Applicator Credit Classes Now Available

During this time of year Oregon growers are thinking about pesticide recertification credit. The Professional and Continuing Education (PACE) unit at Oregon State University offers online pesticide applicator courses. There are currently six one-hour courses that qualify for both Core and Other hours: Crop Pests, Integrated Pest Management, Preventing Herbicide Resistance, Pesticide Labels & Formulations, Personal Protective Equipment and Pesticide Formulations for Increased Safety and Efficacy. These courses are accessible at: pace.oregonstate.edu/catalog/pesticide-applicator. The cost for these one-hour courses is $20 each. Register by clicking on the large "Register Now" button at the top right-hand corner of the page after you have made your class choice. While onsite courses continue to be provided throughout the state, online classes provide another option for the agricultural community to meet continuing education requirements when convenient or needed.



Effects of Applying Varying Amounts of Mint Slugs on Established Mint in Northeast Oregon

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

This research investigates if there are any negative or positive results of applying fresh mint slugs to live mint fields after harvest. It also investigates the best time and rate of mint slugs to apply.

Objective

Measure any effects on weed control, pests, diseases and mint growth from applying different amounts of mint slugs, at different times, to established mint in the La Grande area.

Materials and Methods

Four trials were established in four grower fields in the La Grande area. Plots were 18' x 20' in size and replicated four times. The mint slugs were applied after the 2013 harvest. In addition, more mint slugs were applied in the fall of 2014 to different plots, which are next to the original plots. The following treatments were applied:

1. Untreated check (No mint slugs).
2. Early application of mint slugs at a medium rate (1 inch) September 2 and 19, 2013.
3. Early application of mint slugs at a high rate (2 inches) September 2 and 19, 2013.
4. Late application of mint slugs at a low rate (0.5 inch) November 8 and 12, 2013.
5. Late application of mint slugs at a medium rate (1 inch) November 8 and 12, 2013.
6. Early application of mint slugs at a low rate (0.5 inch) September 6 and 10, 2014.
7. Early application of mint slugs at a medium rate (1 inch) September 6 and 10, 2014.
8. Late application of mint slugs at a low rate (0.5 inch) October 31 and November 6, 2014.
9. Late application of mint slugs at a medium rate (1 inch) October 31 and November 6, 2014.

Mint slugs were applied by measuring the volume of mint slugs needed to cover the entire plot area with the correct rate of mint slugs. Mint slugs were spread evenly by hand.

Results

Observations made in October of 2013 found that two inches of mint slugs was likely too much and was going to smother the mint so the rate of mint slugs for the late application was reduced.

New mint growth was observed under the early application of mint slugs in October of 2013, but no new growth appeared under the mint slugs of the late applications. This new growth under the early applications proved to be detrimental to the mint stand and growth in the spring and summer of 2014.

No meaningful data was collected from Experiment Two due to flooding.

The following observations and results were gathered from the remaining three experiments:

In the spring of 2014, both rates of the early applications were very damaging to the mint stand and growth in all three of the experiments. The mint in Experiments Three and Four mostly outgrew the damage from the early applications while the mint in Experiment One never did recover.

In the spring and summer of 2014, Experiment One had both of the late application rates providing earlier and more vigorous mint growth compared to the untreated check. This extra vigor appeared to fade during the season, but this was because the mint lodged and the extra growth was not so noticeable. At harvest time both late applications in Experiment One had more growth compared to the untreated check (Table 1).

Experiments Three and Four had little to no increases of vigor or growth from the late applications of mint slugs in the spring and summer of 2014. However, in October of 2014 there was slightly more re-growth from all the slug treatments in Experiments One and Three. It appeared that the mint slugs were still breaking down and releasing nutrients that were aiding in the mint growth compared to the untreated check.

Experiment Four did not have any clear increase in fall re-growth from the treatments. The stand seemed uneven and did not lend to visually determining differences in re-growth.

It is unknown how much the different soil types affected the results of the experiments. By visual observation, it appeared that the soil in Experiment One (Catherine silt loam) might have been more deficient in nutrients than the soil of the other three experiments. All experiments had the growers apply their normal fertilizer applications over the plot areas. The main nutrients from the mint slugs would have been nitrogen and potassium. It is speculated that it may have been the potassium that helped the mint grow better, because the grower would have applied adequate amounts of nitrogen but may not have applied very much potassium. The nutritional value of mint slugs has been documented to contain approximately 180 lbs. of nitrogen and 200 lbs. of potassium per acre of harvested mint hay.

There were no noticeable differences in weed control or diseases between any of the treatments and the untreated check.

In late May of 2014, there was a high level of spider mites infesting the field that Experiment One was in. In this experiment

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the extra growth and vigor of the mint in the late application treatments reduced the amount of spider mite damage compared to the untreated check. The grower eventually controlled the spider mites and there was no apparent lasting effect of the reduced damage by the spider mites.

There were no other noticeable differences in insect or mite pests in Experiments Three or Four compared to the untreated check.

Table 1 - Average mint hay dry weight per 50 sq. ft
Sampled between August 11 and 14, 2014

Treatments	Mean lbs of dry mint hay per 50 sq. ft.		
	Experiment 1	Experiment 3	Experiment 4
UTC	7.2 c	7.3 b	8.2
Early, low rate	3.3 b	7.4 b	8.5
Early, high rate	0 a	2.3 a	8.2
Late low rate	9.2 d	7.3 b	8.7
Late high rate	10.0 d	7.4 b	8.0
LSD	1.7	1.5	NS

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

Between August 11 and 14, 50 sq. ft. of mint hay was cut from every plot and air-dried. The dry hay weights were averaged to assess the total hay dry weight of each treatment (Table 1). No oil yields were taken. The increase in hay weight does not necessarily equate to increased oil yields, but it is likely that the yields would be increased when there is significantly more mint hay grown.

The early applications were very detrimental to the hay weight in Experiment One. The early high rate in experiment three significantly reduced the hay weight while there was no effect on the hay weight in experiment four.

Both rates of mint slugs applied late on Experiment One significantly increased the hay weight, while there was no significant effect in Experiments Three and Four.

Summary

The early applications of mint slugs were generally detrimental to the mint growth with the high rate (2 inches) being very detrimental and the medium rate (1 inch) sometimes being detrimental.

Generally the mint outgrew the damage from the early, low rate of mint slugs with no lasting effects.

The late applications of mint slugs were apparently beneficial in one of the experiments but had no positive or negative effect in the other two experiments.

The late applications of 1 or 0.5 inch of mint slugs was determined to be beneficial in one experiment by significantly increasing the stem length and increasing the dry hay weight compared to the untreated check.

It appears that by applying mint slugs to less vigorous mint fields in early November that mint growth can be increased. Increased nutrient levels appear to benefit the mint growth, after mint harvest, approximately one year after being applied.

The application of mint slugs in early November to young, vigorous mint fields generally appears to have no negative or positive effect in the first year, but may contribute some nutrients to the mint the second year.

The increased vigor from the late mint slug applications helped to temporarily reduce mite damage in one experiment.

There were no detrimental effects to the mint from insects, mites, weeds or diseases.

A second year of data will be collected from both the fall 2013 and fall 2014 mint slug applications.

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Moving the Industry Forward

MIRC's New Coordinator At Home in His Role

Steve Salisbury wasn't born or raised on a farm. But Salisbury, the new research and regulatory coordinator of the Mint Industry Research Council, who grew up in Harrisburg, Oregon, found early in life that farming was something he could get behind.

"I always liked the farms and working on farms," Salisbury said.

Science was another discipline that Salisbury found intriguing. While in college, he decided to merge his two interests, eventually earning a master's degree in soil science from Oregon State University.

While at OSU, Salisbury also started specializing in agronomy, a discipline that takes into account several agricultural disciplines.

"What I like about agronomy is it is not focused on just one thing," he said. "It is not just weed science. It is not just soil fertility and plant nutrition. It is not just insects or diseases. It is the whole thing.

"Then you roll in the business side, and to me it is just fascinating," he said.

Salisbury brings a high degree of experience to his position at the MIRC and that experience showed early in his participation in the IR-4 Project, a program critical to the success of mint producers. Most of the crop protection products in use today in mint were registered with the help of data provided by the project, Salisbury said.

Jerry Baron, executive director of the IR-4 Project, which is based in Rutgers, New Jersey, said he was very impressed with the way Salisbury fit into the organization, immediately assuming a position on the project's Commodity Liaison Committee.

"For many years, (former MIRC Chair) Rocky Lundy had served as the IR-4 Commodity Liaison Committee chair … and we were very pleased that his replacement, Steve Salisbury, came out to our meeting this spring and very rapidly became fully engaged in the committee," Baron said.

"We were very pleased that Steve hit the ground running and was so active in his first meeting with IR-4," Baron said.

While at the Commodity Liaison Committee meeting in Washington, D.C., March 4 and 5, Salisbury spent one day working with other committee members on prioritizing projects and one day lobbying lawmakers on Capitol Hill as part of an effort to obtain a boost in federal funding for IR-4.

"Basically, the message we were trying to convey to senators and representatives is that because EPA is asking for more data, more science to back the registration of crop protection products, IR-4 has to generate more science and that takes a whole lot more money," Salisbury said.

Steve Salisbury

Salisbury started in agriculture as an extension agent in Twin Falls, Idaho, working in alfalfa, field corn, dry beans, wheat, malt barley, sugar beets and potatoes. He next worked for seven years as a field agronomist and branch manager for Wilbur-Ellis in Shedd, Oregon.

With his experience in university and private settings, Salisbury has the rare combination that can provide big dividends for the Oregon mint industry, said Bryan Ostlund, administrator of the Oregon Mint Commission.

"There are three facets you need in a person to fill his position," Ostlund said. "One is experience with the science: understanding the chemistry, the agronomy. Two is understanding the growers in Oregon. And the third piece is the communication piece. You need to speak the grower language and also work with our university partners in production.

"Steve has all of those elements," Ostlund said.

Salisbury, who was hired by MIRC in May of 2014, said he has spent most of his first year visiting with growers and researchers. As part of his work, he has put researchers in touch with one another to help avoid duplication of efforts in an attempt to facilitate better production and cooperation by researchers.

Salisbury, for example, put Rick Boydston of the USDA Agricultural Research Service in Prosser, Washington, in touch with California Farm Advisor Rob Wilson and Oregon State University weed scientists Carol Mallory-Smith and Andy Hulting to try and get them to coordinate their research.

The scientists, who had never before worked together on a weed research project for mint, presented a joint proposal to the MIRC for pursuing registration of pyroxasulfone in mint at the MIRC's January meeting in Las Vegas.

Salisbury also has connected with Steve Weller of Purdue University and Jed Colquhoun of the University of Wisconsin, who also are researching the use of pyroxasulfone in mint. And Boydston is sharing trial protocol with Weller in the hopes of getting Indiana data to add to the pool.

Sold as Zidua by BASF, pryroxasulfone is recognized as one of the top new herbicides to come down the pike in recent years. It

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provides excellent pre-emergence control of broadleaf weeds and grass plants, Salisbury said, and could provide mint growers a valuable new tool in their weed-control arsenal.

With scientists in five states researching its efficacy in mint, the chances that BASF will support the mint label improve dramatically, Salisbury said.

"The more efficacy data we can submit to BASF, the more likely that BASF will support the label," Salisbury said.

Also last year, Salisbury discovered that Oregon State University plant pathologist Jeremiah Dung was looking into the use of biofumigants for *Verticillium* wilt control in mint. Being familiar with the work University of Idaho nematologist Saad Hafez has done with biofumigants, Salisbury asked Dung if he'd talked to Hafez. Dung said he had never heard of him. Salisbury put the two in contact and they now are sharing information.

"It's good because now Jeremiah doesn't have to reinvent the wheel, so to speak," Salisbury said.

In a nutshell, Salisbury said he views his responsibilities as "taking care of people, listening to them, and when you see an opportunity to address an issue, getting it done."

Salisbury asks growers and end users to contact him at 503-551-3747 if they have questions or suggestions for possible research proposals.

"My goal is to bring everybody together on a positive note," Salisbury said, "and make sure we're moving forward together."

This publication is available in alternative formats upon request.

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