OREGON MINT COMMISSION

UPDATE

Spring 2012

Weed Control in Peppermint in Oregon

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This research was conducted to provide peppermint growers and agribusiness personnel with the most current information available on weed management in peppermint production. Specifically, the objectives of our weed management program are to develop new weed control options for peppermint production and to provide data that can be used by growers to make informed decisions on new technology. Data from these trials are used to support the future registration of herbicides for use in peppermint production. Not all treatments discussed in this report are currently registered for use in peppermint. Refer to the Pacific Northwest Weed Management Handbook (http://pnwhandbooks.org/weed/) for a current list of registered products for use in peppermint.

MCPB-based Tank Mix Combinations for Common Groundsel Control in Non-dormant Peppermint

MCPB is the best tool currently available for management of field bindweed and broadens the weed control spectrum of herbicides such as terbacil (Sinbar), bentazon (Basagran) and bromoxynil (Buctril) in non-dormant peppermint. Previous research indicated MCPB-based tank mix treatments and MCPB applied alone were safe on non-dormant peppermint. A study was established near Junction City, Oregon to further evaluate the efficacy of tank mixes and to quantify the impact of the tank mixes on peppermint injury. Treatments were applied to 14-18 inch tall peppermint. The most common weed at the study site was common groundsel. The common groundsel was the same height as the peppermint and starting to flower at the time of the herbicide applications. Visual ratings of peppermint injury and weed control efficacy, along with yield, are presented in Table 1. Peppermint injury varied among treatments and ranged from 0-35 percent at the end of June. While initial visible injury was quite dramatic as a result of some of the treatments, little injury was apparent at harvest nor did the treatments cause significant losses in yield. The bentazon (Basagran) + bromoxynil (Buctril) treatment provided the best control of common groundsel. The fluroxypyr-florasulam (Starane Flex) treatment also provided good control, but the treatment caused the most peppermint injury and is not currently labeled for use in peppermint.

Crop Safety with Carfentrazone

Carfentrazone (Aim or Shark) is a contact herbicide with no soil residual properties, which effectively controls broadleaf weeds when applied to small weeds (less than 2-4 inches). Our past research indicates that crop safety and weed control efficacy with carfentrazone can be variable depending on the timing of the application. Two studies were established in southern Benton County, Oregon to determine the range of application timings that maximize weed control and crop safety. Carfentrazone applications were made from February through June. Visual ratings of peppermint injury and weed control efficacy were completed. The carfentrazone treatments resulted in varying levels of peppermint injury. Substantial injury

Table 1. Tank Mixes for Control of Common Groundsel in Non-Dormant Peppermint, Junction City, OR, 2011

Herbicide[1]	Rate	Groundsel Control	Peppermint Injury	Peppermint Oil Yield
	lb ai/A	---------------%	--------------	lb/A
Check		0	0	69
MCPB	0.375	13	6	68
MCPB + terbacil	0.375 0.8	5	9	65
MCPB + bromoxynil	0.375 0.25	38	6	81
MCPB + carfentrazone	0.375 0.015	5	33	63
MCPB + bentazon	0.375 0.75	43	8	81
MCPB + fluroxypyr-florasulam	0.375 0.092	85	33	67
bentazon	0.75	38	1	81
bentazon + terbacil	0.75	43	1	75
bentazon + bromoxynil	0.75 0.25	95	3	78
bentazon + carfentrazone	0.75 0.25	5	35	76
fluroxypyr-florasulam	0.092	80	30	60
LSD (P=0.05)				NS
CV				16

[1]*Applied 6/8/2011, 14-18 inch peppermint*

Table 2. Tolerance of Peppermint to Carfentrazone, Junction City, OR, 2011

Herbicide	Rate	Date	Peppermint Injury 5/2	Peppermint Injury 5/31	Peppermint Injury 6/27	Peppermint Oil Yield
	lb ai/A		-----------------------------	%	-----------------------------	lb/A
check			0.0	0.0	0.0	52.2
carfentrazone	0.015	2/2[a]	0.0	0.0	0.0	44.4
carfentrazone	0.015	3/22[b]	10.0	0.0	0.0	51.6
carfentrazone	0.015	4/19[c]	12.5	7.5	0.0	55.5
carfentrazone	0.015	5/19[d]	-	30.0	5.0	55.7
carfentrazone	0.015	6/16[e]	-	-	30.0	47.2
LSD (P=0.05)					NS	NS
CV					16.0	21.0

[a]Dormant peppermint; [b]1/4 - 1/2 inch peppermint; [c]4 inch peppermint; [d]8 inch peppermint; [e]18 inch peppermint

was apparent the week following application, but the peppermint recovered quickly and the injury was not apparent several weeks following the application. Peppermint injury ratings and yield results from these trials are presented in Tables 2 and 3. No significant yield reductions were quantified at the Junction City site. However, there was a trend towards lower peppermint oil yield following both the first (February) and the last (June) carfentrazone application dates.

Table 3. Tolerance of Peppermint to Carfentrazone, Monroe, OR, 2011

Herbicide	Rate	Date	Peppermint Injury 5/2	Peppermint Injury 5/31	Peppermint Injury 6/27
	lb ai/A		----------------	%	----------------
check			0.0	0.0	0.0
carfentrazone	0.015	2/2[a]	0.0	0.0	0.0
carfentrazone	0.015	3/22[b]	5.0	0.0	3.0
carfentrazone	0.015	4/19[c]	12.5	10.0	4.0
carfentrazone	0.015	5/19[d]	-	30.0	10.0
carfentrazone	0.015	6/16[e]	-	-	15.0

[a]Dormant peppermint; [b]1/4 - 1/2 inch peppermint; [c]4 inch peppermint; [d]8 inch peppermint; [e]18 inch peppermint

Pyroxasulfone (Zidua) Crop Safety

Pyroxasulfone is a pre-emergence herbicide developed by Kumiai that is being marketed by several companies. Our past research indicates it is safe on peppermint and is an herbicide that has proven to be effective for controlling many winter and summer annual weeds. Research conducted in 2010 resulted in nearly 100 percent pigweed control following a May application to peppermint. Therefore, a study to evaluate peppermint injury resulting from a range of pyroxasulfone application timings was established near Monroe, Oregon. Pyroxasulfone was applied at 0.09 lb ai/A on February 16 to dormant peppermint, March 16 to ¼ inch tall peppermint, April 19 to four inch tall peppermint, May 19 to eight inch tall peppermint and finally on June 16 to 18 inch tall peppermint. These treatments were incorporated with either rainfall or irrigation following application. Visual ratings of peppermint injury were collected on May 2, May 31 and June 27. The pyroxasulfone treatments resulted in no visible peppermint injury. Similar timing studies utilizing pyroxasulfone have been proposed for the 2011-2012 growing season so that the potential impact of pyroxasulfone on peppermint yield, if any, can be quantified.

Summer Annual Broadleaf Weed Control with Post-emergence Herbicides

Summer annual weeds continue to be a significant production problem for peppermint growers. A non-crop study was conducted at Hyslop Farm to evaluate summer annual weed control resulting from applications of experimental and registered post-emergence herbicides. Herbicide treatments included MCPB and bentazon applied alone and as tank mix partners. MCPB and bentazon were also applied in combination with low rates of carfentrazone. Visual ratings of sharppoint fluvellin, redroot pigweed and Powell amaranth control are presented in Table 4. The MCPB + carfentrazone application resulted in the greatest control of both of the pigweed species and sharppoint fluvellin.

Table 4. Summer Annual Control With Post-emergence Peppermint Herbicides, Corvallis, OR, 2011

Herbicide[1]	Rate	Sharppoint fluvellin[2]	Redroot pigweed[3]	Powell amaranth[3]
	lb ai/A	-------------------------	%	------------------------
check		0	0	0
MCPB	0.25	17	43	43
MCPB + bentazon	0.25 0.5	20	33	30
carfentrazone	0.012	20	47	60
MCPB + carfentrazone	0.25 0.012	47	63	80
bentazon + carfentrazone	0.5 0.012	37	27	23

[1]Applied 7/29 to 4 leaf redroot pigweed and 6 inch Powell amaranth; [2]Rated 8/5; [3]Rated 8/19

These research trials have been viewed by various field consultant groups who manage peppermint in the Willamette Valley including those from CPS, Wilco Farmers, Simplot and Wilbur-Ellis among others. The off-station research trials have been viewed by field consultants and by the grower cooperators. Final research results were presented to peppermint growers at various winter meetings including the Oregon Mint Growers Annual Meeting and the OSU Extension Northeast Oregon IPM Workshop.

Kyle Roerig was hired as a Faculty Research Assistant and will have responsibility for peppermint trials.

Further Evaluation of Biological Control Agents for *Verticillium* Wilt in Peppermint

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Results of our 2010 study with potted peppermint suggested that the incidence of *Verticillium* wilt was lower in the treatment of RhizoStar+Headline than that in other inoculated treatments, but the difference was not statistically significant. To test if significant differences would result if a greater number of plants were assessed, the RhizoStar+Headline treatment was evaluated in a plot trial at an increased scale during 2011.

Other published studies suggested that mycorrhizal fungi could colonize peppermint roots, improve the growth of peppermint and reduce yield losses due to *Verticillium* wilt. However, colonization of potted peppermint roots by mycorrhizal fungi was very low in our 2010 study. Two greenhouse experiments were conducted in 2011 to determine if the low colonization in our previous study was due to low soil temperature or high phosphorus levels. We also conducted a plot trial at COARC and a field trial in Culver, Oregon to further evaluate mycorrhizae products for controlling *Verticillium* wilt in peppermint. Two other biological control agents, Actinovate and Tenet, were also added in the evaluation.

Materials and Methods

Greenhouse studies. Two greenhouse experiments were conducted in 2011 to determine the effects of soil temperature and phosphorus level on the colonization of peppermint roots by mycorrhizal fungi. In the first experiment "Black Mitcham" seedlings growing in 0.5 gallon pots with potting mix were drenched with 0.423 cup of mycorrhizae products, either Ultrafine Endo Powder water suspension (0.534 oz/gal) or Liquid Endo dilution (1.28 fl oz/gal) (manufactured by Mycorrhizae Application Inc., Grants Pass, OR). Plants were then grown at two different temperatures, "low" and "high" temperature regime. The plants in the low temperature treatment were placed directly on a bench in the greenhouse while the plants in high temperature treatment were placed on an electric heating pad. The soil temperature was monitored using soil temperature probes in three pots for each temperature treatment. After growing for 40 days, roots of the peppermint plants were collected, rinsed with tap water, cleared by boiling in 10 percent potassium hydroxide, stained in 0.05 percent w/v trypan blue in lactoglycerol (1:1:1 lactic acid, glycerol and water) and then examined under a microscope to determine the colonization by vesicular arbuscular mycorrhizae (VAM). Twenty hairy roots per plant were examined and the percentage of root length where either spores or mycelium of mycorrhizae were present was estimated and an average percentage used in analyses.

In the second experiment "Black Mitcham" seedlings were planted in one-gallon pots using a mixture of field soil and river sand (phosphorus level was as low as 12 ppm) and were treated to represent low, moderate and high phosphorus levels, with and without mycorrhizae. The following seven treatments were arranged in a randomized complete block design with ten potted-plants per treatment: 1) Low phosphorus, Liquid Endo 1.28 fl oz/gal at 0.845 cup/pot on August 1 and 30; 2) Low phosphorus, Ultrafine Endo Powder 0.534 oz/gal at 0.845 cup/pot; 3) Low phosphorus, no mycorrhizae check; 4) Moderate phosphorus, Ultrafine Endo Powder 0.534 oz/gal at 0.845 cup/pot; 5) Moderate phosphorus, no mycorrhizae check; 6) High phosphorus, Ultrafine Endo Powder 0.534 oz/gal at 0.845 cup/pot; and 7) High phosphorus, no mycorrhizae check. The low, moderate and high phosphorus levels were achieved by drenching the soil with a liquid fertilizer containing N at 0.04 percent and P at 0 percent, 0.012 percent and 0.036 percent, respectively. On August 23 and September 5 each pot was drenched with 0.845 cup of the liquid fertilizer. Root samples were collected on December 12 from each pot and assayed for colonization of VAM as described above.

Plot trial at COARC. Eight treatments were included in the plot trial at COARC: 1) Untreated check; 2) Seedling drench with Ultrafine Endo Powder water suspension (0.534 oz/gal, 0.845 fl. oz/plant) before transplanting on April 20, 25 and 29; 3) In-furrow spray with Ultrafine Endo Powder water suspension (0.534 oz/gal, 0.845 fl. oz/plant) at transplanting on May 27; 4) Seedling drench with Ultrafine Endo Powder water suspension (0.534 oz/gal, 0.845 gal per plot) on June 13 when soil temperature reached 59°F; 5) In-furrow spray with Actinovate (0.21 oz/gal, 0.845 fl. oz/plant) at transplanting; 6) Seedling soak in RhizoStar water suspension (1:1) for one hour immediately prior to transplanting; 7) RhizoStar+Headline: seedling soak in 1:1 RhizoStar water suspension prior to transplanting and in-furrow spray with Headline (0.67 fl. oz/gal H_2O, 0.845 fl. oz/plant) at transplanting; and 8) In-furrow spray with Tenet (0.32 oz/gal, 0.845 fl. oz/plant) at transplanting.

The treatments were arranged in a randomized complete block design with five replicates. Each plot was 5 ft. × 5 ft. in size with a five foot buffer between adjacent plots. Laboratory-produced microsclerotia of *Verticillium dahliae* were used to infest the top six inches of soil in all plots, resulting in one microsclerotia per gram soil in the top six inches. Twenty-four peppermint seedlings (cv. Black Mitcham) were planted in each plot. Disease incidence was recorded on August 30, September 7 and September 14. Plant height and fresh weight were determined at harvest on September 14. Stems sections assayed for *V. dahliae* on NP-10 medium. Root samples were collected, cleared, stained and examined for colonization by VAM under a microscope as described above.

Trial in a commercial field. A commercial field was planted with certified peppermint roots during the spring of 2011, after rotation with other crops for about 25 years. The following five treatments were arranged according to a randomized complete block design

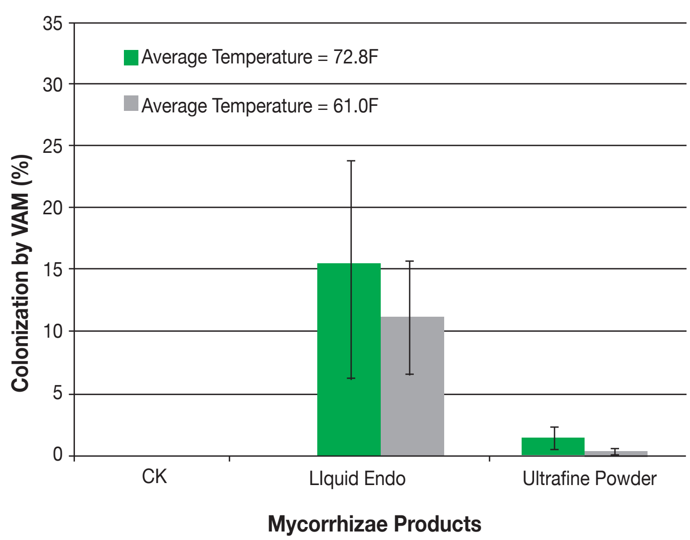
(continued on page 4)

with five replicates: 1) Untreated check; 2) Tenet at 6 oz/A; 3) Liquid Endo at 3.4 oz/A; 4) Ultrafine Endo Powder at 12 oz/A; and 5) Actinovate at 6 oz/A. Each plot was 1,200 ft. × 27.5 ft. in size. All treatments were done by band spraying in 20 gallon water/acre on June 3 when soil temperature reached 55°F, immediately followed by a two-hr sprinkler irrigation. Early in May, five soil cores (1-inch diameter, 6-inch deep) were taken and pooled as one soil sample from each plot. Each soil sample was assayed for *V. dahliae* via plating on NP-10 medium plates (0.1 g pulverized dry soil per plate). Prior to harvest, peppermint plants in an area of 2,000 square feet were evaluated for *Verticillium* wilt.

Results and Discussions

Greenhouse studies. The average soil temperature recorded over the study period was 72.8°F and 61.0°F, respectively, for high and low temperature treatments. Because the temperature started to warm up during our study period, the low temperature in the greenhouse during March was already higher than the soil temperature in commercial fields in May. Therefore, we didn't observe the limiting effects of low temperature (<50°F). There was no significant difference between temperature treatments in colonization of peppermint roots by VAM (Fig. 1). Roots treated with Liquid Endo showed higher VAM colonization than roots treated with Ultrafine Endo Powder, but even the Liquid Endo treatment resulted in relatively low colonization rates (Fig. 1). The higher VAM colonization in Liquid Endo treatment than Ultrafine Endo Powder treatment was probably due to a greater number of VAM propagules contained in Liquid Endo (36,718 propagules/gal in the diluted Liquid Endo vs. 5,663 propagules/gal in the Ultrafine Endo Powder suspension). The potting mix used in this first study had a high phosphorus level (test results ranged from 79 to 268 ppm) which may account for the low mycorrhizal colonization rate found with both products. The results of our 2011 greenhouse study # 2

Figure 1 Rate of VAM colonization for peppermint roots subjected to different soil temperature treatments in a greenhouse experiment at COARC.



suggested that phosphorus level may not be the only factor affecting colonization of root by mycorrhizae since no significant difference in mycorrhizae colonization was observed among different phosphorus levels (data not shown).

Plot trial at COARC. No significant difference was detected in incidence of *Verticillium* wilt among the eight treatments tested (Fig. 2). The average incidence varied in a narrow range from 24.5 percent to 32.5 percent. Differences in plant height and plant fresh weight were also insignificant among the eight treatments (Figs. 3 and 4). The percentage of root length colonized by VAM was significantly higher in plots treated with mycorrhizae products than in plots without mycorrhizae treatment (Fig. 5). However, considerable amounts of roots were also colonized by VAM in plots without any mycorrhizae treatment. These results are very different from our results obtained when using potting mix. This might be partially attributed to natural mycorrhizae inoculum in the field soil and the relatively low phosphorus level in the soil (24 ppm). The colonization of peppermint roots, based on the presences of spores and/or mycelium of VAM, was generally high in this study (Fig. 6), but no effects of mycorrhizae on disease incidence, plant height or fresh weight were detected. The reasons why high mycorrhizae colonization did not provide protection to peppermint roots against infection by *V. dahliae* are unclear, but uneven coverage of roots by VAM may be one major reason. An overwhelming disease pressure due to a great number of pathogen propagules in the soil might be another reason. Interestingly, peppermint roots treated with Headline showed the lowest colonization by VAM, which is consistent with reports that fungicides negatively affect the colonization of roots by VAM.

Trial in a commercial field. For all 25 soil samples, no *V. dahliae* was detected by plating 0.5 gram soil (Table 1). This suggested the soil-borne *V. dahliae* inoculum level was very low after rotation with other crops for 25 years. A method assaying a larger volume of soil is needed for detecting such a low level of *V. dahliae*. As the result of low inoculum level, incidence of *Verticillium* wilt was also very low in the field regardless of treatments. The highest incidence of *Verticillium* wilt was four diseased plants in 2,000 square feet (Table 1) and the difference among treatments were statistically insignificant (data not shown). Therefore, no conclusion can be drawn on the effects of treatments.

Table 1 Inoculum density of *Verticillium dahliae* in the top 6-inch soil and number of diseased plants within 2,000 square ft in a commercial peppermint field.

Treatments	No. of Diseased Plants		Microsclerotia
	Mean	Range	in 0.5 g soil
Untreated check	1.8	1-3	0
Actinovate	0.8	0-3	0
Tenet	1.2	1-2	0
Mycorrhizae--Liquid Endo	1.4	0-2	0
Mycorrhizae--Endo Powder	1.4	0-4	0

Figure 2 Incidence of *Verticillium* wilt in peppermint plots with different treatments in a plot trial at COARC in 2011.

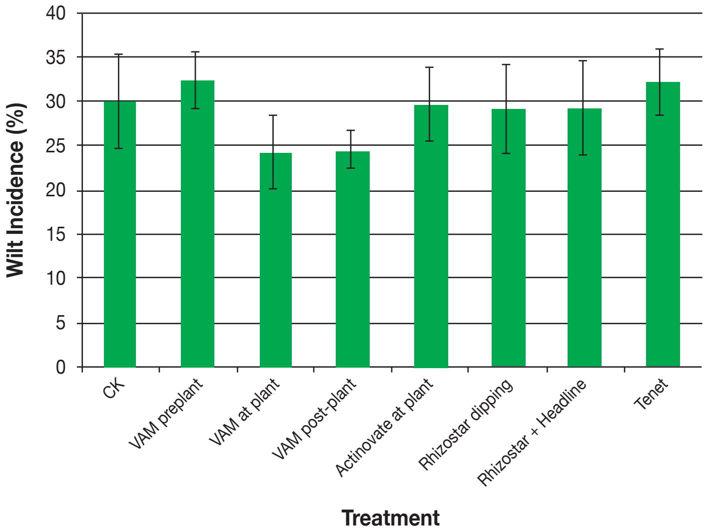


Figure 4 Average fresh weight (gram) of peppermint plants in plots with different treatments in a plot trial at COARC in 2011.

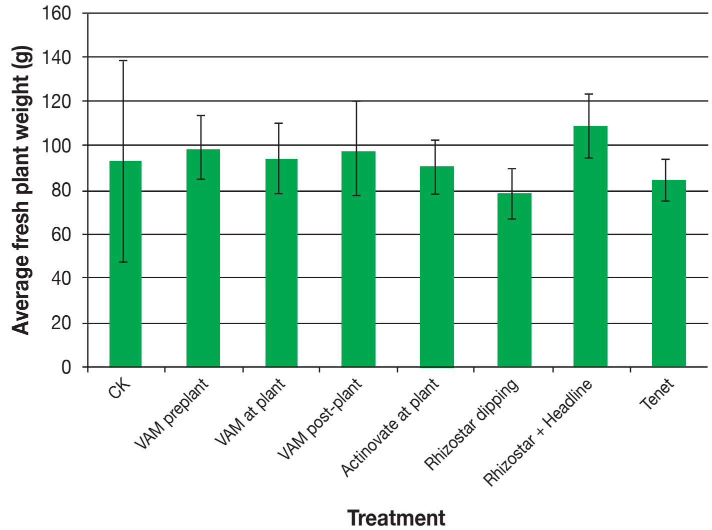


Figure 3 Average heights (inch) of peppermint plants in plots with different treatments in a plot trial at COARC in 2011.

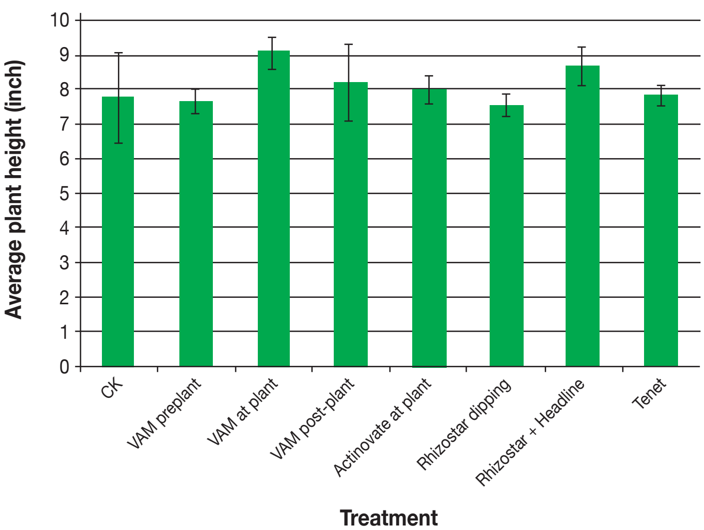


Figure 5 Average percent root length that was colonized by vesicular arbuscular mycorrhizae for peppermint plants subjected to different treatments in a plot trial at COARC in 2011.

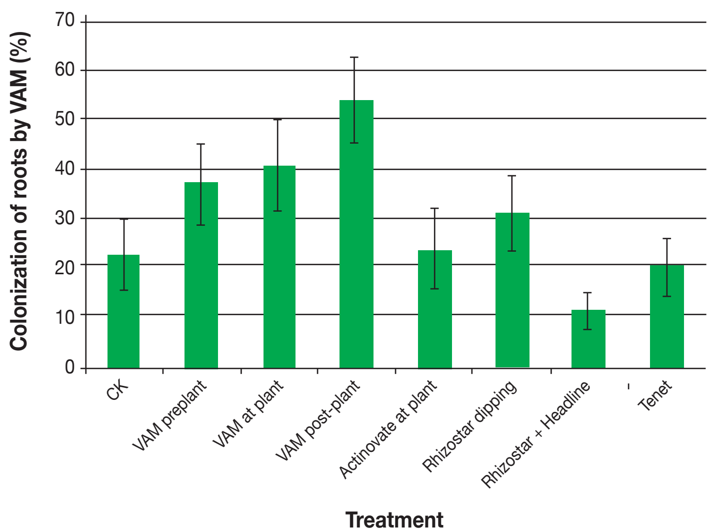
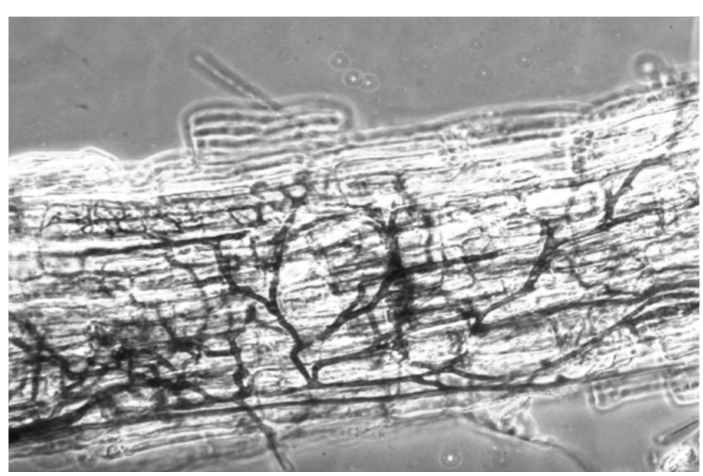


Figure. 6 Microscopic photos of peppermint roots colonized by vesicular arbuscular mycorrhizae (VAM) showing spores (left) and mycelium (right) of VAM in the root tissues.



2011 MIRC Variety Trials – Field Performance of Mint Derived from Long Term Tissue Culture Versus Mother Bed Stem Cuttings

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Ray Baker, Research Technologist III, WSU-IAREC, Prosser, WA

Mint Industry "Mother Bed" varieties are currently maintained in the MIRC Repository using potted stem cutting propagation techniques (MB). The varieties are also maintained and propagated by in-vitro tissue culture (TC) as a back-up. In-vitro tissue culture is used to maintain and regenerate propagation stock free of systemic pathogens. Mint plants derived from long-term in-vitro tissue culture storage have not been field tested to determine whether any physiological and/or morphological changes may occur from long term in-vitro tissue culture storage. These studies evaluated the field performance of five mint varieties planted in 2010 and three mint varieties planted in 2011 derived from both long term (5-year) in-vitro tissue culture (TC) maintenance/storage and standard potted stem cuttings (MB) to determine field performance of plants derived from both propagation techniques. Results will help to ascertain the value of both propagation techniques in maintaining mint industry certified varieties.

Materials and Methods

Trials were located at the WSU Roza Research unit near Prosser, WA. Trials were conducted on a Warden sandy loam soil containing one percent organic matter and the soil was fumigated with metham sodium (Vapam) at a rate of 75 gal/acre prior to transplanting to control soil pathogens and nematodes. Study sites had no previous history of any peppermint plantings. The trials were maintained free of weeds with standard labeled herbicides and hand weeding. Each mint variety and propagation method were replicated three times in a RCB design.

2010 Plantings: Plantlets of three peppermint varieties, one native spearmint and 770 Scotch spearmint were received as both in-vitro tissue culture (TC) plantlets and potted stem cuttings from the MIRC Mother Block repository (MB) in 2010. A total of 80 plantlets were transplanted in each 10 x 20 foot plot May 10, 2010.

2011 Plantings: Plantlets of one peppermint, one native and one 770 Scotch spearmint were received as both TC plantlets and MB in 2011. Plantlets were transplanted on June 2, 2011 at the same density as 2010 plantings.

Mint vigor was rated on a scale of 1 to 5, with 1= excellent vigor and healthy growth to 5= poor vigor, stunted and weak growth. All plots were single cut in the year of planting and double cut in the second year after planting.

For the 2010 planting, native spearmint and 770 Scotch spearmint plots were harvested July 7, 2011 and September 13, 2011. All peppermint plots were harvested July 28, 2011 and October 11, 2011.

For the 2011 planting, varieties were harvested as each variety matured as determined by bloom percent. Scotch spearmint plots were harvested on August 8, 2011, native plots on August 15, 2011 and peppermint plots on September 12, 2011.

Table 1. First cutting vigor and bloom ratings, hay and oil yields of TC and MB varieties Todds, Black, Rdf Murray Mitcham peppermints, native spearmint and 770 Scotch spearmint planted in 2010.

Variety	Culture	Vigor 7/7/2011	Percent Bloom 7/7/2011 %	Hay July 2011* Tons/Acre	Oil July 2011* lb/Acre
Todd's	TC	1	2	15.1	78
Todd's	MB	1	2	13.9	79
Black Mitcham	TC	1	2	13.6	79
Black Mitcham	MB	1	5	12.9	78
Rdf Murray	TC	1	3	13.5	83
Rdf Murray	MB	1	3.5	12.9	75
Native spearmint	TC	1	2	15.9	46
Native spearmint	MB	1	2	15.6	52
770 Scotch	TC	1	10	13.2	61
770 Scotch	MB	3.8	10	9.8	60
LSD + (0.05)		0.23	1.02	4.18	16.72

Vigor = Scale of 1 to 5 with 1 = vigorous and healthy, 5 = being extremely weak.

*Native and 770 Scotch spearmint plots were harvested July 7, 2011 and peppermints on July 28, 2011.

Hay yield was determined by weighing freshly cut hay samples. Hay was dried in burlap bags and oil was steam distilled in mini-stills at the WSU-Prosser experiment station. Oil samples were sent to I.P. Callison & Son's lab for compositional oil analysis.

Results and Discussion

2010 Plantings. Mint vigor ratings were not significantly different between the TC and MB peppermints or native spearmints during the summer of 2011 (Tables 1 + 2). Vigor of 770 Scotch spearmint was lower in the MB cuttings compared to the TC at the first cutting, but no differences in vigor were evident by the time of the second cutting (Tables 1 + 2). Similarly, in 2010, vigor of 770 Scotch spearmint derived from TC was greater than plants derived from MB.

In 2010, TC derived plants had a delayed bloom when compared to plants derived from MB. In 2011, percent bloom between the TC and MB derived plants were similar at first cutting, with exception of Black Mitcham peppermint, in which plants derived from MB cuttings bloomed slightly earlier than plants from TC (Table 1). No bloom was observed in all peppermint varieties at second cutting (Table 2). TC native and 770 Scotch spearmint tended to bloom later than MB derived cuttings of native and 770 Scotch spearmint (Table 2).

Hay yields were not different between the TC and MB derived plants for all peppermint and native spearmint varieties. However, second harvest hay yield of 770 Scotch derived from MB was lower than 770 Scotch spearmint derived from TC (Tables 1 + 2). Oil yields within varieties and among TC and MB cuttings were similar in 2011 for each harvest (Tables 1 + 2).

2011 Plantings. There were no significant differences in vigor between TC or MB derived peppermint, native spearmint or 770 scotch spearmint in 2011 (data not shown).

For all three mint varieties bloom was delayed in TC derived plants compared to stem cuttings from MB (Table 3). Hay yields were not significantly different between the TC and MB for all mint types (Table 3). There were no significant differences in oil yield between TC and MB cuttings for native spearmint and 770 Scotch spearmint in 2011. However, TC peppermint yielded lower oil than MB peppermint (Table 3). Oil analysis was very similar between TC and MB derived plants within each mint variety at each harvest (data in MIRC 2011 report).

Conclusions

Vigor ratings of the 2010 plantings were similar among TC and MB for most mint varieties in early July with the exception of MB 770 Scotch, in which plantlets from TC tended to be more vigorous than MB plantlets. Bloom tended to be later in TC derived spearmint plants compared to plants derived from MB at second harvest. There was no significant difference in the oil yields from each harvest when comparing plants from TC and from MB stem cuttings within each variety.

Vigor ratings of the 2011 plantings were similar among all the TC and MB derived plants. In both years bloom was delayed in all TC derived varieties compared to plants derived from MB stem cuttings in the year of planting. There was no significant difference in hay yield among plants derived from different propagation techniques in 2011. Peppermint derived from MB stem cuttings yielded more oil than peppermint from TC in the 2011 plantings, but no significant differences in oil yield were observed in spearmint varieties from TC and MB propagation techniques.

Table 2. Second cutting vigor and bloom ratings, hay and oil yields of TC and MB varieties Todds, Black Mitcham, Rdf Murray peppermints, native spearmint and 770 Scotch spearmint planted in 2010.

Variety	Culture	Percent Bloom 2011* %	Hay 2011* Ton/Acre	Oil 2011* lb/Acre
Todd's	TC	0	7.3	29
Todd's	MB	0	6.6	34
Black Mitcham	TC	0	6.6	35
Black Mitcham	MB	0	6.6	33
Rdf Murray	TC	0	6.6	32
Rdf Murray	MB	0	3.9	26
Native spearmint	TC	11	14.4	62
Native spearmint	MB	25	13.7	53
770 Scotch	TC	26	10.4	56
770 Scotch	MB	35	7.0	54
LSD + (0.05)		----	2.27	12.85

*Native and 770 Scotch spearmint plots were harvested September 13, 2011 and peppermint on October 3, 2011.

Table 3. Vigor ratings, bloom percent, and hay and oil yields of TC and MB 770 Scotch spearmint, native spearmint and Black Mitcham peppermint planted on June 2, 2011.

Variety	Culture	Percent Bloom %	Hay Ton/Acre	Oil lbs/Acre
		8/8/2011	8/8/2011	8/8/2011
770 Scotch	TC	33 b	7.6 a	47 a
770 Scotch	MB	68 a	9.1 a	58 a
		8/15/2011	8/15/2011	8/15/2011
Native	TC	9 b	6.6 a	34 a
Native	MB	50 a	6.8 a	37 a
		9/12/2011	9/12/2011	9/12/2011
Black Mitcham	TC	4 b	10.3 a	57 a
Black Mitcham	MB	12 a	9.7 a	77 a

Values without letters or values followed by the same letter are not significantly different at P = 0.05

In Crop Use of Telone II for the Control/Management of *Verticillium* Wilt and/or Nematodes Impacting Mint…the Final Word

Philip Hamm and Jordan Eggers, Hermiston Agricultural Research & Extension Center
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Root lesion nematode can cause substantial damage during mint production. Control is possible either through the use of products like Telone II prior to planting root stocks or the use of Mocap or Vydate once nematode problems are identified in a field. These products are expensive. In addition, Mocap and Vydate must be used repeatedly through the course of the years the field is in mint since a single application will provide immediate control but with time the effects wear off and nematode feeding returns. One potential solution to repeated use of Vydate or Mocap could be the use of Telone II, after root stock planting and after nematode damage is confirmed in an established field. A single application of Telone II at this time may not only be more economic than multiple applications of the other products but could also save time and be more efficacious. Another important disease of mint, *Verticillium* wilt, is caused by a soilborne fungus and must be controlled prior to planting root stocks since there is no fungicide that provides control of this pathogen. Further, there is a clear synergistic (additive effect) relationship between this fungus and root lesion nematodes in potatoes where more disease is recorded when both pathogens are present than what would normally be expected. The same relationship likely happens in mint. Telone II has shown at times some benefit by reducing *Verticillium* wilt during potato production by its use. Could an application of that product, when the mint is already established, provide significant benefit to control nematodes and *Verticillium* wilt? What is described here was initiated to investigate the use of Telone II for the control/management of two related diseases impacting peppermint; root lesion nematodes (*Pratylenchus penetrans* and *P. neglectus*) and *Verticillium* wilt (*Verticillium dahliae*).

Material and Methods

Year 1. A one-year-old commercial center pivot irrigated field near Boardman, OR that had a high root lesion nematode population (determined by survey sampling prior to plot establishment) was selected for this research. Two sites (wedges) were established in the field in the fall of 2009, each containing four treatments (Telone II [0 (shanks run through plots but no Telone II added), 15 and 20 gpa] and an undisturbed control) with four replications. Treatments were applied October 21, 2009. Plots were 50 feet long by the width of the fumigator wide (17 feet). A Noble blade with nozzles appropriately placed was used for Telone II applications at a 14 inch depth. Bladed treatments were immediately disced and packed to the seal soil surface. One of the two wedges (wedge identified as # 8) had an additional treatment of Mocap applied at four quarts/acre and watered in October 27-28, 2009. Soil and root samples were taken prior to application (October 21, 2009), post-fumigation (March 19, 2010) and after the second cutting (October 17, 2010) to assay population of *Verticillium* (soil only) and plant pathogenic nematodes (both soil and roots). Yield was determined by hand harvesting on July 17 and September 17, 2010. Two 4' x 30' strips were cut from each replication at each site and total fresh hay weights were determined in the field.

Year 2. A 2-year-old commercial mint field with high root lesion nematode populations (determined by survey sampling prior to plot establishment) was used for the second year of the trial. Two sites were established (north and south) in the Fall of 2010, each containing four replications of three treatments (Telone II at 0 [shanks run through plots], 15, and 20 gpa) as well as an untreated/undisturbed control. Treatments were applied November 19, 2010. Replicate plots of each treatment were 17 feet wide (fumigator width) and 150 feet long arranged as parallel strips in a randomized complete block design with 12 feet buffer strips between blocks. A Noble blade with nozzles appropriately placed was used to apply Telone II at a depth of 14 inches. Bladed treatments were immediately disced and packed to seal soil surface. Soil and root samples were taken from each replication at each site prior to treatment application (November 18, 2010), post-fumigation (May 24, 2011) and immediately after the second yield cutting (September 20, 2011) to assay populations of *Verticillium* (soil only) and plant pathogenic nematodes (both soil and roots). Yield was determined by hand cutting a 4' x 60' swath from the center of each replicate at each site using a jerry mower on July 11, 2011 and September 20, 2011. Fresh weights of mint hay (lbs.) were determined in the field. Plots were visually assessed 53 days after the first harvest. If differences in plant height were observed at a site, four plant height measurements were taken from each replicate plot at that site and were used to calculate average plant height. Both sites were treated with Vydate and Mocap by the grower during a whole field application on September 22, 2010. This occurred before the first soil sampling and treatment application. Plots were again treated with Vydate during a whole field application on August 3, 2011. All plots at both sites were treated the same during these applications.

Results and Discussion

Year 1. Pre-fumigation CFU (colony forming units/gram of dry soil) levels of *Verticillium* were low prior to fumigation in 2009 but apparently increased following fall fumigation when the post-fumigation sample was collected the following spring (Table 1). While not significantly different, CFU levels of *V. dahliae* were often times higher where shanked applications of Telone II had been applied. Highest mint foliage weights came from the treatment where Mocap had been applied in the plot identified as Wedge 8. Nematode levels prior to fumigation were high (Table 2). Following fumigation numbers were still high though significant reductions occurred more often where Telone II had not been applied. Nematode levels in the roots/rhizomes prior to fumigation were very high (Table 2) but samples taken after fumigation showed no significant reduction in population levels except possibly where Mocap was used.

Table 1. Impact of treatments on soil populations of *Verticillium* (CFU/g dry soil) and mint yield (lb hay/240 sq. ft.), 2010.

Wedge[1]	Treatment	Pre-Fumigation V. dahliae (CFU/g dry soil)[2]	Post-Fumigation V. dahliae (CFU/g dry soil)[3]	Harvest (CFU/g dry soil)[4]	1st Harvest Yield (lbs fresh foliage)[5]	2nd Harvest Yield (lbs fresh foliage)[5]
5	Non-tilled Control	0.0 a[6]	17.0 a	8.0 a	63.2 a	34.9 a
5	Shanked Control	0.5 a	23.5 a	5.0 a	43.9 c	19.2 b
5	Telone II 15 gpa (shanked)	0.0 a	29.5 a	30.0 a	43.2 c	19.6 b
5	Telone II 20 gpa (shanked)	0.0 a	27.5 a	27.0 a	37.2 c	17.0 b
5	Non-tilled Control	0.5 a	14.0 a	6.0 a	59.1 a	28.6 a
		P=0.7021	P=0.5982	P=0.0683	P=0.0011	P=0.0003
8	Non-tilled Control	5.0 a	20.0 a	11.0 a	96.4 a	42.9 a
8	Shanked Control	0.0 a	17.0 a	13.0 a	61.6 b	25.5 a
8	Telone II 15 gpa (shanked)	10.0 a	48.5 a	19.0 a	59.7 b	32.4 a
8	Telone II 20 gpa (shanked)	1.0 a	45.0 a	7.0 a	58.1 b	27.8 a
8	Mocap 4 quarts/a[7]	1.5 a	25.5 a	5.0 a	106.4 a	43.9 a
		P=0.0686	P=0.2798	P=0.2221	P<.0001	P=0.2783

[1]Two areas within the field were used, Wedge 5 and Wedge 8. The plots in Wedge 8 also included the Mocap treatment.
[2]Values are the numbers of Colony Forming Units (CFU)/gram of dry soil. Soil samples were taken in the fall before fumigation.
[3]Values are the numbers of CFU/gram of dry soil. Soil samples were taken in the spring as mint was beginning to grow.
[4] Values are the numbers of CFU/gram of dry soil. Soil samples were taken in the fall right after the second hand harvest.
[5]The lbs. of mint foliage obtained from the first and second cuttings, harvested just days before the commercial harvest.
[6]Numbers in the same column followed by the same letters are not significantly different by the P level indicated.
[7]Mocap was applied by ground rig and then water incorporated.

Table 2. The impact of treatments on soil and root populations of root lesion nematodes (primarily *Pratylenchus penetrans*), 2010.

		# *Pratylenchus* per 250 grams of Dry Soil			# *Pratylenchus* per gram of Fresh Mint Roots		
Wedge[1]	Treatment	Pre-Fumigation[2]	Post-Fumigation[3]	Harvest[4]	Pre-Fumigation	Post-Fumigation	Harvest
5	Non-tilled Control	149 a [5]	92 a *	122 a	1939 a	1521 a	1128 a
5	Shanked Control	135 a	66 a *	110 a	1384 a	2747 a	759 a
5	Telone II 15 gpa (shanked)	253 a	102 a	79 a	2219 a	1775 a	562 a
5	Telone II 20 gpa (shanked)	236 a	117 a	53 a	1682 a	1856 a	969 a
5	Non-tilled Control	196 a	87 a *	94 a	2324 a	1509 a	969 a
		P=0.1889	P=0.362	P=0.088	P= 0.738	P=0.988	P=0.449
8	Non-tilled Control	228 a	133 a	249 a	734 a	440 a	2559 a
8	Shanked Control	175 a	197 a	144 a	1564 a	981 a	1507 a
8	Telone II 15 gpa (shanked)	229 a	59 a *	102 a	1161 a	407 a	1164 a
8	Telone II 20 gpa (shanked)	203 a	76 a	136 a	1130 a	516 a	1261 a
8	Mocap 4 quarts/a[6]	299 a	82 a	264 a	1430 a	280 a *	2012 a
		P=0.969	P=0.337	P=0.068	P=0.500	P=0.954	P=0.216

[1]Two areas within the field were used, Wedge 5 and Wedge 8. The plots in Wedge 8 also included the Mocap treatment.
[2]Values are the numbers of nematodes in the soil collected prior to fumigation in the fall of 2009.
[3]Values are the numbers of nematodes in the soil collected in the spring of 2010 as mint was beginning to grow.
[4]Values are numbers of nematode in the soil or roots collected in the fall of 2010 shortly after the second harvest.
[5]Numbers in the same column followed by the same letters are not significantly different by the P level indicated.
[6]Mocap was applied by ground rig and then water incorporated.
*Significantly lower than the pre-fumigation nematode counts of the same treatment at P<0.06.

Harvest data shows that all of the shanked treatments (shank-no Telone, Telone II shanked at 15 and at 20 gpa) had significantly lower yields than the non-shanked controls for both the first and second harvests in Wedge 5 and the first harvest in Wedge 8. There were no significant differences in mint yield for the second harvest in Wedge 8.

The lack of reduction in the soil populations of *Verticillium* following fumigation was expected, given the low beginning numbers and the fact that Telone II is not reported to specifically target this soilborne fungus (Table 1). Previous work with this product with potatoes did not show a direct reduction of *Verticillium* though a further reduction in *Verticillium* levels and/or benefit has been seen many times with the combination of Telone II with metam sodium over the use of metam sodium alone. In addition, given the close relationship and synergistic impact of *P. penetrans* and *Verticillium* in potatoes, controlling one of these pathogens would be expected to help reduce *Verticillium* wilt. What was not expected was the much higher levels of *Verticillium* found following fumigation. However, in nearly every case, whether looking at soil or root population numbers, the fumigation treatments had little impact on nematode populations. Mocap when applied in the fall was the only treatment that resulted in a near significant reduction in nematodes (Table 2) and also had a significantly greater yield of mint (Table 1).

Verticillium and nematode levels seem to have been favored by ground tillage during fumigation and yield was negatively impacted. Infrared photography supports that conclusion given the fact that stands in the areas where shanks were used without applying fumigant,

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or when applying fumigant, were in poor shape in the spring and never fully recovered from the treatment. Apparently the use of the Noble blade applicator disrupted the rhizomes at significant levels as to harm the plants. Stressing the plants in this way likely allowed both pathogens, *Verticillium* and the lesion nematodes, to take advantage of the poor plant condition and therefore were able to replicate at a high frequency.

When the application of Telone II was first tested in a non-replicated manner in a field with established mint, substantial growth increase occurred. That application consisted of a Noble blade followed by a disc and a Schmeiser packer and was in strips one-half mile long. The first year of this trial used what the researchers and applicator believed would be an even better way to apply the material, again using a Nobel blade but this time with blades that were straight and then followed with a disc. The strips in this case were only 50 feet long. We believe now that the short strips didn't allow for the blade to run properly and actually did more damage to the plants by the frequent putting in and pulling out of the blade in these small replicated and randomized plots. New plots established in a different field in the fall of 2010 (Year 2) used identical equipment as used in the original strip trial but much longer strips were utilized. It is hoped that the plants will not be harmed by this application method.

Year 2. Pre-fumigation *Verticillium* CFU levels were similar for all treatments at both the north and south sites (Table 3). Post-fumigation soil measurements of the north site treatment plots showed a numerical decrease in *Verticillium* CFU/g dry soil in all treatments except the shank only treatment, which had an increase in *Verticillium* CFUs. However, these differences were not statistically different. In the south site, *Verticillium* CFU/g of soil was significantly decreased with the use of Telone II at 20 gpa treatment, compared to the two treatments where Telone II had not been used. *Verticillium dahliae* CFU levels in harvest soils were not significantly different between treatments. Only the Telone II 20 gpa treatment located at the south site showed a significant difference in *V. dahliae* CFU levels between pre-fumigation, post-fumigation and harvest samples where levels declined following fumigation but increase significantly by season's end (Table 3).

Before fumigation soil population densities of root lesion nematodes at both sites and root densities at the north site were not different between plots assigned to the different treatments (Table 4). However, root densities at the south site were significantly less in the plots designated to be fumigated than in the control plots. After fumigation soil nematode densities were less than the control plots in the 20 gpa rate of Telone II at the north site and for both rates of Telone II at the south site. Root population densities at the north site were less than in the untreated control in the shanked/no Telone II treatment and in the 20 gpa Telone II treatment but not in the 15 gpa treatment. There was a trend for lower root populations in both Telone II treatments at the south site but these differences were not significant. By harvest there was no effect of fumigation remaining for any treatment at ether site which may have been why there were no differences in yield between the Telone II treated and untreated areas.

The first mint cutting from the north plot resulted in a significantly higher yield in the untreated and both Telone II treatments compared to the shank only treatment (Table 5). At the second cutting the untreated control had a significantly higher yield than the Telone II at 15 gpa treatment. In the south plot the first harvest yield of the Telone II used at 20 gpa was significantly higher than the untreated and shank only treatments. No significant differences were observed in the second south site harvest. Interestingly, some treatments did show an easily recognizable impact but the impact was not seen consistently across all replications so yield benefit was not apparent. (See photo 1 and Table 5.)

There were no observed differences in plant height among treatments at the north site 53 days after the first harvest therefore no height measurements were taken. The south site did have observable differences in mint plant heights. Mint plant heights in both of the Telone II treated plots were significantly greater than in the untreated and shanked only plots (Figure 1).

Conclusion. The use of Telone II as an in-crop method to control nematodes, which may also reduce the impact due to *Verticillium*, was an innovative way to use this material in a perennial crop. Most crops are grown for one year or less making soilborne diseases more easily controlled, either through crop rotation or the use of soil fumigants. In the case of peppermint, where the crop could be grown for three years or longer, there is little that can be done to control *Verticillium* after planting, though there is opportunity to control nematodes, but only through the repeated expensive use of either Mocap, Vydate or both. The hope here was that a single application of Telone II would effectively control nematodes and do so for a period of more than one year, hence reducing

Table 3. Impact of treatments on soil populations of *Verticillium* (CFU/g dry soil), 2011.

		V. dahliae Counts (CFU/g dry soil)		
Site[1]	Treatment	Pre Fumigation[2]	Post-Fumigation[3]	Harvest[4]
North	Untreated	35 a [5]	22 a	60 a
	Shanked/No Telone II	27 a	43 a	58 a
	Telone II 15 gpa	29 a	21 a	21 a
	Telone II 20 gpa	34 a	14 a	32 a
		P=0.7673	P=0.5504	P=0.29
South	Untreated	11 a	5 a	7 a
	Shanked/No Telone II	9 a	5 a	9 a
	Telone II 15 gpa	10 a	3 ab	12 a
	Telone II 20 gpa	10 a, a [6]	1 b, b	19 a, c
		P=0.5177	P=0.0376	P=0.28

[1] The two areas in field used for the study were on the north and south ends of the field.
[2] Soil collected November 18, 2010 prior to treatment application.
[3] Soil collected May 24, 2011, the spring after treatment application.
[4] Soil collected September 20, 2011 immediately after the second cutting.
[5] Numbers in the same column followed by the same letters are not significantly different at the P level indicated.
[6] Pre-fumigation, post-fumigation, and harvest *Verticillium dahliae* CFU values for the Telone II 20 gpa treatment at the south site. Numbers followed in the same row by a different letter are significantly different at P<0.05.

need for repeated use of the nematicides and reducing grower costs. The work presented here showed some progress toward controlling soilborne diseases, particularly in year two when the application methods were changed so that the mint rhizomes were not as damaged with Telone II application. However, this product showed a limited time frame for reducing nematodes; numbers rebounded in roots and soil not long following use. Additional testing may provide an efficacious and cost effective way of using Telone II in an established crop. However, we concluded that still the best way to control soilborne nematodes and fungal diseases in peppermint would be to use soil fumigants (Telone II and metam sodium) before the field was planted to mint, while also following the long standing recommendation of purchasing root stocks that are free of both nematodes and *Verticillium* and practicing long-term crop rotation between mint plantings.

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- When applying any pesticide be certain to read and follow the label.

Photo 1. Impact from the in crop use of Telone II. The plot on the left is new growth from the Telone II treatment at 15 gpa, the one on the right is a non-tilled, non-Telone II treatment. Photo was taken August 16, 36 days following the first harvest. This benefit was not consistently seen from Telone II applications.

Table 4. Impact of treatments on soil and root populations of root lesion nematodes (primarily *Pratylenchus penetrans*), 2011

		# *Pratylenchus* per 250 grams of Dry Soil			# Pratylenchus per gram of Fresh Mint Roots		
Site[1]	Treatment	Pre-Fumigation[2]	Post-Fumigation[3]	Harvest[4]	Pre-Fumigation[2]	Post-Fumigation[3]	Harvest[4]
North	Untreated	97 [5]	69 a	104	211	2010 a	669
	Shanked/No Telone II	80	53 a	77	513	637 b	503
	Telone II 15 gpa	94	30 ab	192	406	1336 ab	896
	Telone II 20 gpa	119	16 b	83	714	444 b	566
		P=0.6487	P=0.0204	P=0.3420	P=0.6869	P=0.0564	P=0.9005
South	Untreated	55	36 a	211	90 a	1601	227
	Shanked/No Telone II	35	20 ab	111	344 a	1557	340
	Telone II 15 gpa	65	5 b	143	5 b	619	313
	Telone II 20 gpa	33	7 b	205	6 b	280	1,762
		P=0.2613	P=0.0024	P=0.3858	P=0.0277	P=0.1416	P=0.4854

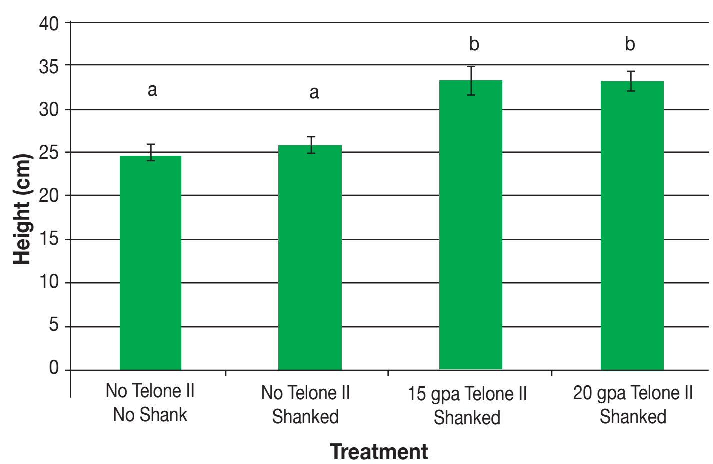
[1] The two areas in field used for the study were on the north and south ends of the field.
[2] Number of nematodes in soil collected November 18, 2010 prior to treatment application.
[3] Number of nematodes in soil collected May 24, 2011, the spring after treatment application.
[4] Number of nematodes in soil collected September 20, 2011 immediately after the second cutting.
[5] Numbers in the same column followed by the same letters are not significantly different at the P level indicated.

Table 5. Mint yields (lbs. fresh hay/240 ft^2) of first and second harvests, 2011.

Site[1]	Treatment	First Harvest[2] Yield (lbs.) 7/11/2011	Second Harvest [2] Yield (lbs.) 10/8/2011
North	Untreated	15.5 a[3]	8.8 a
	Shanked/No Telone II	10.4 b	6.5 ab
	Telone II 15 gpa	14.3 a	6.2 b
	Telone II 20 gpa	12.3 a	8.5 ab
		P=0.0015	P=0.0457
South	Untreated	16.6 a	9.7 a
	Shanked/No Telone II	16.0 a	7.1 a
	Telone II 15 gpa	18.3 ab	10.7 a
	Telone II 20 gpa	19.6 b	9.9 a
		P=0.0392	P=0.0619

[1] The two areas in field used for the study were on the north and south ends of the field.
[2] The lbs. of mint foliage obtained from the first and second cuttings, harvested just days before the commercial harvest.
[3] Numbers in the same column followed by the same letters are not significantly different at the P level indicated.

Figure 1. Average mint heights 53 days after first harvest in the south study site, 2011. Columns with different letters are significantly different at P<.001.



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Evaluation of Mycorrhizal Fungus Applied to Baby and Established Peppermint Grown in Northeast Oregon.

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Mycorrhizal fungi can form close associations with plant roots, which can provide benefits to most plants by increasing nutrient and water uptake and resistance to diseases. A company called Mycorrhizal Applications Inc., located in Grants Pass, Oregon, is commercially producing a type of mycorrhizal fungus called MycoApply® Micronized Liquid Endo.

In the spring of 2010 there were two identical experiments conducted in which MycoApply® Micronized Liquid Endo mycorrhizal fungus was applied to established mint. No yield or growth differences were found from these two experiments in the summer of 2010. It was speculated that if the mycorrhizal fungus could be applied to the mint at planting time that more positive results could be observed. In 2011, a second study was done with MycoApply® Micronized Liquid Endo by applying it at planting time.

There has also been anecdotal evidence that applying a fungicide at planting time increases the vigor of the emerging mint. This 2011 trial also included a treatment of Headline fungicide applied at planting time so it could be compared to the results of the mycorrhizal fungi application at planting and to untreated mint.

Objectives

1. Compare growth differences and competition with weeds of mint planted with rhizomes treated with MycoApply® Micronized Liquid Endo to untreated mint.

2. Compare growth differences of mint rhizomes treated with Headline fungicide (pyraclostrobin) to untreated mint rhizomes.

3. Compare root colonization of rhizomes treated with MycoApply® Micronized Liquid Endo to untreated mint:

   a) when applied to mint rhizomes, as they were planted, in fall of 2010.

   b) when applied to established mint in the spring of 2010.

In the fall of 2010 two identical experiments were established in two baby production peppermint fields. A spray boom was attached to the grower's mint planter, along with a $C0_2$ powered spray tank. Spray nozzles were mounted behind each shoot of the planter. The spray solutions of MycoApply® Micronized Liquid Endo or Headline were applied in 10 GPA water. The spray solution was applied to the mint rhizomes in the furrow just before they were covered by soil. The Headline fungicide was applied at a rate of 10 oz/acre.

Root samples were taken in these two baby mint experiments in early September 2011 (approximately eleven months after application).

Root samples were also taken in the established mint experiments in early September 2011.

Results and Discussion

In the spring and summer of 2011 there were no visible differences in the vigor or size of the baby mint during or after emergence between the mycorrhizal, Headline and untreated plots in either experiment. In addition, no differences were observed in weed populations and mint growth during the remainder of the summer, between the two treatments and the untreated plots, in either experiment. Experiment One had very noticeable strikes of *Verticillium* wilt randomly scattered throughout the entire field, including the plot area. There were no noticeable differences in the amount or severity of wilt strikes between either of the treatments and the untreated check.

Table One shows the level of root colonization of the fall-applied, MycoApply® treatments compared to the untreated checks. There are no statistical differences between the treatments. The average mycorrhizal colonization of Experiment One is numerically higher in the treated plots compared to the untreated check, however ,Experiment Two has the exact opposite result.

In the spring of 2010 two identical experiments were established in two established production mint fields. In 2010 no visual differences were observed between the treated and untreated plots. There were also no significant differences between the dry hay weights and oil yields in 2010. (Data not shown.)

Table 1 Comparison of mycorrhizal fungus colonization in baby peppermint roots treated at planting time (fall 2010) with MycoApply® Micronized Liquid Endo to untreated mint.

Treatment	Rate	Exp. 1W Average percent	Exp. 2H colonization of roots
Untreated check	---	37	46
MycoApply® Micronized Liquid Endo	3.5 fl oz/acre	50	16
P=0.05		NS	NS

Root samples collected in September 2011

In 2011 only visual observations were made of these two established mint experiments. Again no visual differences in plant growth were observed in 2011.

No assessment of weed control could be made in 2011 because there were no significant weed populations in either field due to good weed control.

In early September 2011 root samples were taken from these two established mint experiments (Table Two).

Results and Discussion

The results in Table Two show no significant differences between the treated and untreated root samples in the established mint for both years (2010 and 2011). It appears that there is naturally occurring mycorrhizal fungus in the soils of these fields.

Conclusions:

The experiments conducted in 2011 only indicate that on baby mint, naturally occurring mycorrhizal fungi colonize mint roots by

Table Two Comparison of mycorrhizal fungus colonization in established peppermint treated with MycoApply® Micronized Liquid Endo in the spring of 2010 to untreated mint.

Treatment	Rate	Experiment 1B		Experiment 2N	
		Sampled Post-harvest 2010	Sampled Post-harvest 2011	Sampled Post-harvest 2010	Sampled Post-harvest 2011
		Average percent colonization of roots			
Untreated check		4	32	10	31
MycoApply® Micronized Liquid Endo	7 fl oz/ac	37	32	43	22
P=0.05		NS	NS	NS	NS

fall of the establishment year. The testing of the mint roots showed no significant difference in the percent of colonization of roots between the treated and untreated roots.

The experiments started in 2010 on the established mint showed a trend for the mycorrhizal application to increase the percent colonization the first year, but in the second year the colonization percentages were nearly equal.

The results from these two experiments indicate that MycoApply® does not increase oil yields, reduce weed or disease pressure in Northeast Oregon. It appears that this beneficial fungus occurs naturally in the soil of Northeast Oregon and applying it does not provide any economic benefit. No further research is planned for testing this product on mint.

Although this product does not appear to have a practical use in Eastern Oregon on peppermint, it is unknown if this product is beneficial in other areas and on other crops.

The Mint Biotechnology Project

Research Activities with Erospicata Variety and Field Trials with Peppermint

Mark Lange, Washington State University

Generation of *Verticillium*-resistant mint lines. We are currently working with a *Verticillium*-tolerant mint variety termed Erospicata, which was developed by Aromatics Inc. in the 1990s. Erospicata essential oil contains high amounts of menthone, which is an important component of peppermint oil, but it lacks menthol, another key constituent of peppermint. To generate plants that retain *Verticillium* resistance but accumulate an oil with a composition even closer to that of peppermint, we generated a series of transgenic Erospicata lines that were designed for a high activity to convert menthone to menthol. We identified three promoters (strong "on/off switches" for gene expression) that guide the expression of genes to the specialized anatomical structures (glandular trichomes) that carry out essential oil biosynthesis. Each of these promoters was fused to the gene encoding menthone:menthol reductase (MMR), which is responsible for the menthone-to-menthol conversion in peppermint. We also generated analogous constructs in which we used a promoter for the expression of MMR everywhere in the plant (not just in glandular trichomes). These four different promoter-MMR fusion constructs were then transformed into the Erospicata variety. Over the last year we generated several thousand transgenic events and we are continuing the regeneration of transgenic plants from these primary transformations. About 40 regenerated transgenic lines have already been transferred to the greenhouse (with more than a hundred transgenic lines at various stages in the regeneration process), where they are grown to maturity. Preliminary experiments indicate that some of our transgenic lines have significant activities for the conversion of menthone to menthol, but it is too early to tell if these results will hold up under growth conditions that are more similar to those in the field. Although our greenhouses are equipped with supplemental sodium vapor lights, the light intensity is still too low to trigger substantial essential oil production. In our experience, direct comparisons of oil distilled from transgenic, Erospicata and peppermint plants (yield and composition) will not be meaningful until late May. While we are waiting for the appropriate conditions to evaluate our transgenic plants, we will continue with transformations to further increase the likelihood of finding a winner.

Field trials with transgenic peppermint lines. The Board of the Mint Industry Research Council recently voted in favor of performing field trials for elite transgenic peppermint lines with enhanced oil yield and composition. In particular, these are the lines MFS7A (menthofuran synthase (MFS) expressed in antisense orientation to lower MFS expression levels) and MFS7AA (MFS7A line taken through an additional round of tissue culture). Both lines had shown excellent results in greenhouse-scale trials. The MFS7A line had also been taken to multi-year field trials (2003-2005) and the results of these tests were very promising. As part of these field trials, we will evaluate the suitability of these transgenic lines for commercial release. A permit application for "Release of a Regulated Article" was filed with the US Department of Agriculture (USDA-APHIS) on February 10, 2012. Over the next three years we will acquire various relevant data sets regarding oil composition and yield, but we will also assess agronomic traits and possible environmental effects of the release. We will also continue to discuss the regulatory requirements with government agencies to make sure we have a viable product when the final commercial release application is submitted.

Efficacy of Coragen® and Avaunt® Insecticides Applied Pre-Harvest for Control of Mint Root Borer in Northeast Oregon

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

Coragen® (Chlorantraniliprole) and Avaunt® (Indoxacarb) are registered for control of foliar feeding cutworms in mint. However, they are rarely used for controlling cutworms because they are more costly than the other commonly used products such as Orthene (Acephate). There is no economic reason to use either of these newer products when the old product, Acephate, can effectively control cutworms for less than one third of the price. However, there may be some cases where using these newer insecticides are preferred or are the only options a grower has.

Both Coragen and Avaunt have very low toxicity levels and have short Restricted Entry Intervals (REI) and Pre-Harvest Intervals (PHI) compared to Acephate. This allows a grower more flexibility.

Coragen and Avaunt are systemic, have ovicidal properties and have a longer residual than Acephate. Both of these new products have the potential to control the Mint Root Borer (MRB) pre-harvest in addition to cutworms. Coragen and Avaunt have the potential to provide a new way and time to control MRB.

Objective

Test efficacy of Coragen and Avaunt when applied at different pre-harvest dates for control of mint root borers in the egg or first instar stage.

Two sites were located in production peppermint fields near La Grande, Oregon. Identical experiments were set up at each site. Three separate treatment dates were determined by using local data and the degree-day model for Mint Root Borer found on the IPMP website (mint.ippc.orst.edu). It was determined that the three application dates would coincide with the accumulated Degree-Days (DD) of 850 DD, 1,000 DD and1,150 DD. The peak MRB egg-laying time occurs around 1,100 DD. These three degree days would give a good spread of times that should determine the most effective application date. In addition, one treatment had the insecticides applied twice, once before and once during the peak egg-laying time.

Results and Discussion

The accumulated degree-days that were chosen to apply the insecticides on occurred approximately two weeks later than the historical average. In the La Grande area the MRB moths generally appeared more plentiful than usual in most mint fields, however, the MRB larvae levels in most mint fields were much lower than usual.

No data was collected on the efficacy of cutworm control from either experiment due to a lack of cutworms.

There were no statistical differences between the MRB levels in any of the treatments in experiment one (Table 1). The MRB levels were so low that differences are not clear.

There is a slight trend that indicates that the first application date and the double application of Coragen were somewhat successful in reducing the MRB larvae levels.

In experiment two there were some statistical differences that indicate that all the Coragen treatments and most of the Avaunt treatments lowered the MRB larvae levels (Table 1).

This data looks encouraging for Coragen and Avaunt controlling MRB in the egg or first instar stage, however, caution should be used in drawing any firm conclusions. Mint Root Borer populations are unevenly distributed and variation in the sampling can cause data to be misleading.

Table 1 Pre-harvest applications of Coragen and Avaunt insecticides for control of Mint Root Borer eggs and first instar larvae in the La Grande, OR area (Summer 2011) Experiments One and Two.

Treatment #	Treatment	Amount of Product (Per Acre)	Application Dates	Mean number of live mint root borer (per sq. ft.)	
				Exp. # 1	Exp. #2
1	UTC			0.49	0.91 c
2	Coragen 18.4% ai	5 fl oz	7/29	0.00	0.04 a
3	Coragen 18.4% ai	5 fl oz	8/5	0.09	0.00 a
4	Coragen 18.4% ai	5 fl oz	8/12	0.53	0.07 a
5	Coragen 18.4% ai	5 fl oz + 5 fl oz	7/29 & 8/12	0.00	0.04 a
6	Avaunt 30 WG	3.5 oz	7/29	0.31	0.42 b
7	Avaunt 30 WG	3.5 oz	8/5	0.31	0.80 c
8	Avaunt 30 WG	3.5 oz	8/12	0.18	0.49 b
9	Avaunt 30 WG	3.5 oz + 3.5 oz	7/29 & 8/12	0.18	0.24 ab
LSD				NS	0.29

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

Conclusions

Several speculations can be made from this data but no firm conclusions can be made due to the low level of MRB in the trials.

It appears that the pre-harvest applications of Coragen and Avaunt were helpful in reducing the MRB levels.

The Coragen may be more effective than Avaunt.

The first application date of 7/29 or 859 degree-days appears to be the best application date for a single application. The double application on 7/29 and 8/12 appear to have provided the best control of all the treatments dates.

The 2011 season was the coolest season in recent history. The cool temperatures could have disrupted the MRB development and have been the cause of the unusually low levels of MRB. This research will be repeated in 2012.

Efficacy of Coragen® Incorporated with Different Amounts of Irrigation Water for Control of Mint Root Borer

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

In the fall of 2010 most mint fields in the La Grande area that were treated with Coragen® (Chlorantraniliprole) had the Coragen applied by ground sprayer and then incorporated with overhead irrigation. Fields that had the Coragen incorporated with center pivots had poor control of Mint Root Borer (MRB), while other fields that had the Coragen incorporated with wheelines had good MRB control. It is speculated that the pivots did not apply enough water on the first irrigation to incorporate the Coragen.

Objective

Compare the efficacy of Coragen, when applied with a ground sprayer and watered in with different amounts of water, to chemigating the Coragen with different amounts of water.

A single experiment was established post-harvest in a production, pivot-irrigated mint field infested with MRB larvae.

The Coragen treatments were broadcast applied with a $C0_2$ powered backpack sprayer in 20 GPA of water. Water was applied with hand held watering wands. The correct amount of water was determined by measuring the amount of water that came out of the watering wands for a measured amount of time. It was then determined how long a plot had to be watered to obtain the correct amount of water.

The pivot that irrigated the field had shutoff valves attached to the sprinklers over the plot area so only the water amount could be controlled for each plot.

Rhizome and soil samples were taken 27 to 34 days after the treatments were incorporated by water.

Results and Discussion

The MRB levels were so low in this experiment that there were no significant differences between any of the treatments (Table 1). There is a slight trend where the Coragen treatments decreased the MRB levels. There is no trend showing how much irrigation water is needed to incorporate the Coragen in or if chemigating Coragen is more effective than spraying it on and then incorporating it in later with water.

Conclusions

All the Coragen treatments appear to have reduced the MRB levels but no conclusions can be drawn from which treatment is most effective.

The mint root borer levels were so low that it is difficult to determine the effectiveness of the treatments. This research will be repeated in the La Grande area in 2012.

Table 1. Coragen applications of 5 fl oz./acre using different amounts of water, different methods of applications and dates of water applications. (La Grande, OR area 2011)

Treatment #	Treatment	Date insecticide applied	Amount of water applied in inches	Date water applied	Mean number of live mint root borer* per sq. ft
1	Untreated check		2.0	8/27	0.50
2	Coragen applied, and watered in later	8/24	1.0	8/27	0.35
3	Coragen applied, and watered in later	8/24	1.5	8/27	0.07
4	Coragen applied, and watered in later	8/24	2.0	8/27	0.13
5	Coragen applied by simulated chemigation	8-27	0.5	8-27	0.1
6	Coragen applied by simulated chemigation	8-27	1.0	8-27	0
7	Coragen applied, and watered in later	8-24	2.0	9-3	0.06
	LSD				NS

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

Oregon Mint
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Food Safety Certification for Mint Growers

For those of you who attended the Mint Growers Annual Meeting at Salishan in January, you may have heard Macey Wessels, I.P. Callison, give a presentation on Food Safety Certification for Mint Growers. Macey generously provided the Commission office with electronic files from her presentation at no cost. We're very pleased to be able to offer these files to all mint growers. Included are the 31-page Food Safety Program book, policy sheets for employees and visitors and Excel forms and checklists. If you would like to receive the files via email, please contact the office at 503.364.2944 or jenny@ostlund.com. Many thanks to Macey for the time and effort she put into creating the program and presenting at the regional meetings!

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

Tim Butler, Chairman, Aumsville, Oregon

Plans are beginning for the 2013 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 2013 Meeting Program and Directory, a mailing will go out 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.

This publication is available in alternative formats upon request.

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