WASHINGTON MINT GROWERS ASSOCIATION
2023
MINT CONVENTION

TUESDAY, DECEMBER 5, 2023

LABBEEMINT

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Washington Mint Growers 2023 Annual Meeting

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WASHINGTON MINT CONVENTION

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Yakima Convention Center, Yakima, WA
Tuesday, December 5, 2023
PROGRAM

7:30 a.m. Registration Desk Opens

Grab and Go Breakfast ***Sponsored by Callisons***

Morning Session

8:30 a.m. **Welcome**

8:40 a.m. **The Mint Varietal Improvement Project** – Isabelle Henry, UC Davis

9:00 a.m. **Mint Root Borer and Spider Mite Research- 2023 –** Doug Walsh, Washington State University, Prosser, WA

9:20 a.m. **Developing management tools for Verticillium wilt in peppermint and spearmint** – Jeremiah Dung, Associate Professor, Oregon State University

9:40 a.m. ***Morning Break - Coffee and Pastries Sponsored by RCB International***

10:00 a.m. **Fuel Update** – Tina Hampton, Supply and Trade Manager, Christensen

10:40 a.m. **Up to Date Report on Activities of the Mint Industry Research Council** – Steve Salisbury, Research Director, MIRC

11:30 a.m. **Let's Talk About Mint –** Kara Rowe, KR Creative Strategies

12:00 p.m. ***Luncheon - Sponsored by Labbeemint***

2023 WA Mint Growers Association Awards
Washington Mint Commission Annual Meeting

Afternoon Session

1:30 p.m. **Best Management Practices for Profitable Distillation of High-Quality Mint Oil** - Dr. Troy Peters, WSU

1:50 p.m. **Weed Control and Nitrogen Rate Trial on Native Spearmint** - Dr. Rui Liu

2:10 p.m. ***Afternoon Break - Mint Ice Cream Social Sponsored by Norwest Ingredients***

2:40 p.m. **Keynote Speaker – Climate Smart Economic Solutions** – Bob Inglis, Executive Director, republicEn

3:30 p.m. **Buyers Report** – Matt Fagerness, Purchasing Manager, Essex Laboratories

4:10 p.m. **Awarding of Mint Baskets -** ***Mint Baskets Sponsored by AgWest Farm Credit***

4:20 p.m. **Conference Adjournment**

4:30 p.m. WA Mint Growers Association Annual Meeting - All Are Invited to Attend

ONE - Washington State Pesticide Credit Available

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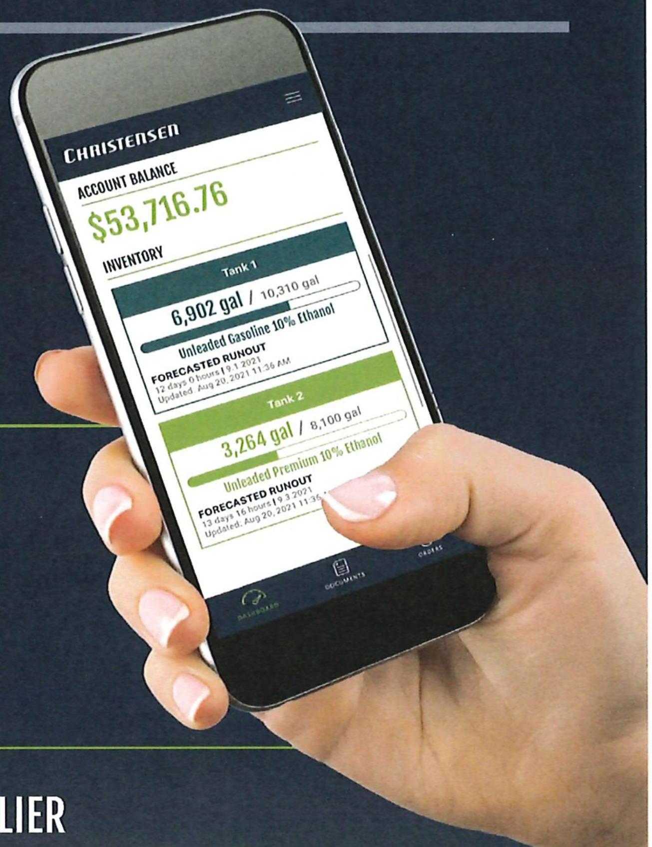

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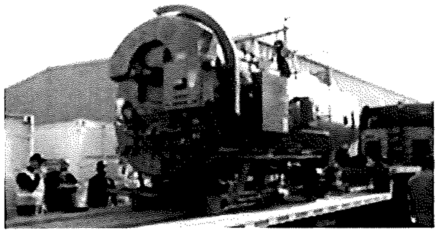

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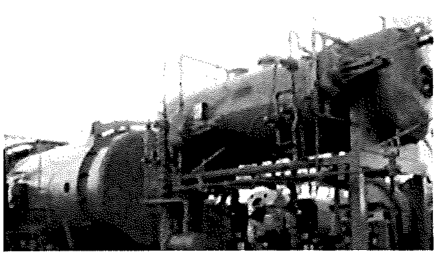

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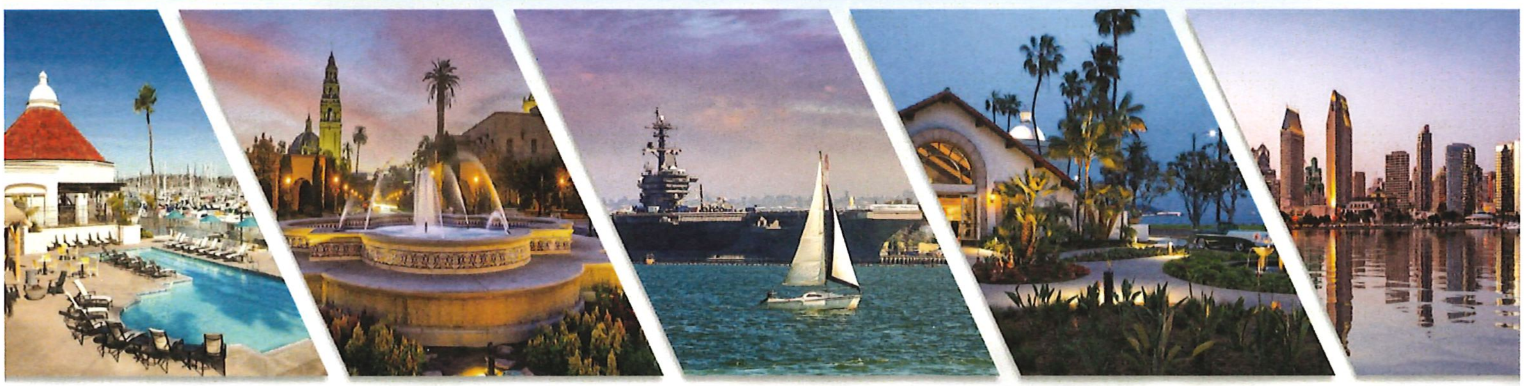

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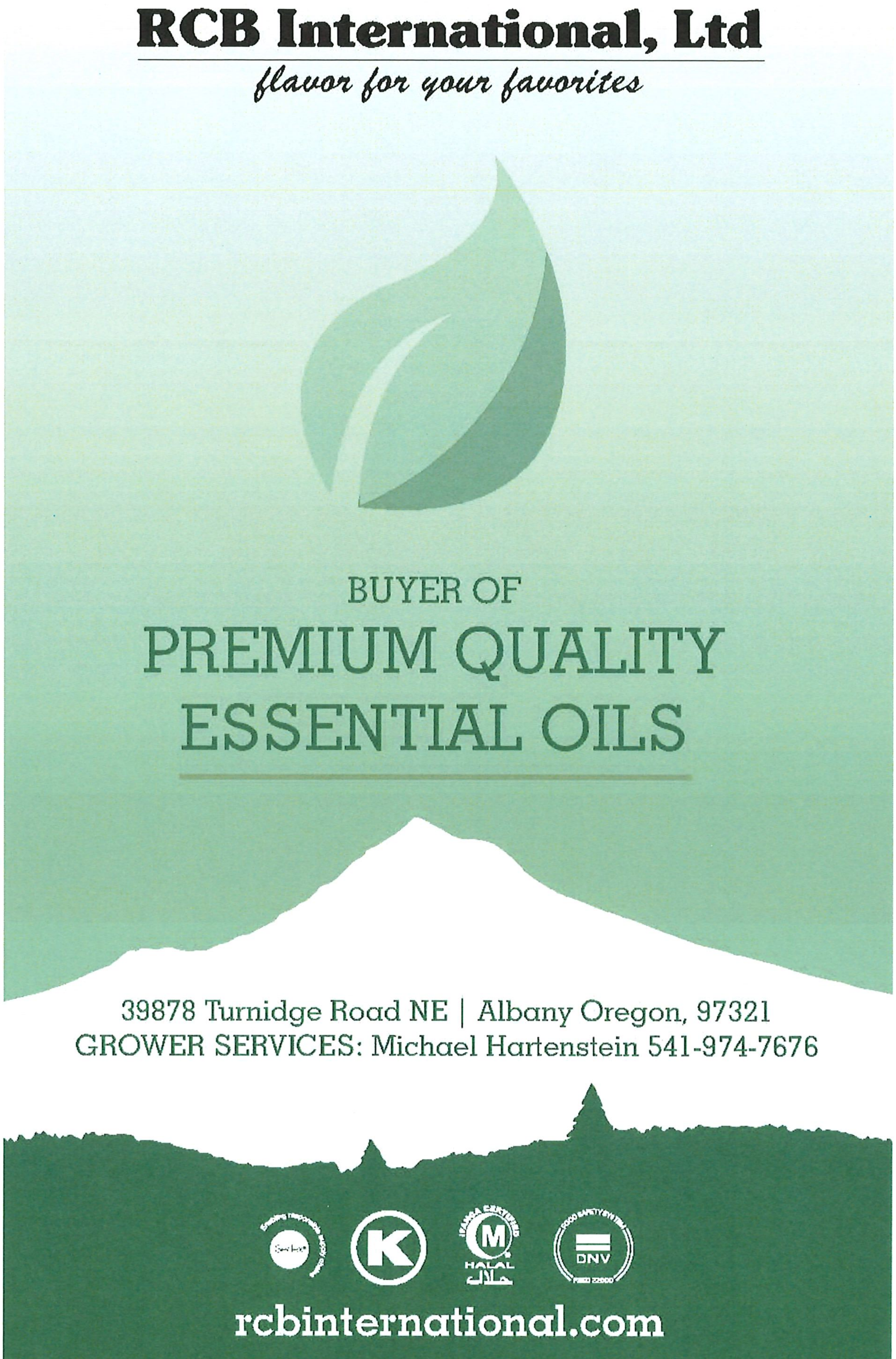

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Final Report for
Development of a pheromone mating disruption pest management strategy for mint root borer control
Submitted to the Mint Industry Research Council
November 10, 2023

1. Executive Summary. With the revocation of all food tolerances for chlorpyrifos and the negative implications this has for mint producers alternative controls for mint root borer need to be investigated. Alternative insecticides, most notably chlorantraniliprole have been demonstrated to control mint root borer. Unfortunately, chlorantraniliprole is less consistent then chlorpyrifos. Cyantraniliprole is another insecticide in the registration pipeline, but we have been unable to collect any efficacy data to date against any pest on mint.

Sex pheromones have been examined for their ability to control and monitor mint root borer. Lures can be bought commercially from different vendors and can be used to monitor adult moths, thus providing valuable information to growers. Currently, pheromones are only used as an indicator of the presence of the adult life stage of mint root borer. While pheromones have been considered in disrupting the mating biology of mint root borer, the methodology is current lacking. This project was designed to investigate a pheromone-based method that would saturate a field with enough pheromone so that males would no longer be able to locate female moths and fail to reproduce, thus protecting the mint field.

While we did observe a treatment effect in reduced capture of male moths in pheromone-baited sentinel traps in plots where pheromone dispensers were deployed compared to traps placed in peppermint fields untreated with pheromone dispensers the trap capture reduction was likely not enough to be considered successful mating disruption.

We are questioning our methodology for monitoring mint root borer larva abundance. Following harvest we went to the 4 plots in which we captured the greatest number of male mint root borer male moths over the course of the collection season and collected ten 1 gallon soil samples and transported these samples back to WSU IAREC. These samples were then split into 2 one half gallon samples that were placed in our research Berlese funnels and subjected to a warm light source above. Insects, mites, and other arthropods are disturbed in these soil samples and crawl out and drop down the funnel into a sample jar with 80% ethanol in it. After 4 days collectively among the 76 samples (we missed 2 samples in the field) we only collected 1 mint root borer larva. This leads us to question the effectiveness of our sampling methods.

2. Principal Investigator(s):
Douglas B. Walsh, Ph.D., Professor of Entomology and Extension Integrated Pest Management Coordinator. Washington State University, IAREC

3. Statement of Purpose: The overriding objective of this study was to develop a pheromone-based mating disruption program to protect mint fields from mint root borer feeding damage. Trece provided us with Pheromone dispensers with a constant amount of mint root borer pheromone in the dispenser per unit area. Differences in treatment rate was accomplished by alternating the length of dispenser on each dispenser station (see Figure 1).

4. Research Project Goals and Objectives: Pheromone dispensers were deployed in early June into a rill-irrigated peppermint field near Royal City, WA at 4 increasing treatment rates of pheromone per dispenser. Treatments were designated as TRE2781, TRE2782, TRE2783, and TRE2784. Control plots were also established. Dispensers at each treatment rate were deployed on wooden stakes in three replicate 2-acre blocks at a rate of 4 dispensers per acre. Three untreated control 2-acre blocks were also included in the trial. Two sentinel delta traps baited with a mint root borer sex pheromone lure were placed in each treatment block for monitoring male moths seeking females. A shut down or significant reduction in the number of male moths caught in these sentinel traps in treated vs untreated blocks would be indicative of successful mating disruption.

Results:
An analysis of variance was conducted with the factors of date and treatment as factors regarding the number of mint root borer moths captured in each trap. Date was a significant factor as the number of moths captured increased in late July into August. Treatment amortized over the entire monitoring period was not significant at p=0.79 However, more MRB moths were captured in sentinel traps placed in treatment 2781 than in the other treatments and the control plots (Figure 1).

This data is somewhat biased because one single sentinel trap in treatment 2781 (Trap 110) in the field we called Royal City North captured far more moths than any other sentinel trap in the other treatments and the control plots (Figure 2). This is indicative of MRB's clumped distribution in peppermint fields.

The amount of pheromone was determined by the length of SideTrak pheromone dispenser was attached to the deployment stake.

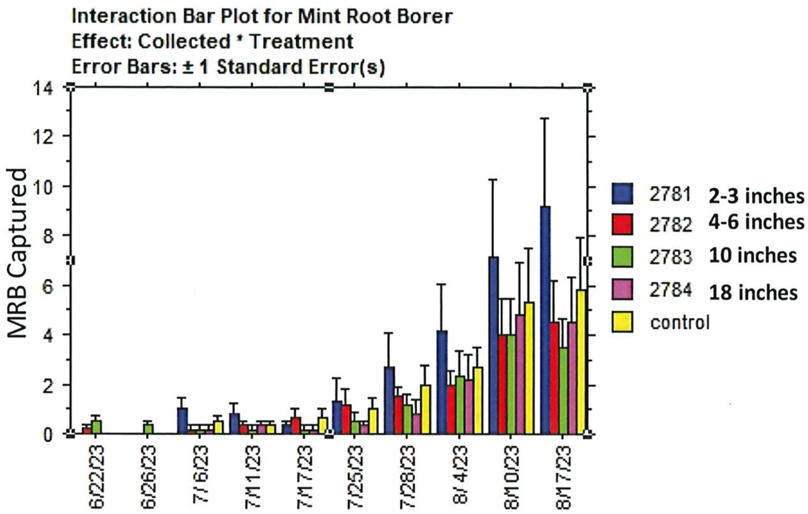


Figure 1. Pheromone dispenser (TRE2783) and MRB moths captured in sentinel traps by treatment per week.

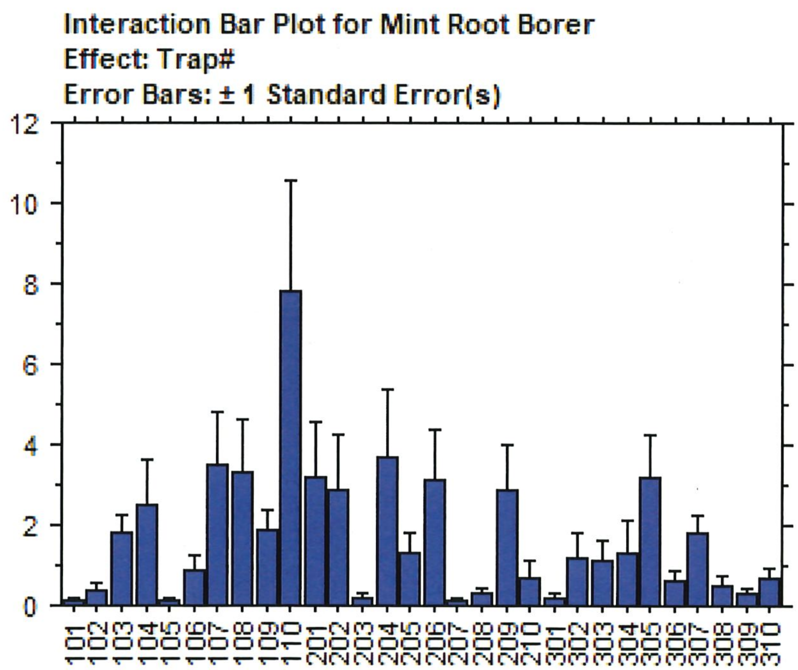


Figure 2 MRB capture by trap number

Ignoring collection dates and lumping all the data by treatment is not significant. Figure 3.

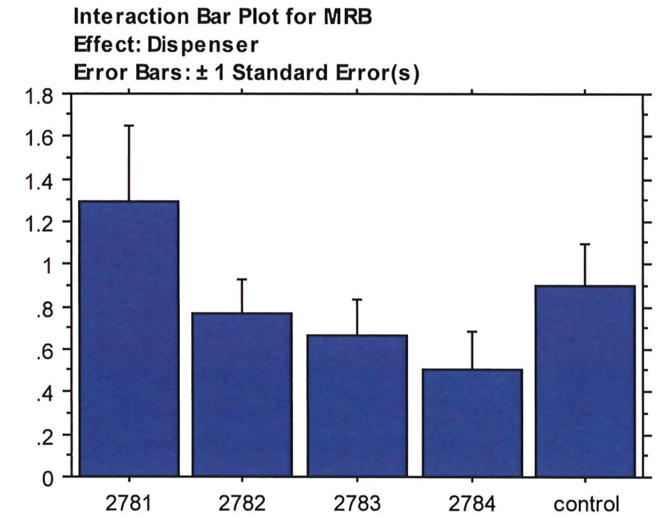


Figure 3 Average total MRB captured by treatment.

Finally, simply eliminating the outlier trap 110 (Treatment 2781) from our analysis provides a better estimate of any treatment effects. This is represented in Figure 4 and although there appears to be a numerical reduction in the sentinel trap capture in the 4 pheromone treated plots the differences between them and the untreated controls are not significant (*df*=4, 285; *F*=0.422; *P*= 0.79).

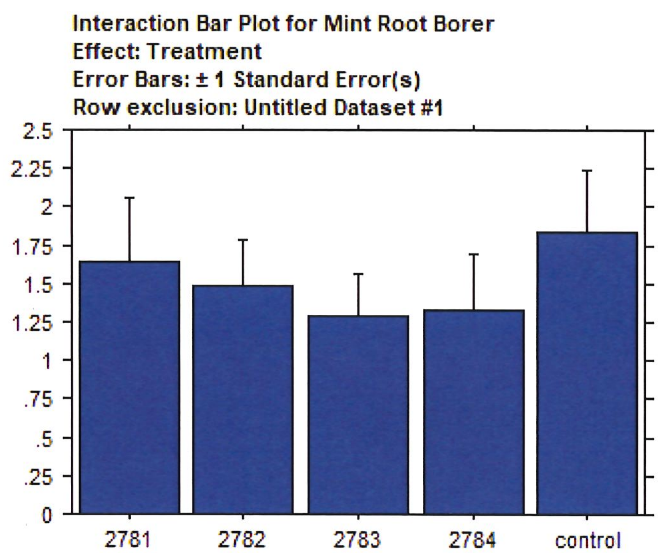


Figure 5. Average number of MRB caught by treatment after removing the results from plot110 from the analysis.

On October 4, 2022, we collected ten 1-gallon soil and root samples from the 4 plots in which we had captured the most MRB from. These were plots 110, 107, 108, and 204. Plots 110 and 204 had TRE-2781 as its dispenser treatment. This was the treatment with the shortest strips of dispenser. Plots 107 and 108 were both untreated controls with no pheromone dispensers near them.

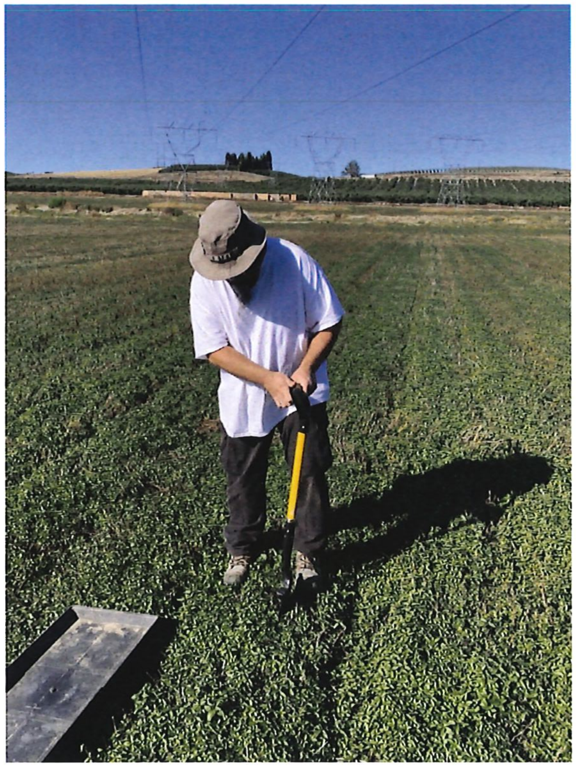


Figure 6. Collecting soil and root samples from our experimental sight

We messed up and failed to collect 2 samples. These one-gallon samples were then split into two 1/2 gallon samples for a total of 76 samples.

Figure 7. Slitting 1 gallon sample to fit in Berlese (left) and final set up of Berlese funnel bank.

From the 76 one half gallon samples processed through the Berlese funnels we collected a single lone mint root borer larva. We question the efficacy and accuracy of our mint root borer sampling methods. Overall, the peppermint field had a substantial abundance and diversity of insects in it through the season and the soil and root samples collected looked good. Other arthropods collected in the Berelese funnel soil and root samples included, annelid, spiders, collembola, tailless springtails, aphids, spider mites, orbatid mites, centipedes, sow bugs, staphylinids, other small beetles, thrips, beetle grubs, midges, small hymenoptera, and Opiliones. All of these arthropods are typically ubiquitous and their presence in abundance is indicative of good soil health.

The data collected in this field trial is inconclusive and frankly this technology will likely never be adopted by mint growers. We acknowledge that having these dispensers and pheromone baited sentinel traps in the grower field was likely a substantial inconvenience and we appreciate his patience in permitting us to complete this study.

Acknowledgements: Funds for this research were provided by the Mint Industry Research Council, the Washington Mint Commission, and the Washington State Commission on Pesticide Registration.

Final Report for
Spider Mite Management in Peppermint
Submitted to the Mint Industry Research Council
November 10, 2023

1. Executive Summary: Spider mite feeding reduces photosynthesis and decreases plant growth and overall mint oil quality and quantity produced. Efficacy studies, resistance management, and impacts on non-target species are mainstays of any IPM program including our programs in mint.

In 2023, we established and completed an acaricide efficacy study with the candidate acaricides Onanger Optek, Nealta, Vigilant 4SC, Magister, Kannemite and the alternative acaricides Cinnerate, TetraCURB and Mighty Mint oil. All of the acaricides provided significant ($p<0.05$) control of mites in treated plots compared to the mite abundance in nontreated control plots. In past years we developed robust molecular markers associated with spider mite resistance to bifenazate and bifenthrin, and etoxazole. We completed a molecular analysis of these mite populations and found some reasons for concern regarding resistance, but resistance levels for the most part were lower in the mite populations we tested from mint fields than in mite populations collected from nearby hopyards in Washington. A transcriptomic study was carried out using four mite populations (susceptible, abamectin resistant and two bifenthrin resistant populations). Differential gene expression analysis uncovered a notable disparity, with a significantly higher number of downregulated genes observed compared to upregulated genes. Gene ontology enrichment analysis revealed a striking consistency among all three resistant populations with downregulated genes predominately associated with chitin metabolism. While upregulated genes in the resistant populations are found to be associated with cellular lipid metabolism. These findings offer valuable insights into the molecular mechanisms underlying acaricide resistance in TSSM. This knowledge can be leveraged to develop innovative pesticides and molecular diagnostic tools that aid in monitoring and managing resistant TSSM populations effectively.

For the first time we augmentatively released predatory mites in concentrated 0.25 acre blocks of peppermint near Granger, WA. Following release, populations of *Gallendromes occidentalis* were able to establish at low population densities and were detectable by hand lens surveys completed in mid-summer. Populations of pest mites was quite low in this peppermint field and we doubt that the *G. occidentalis* released significantly contributed to the bioregulation of the endemic two-spotted mite population. Unfortunately, in plots where we released *Neosiulus fallacis* we were unable to detect any successful colonization in the peppermint field.

2. Principal Investigator(s):
Douglas B. Walsh, Ph.D., Professor of Entomology and Extension Integrated Pest Management Coordinator. Washington State University, IAREC

3. Statement of Purpose: Spider mite feeding reduces photosynthesis and decreases plant growth and overall mint oil quality and quantity produced. Efficacy studies, resistance management, and impacts on non-target species are mainstays of any IPM program including our programs in mint.

We established an acaracide efficacy trial in Washington State. Acaricides tested included Onanger Optek, Nealta, Vigilant 4SC, Magister, Kannemite and the alternative acaricides Cinnerate, TetraCURB and Mighty Mint oil. These alternative acaricide may gain in importance as MRL issues emerge for mint oil exports destined for specific export markets.

A transcriptomic study was carried out in 2023 using four mite populations (susceptible, abamectin resistant and two bifenthrin resistant populations). Differential gene expression analysis uncovered a notable disparity, with a significant higher number of downregulated genes observed compared to upregulated genes. Gene ontology enrichment analysis revealed a striking consistency among all three resistant populations with downregulated genes predominately associated with chitin metabolism. While upregulated genes in the resistant populations are found to be associated with cellular lipid metabolism. These findings offer valuable insights into the molecular mechanisms underlying acaricide resistance in TSSM. This knowledge can be leveraged to develop innovative pesticides and molecular diagnostic tools that aid in monitoring and managing resistant TSSM populations effectively.

In several high-value specialty crops there is an increased interest in the purchase and release of predatory mites. There may be some interest in this in mint production but the expense to augment predatory mites to an abundance that would impact spider mite population abundance is likely cost prohibitive.

4. Research Project Goals and Objectives:

1) Field test candidate compounds and recommended commercial blends of acaricides for their efficacy against spider mites.
2) Conduct field trials in grower collaborator fields with candidate alternative acaricides. This will include plant-based extracts and oils.
3) Develop a sensitive, rapid, and cost-effective method to predict multiple acaricide resistance on a portable platform.
4) Complete augmentative releases of the predatory mites Neoseiulus fallacis and Galendromes occidentalis.

5. Materials, Methods, and Results

For Objective 1, We established small research plots in our research peppermint plots. Plot size was 4 by 6 feet. A pretreatment sample was taken on August 1, following which the plots were treated at the maximum proposed label rate of each acaricide in the equivalent of 18.4 gallons of water per acre. Acaricides tested included Vigilant 4SC, Kanemite, Onanger Optek, Nealta, Magister, and the alternative acaricides Cinnerate, TetraCURB and Mighty Mint oil Treatments described in Table 1). Following the applications on August 1, 2023 samples were taken at 3 DAT (days after treatment) on August 4, 7 DAT on August 8, and 14 DAT on August 15. From these samples a total of 15 leaves per replicate were scanned under a microscope and from these counts the number of mites from these 15 leaves was totaled.

#	Product	Active ingredient	Rate/acre
1	Control	n/a	n/a
2	Cinerate	Cinamaldehyde	64 oz
3	Kanemite 15 SC	Acequinocyl	31 oz
4	Magister	Fenazaquin	36 oz
5	Mighty Mint Oil	Peppermint oils	3 gal
6	Nealta	Cyflumetofen	13.7 oz
7	Onanger Optek	Hexythiozox	20 oz
8	TetraCurb	Essential oils	1 gal
9	Vigilant 4 SC	Bifenazate	24 oz

Table1. Acaricide treatment applied to peppermint on August 1, 2023.

An ANOVA (analysis of variance) was completed on the mite counts on each date and treatment means was compared with the mite population abundance of mites in untreated control plots. Following treatment at 7 DAT on August 8, 2023 all the acaricide treatments provided significant (p<0.05 control of mites (Figure 1) and reduced the number of eggs per 15 leaves (Figure 2).

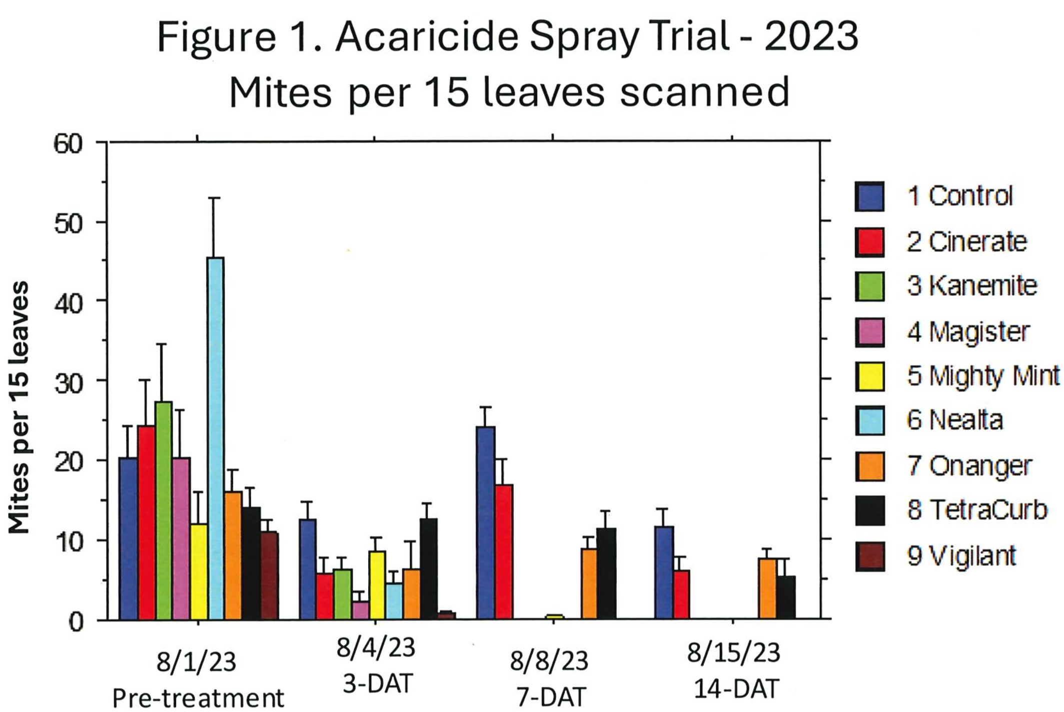
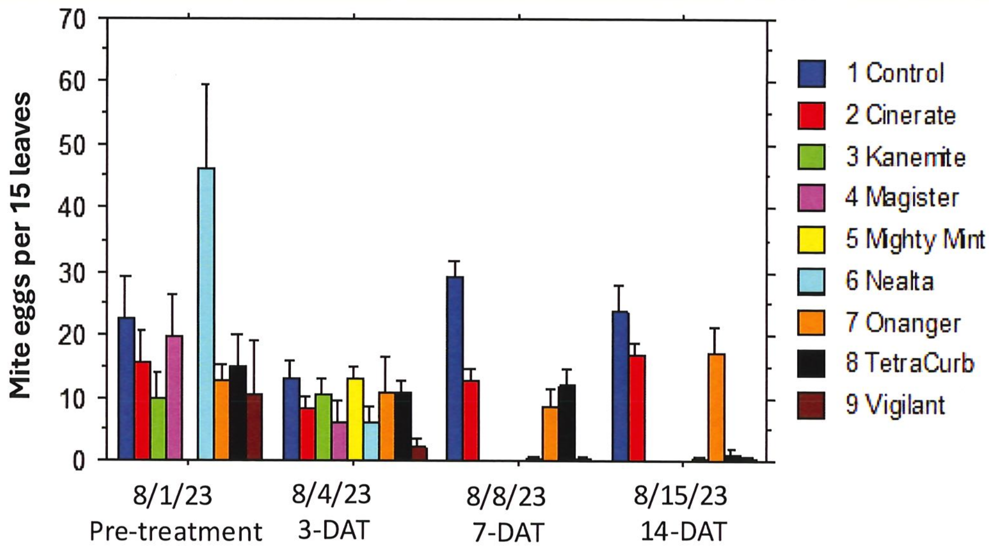


Figure 2. Acaricide Spray Trial - 2023
Mite eggs per 15 leaves scanned



For Objective 2) Conduct field trials in grower collaborator fields with candidate alternative acaricides. This will include plant-based extracts and oils.

Introduction: Based on the promising results we observed on the field trial detailed in objective a, we decided to forego large field trials and conduct more comprehensive laboratory bioassay studies this fall with Mighty Mint Oil, Tetracurb, and Cinnerate on 3 mite populations we collected from commercial mint fields in July and August in addition to running trials on our laboratory susceptible population.

Materials and Methods:

1. We created leaf disk bioassay arenas with clean 60×15 mm Petri dishes into which we placed clean cotton wool cut to fill and fit the cavity of the Petri dish. Clean water was applied to soak the cotton wool to make sure mites could not escape without drowning.
2. We cut leaf disks (2.5 cm diameter) from 2-week-old lima bean plants (*Phaseolus lunatus* L.) and placed 4 leaf disks on the cotton wool in the Petri dishes. We used clean forceps to pull up the cotton wool to form a wall around the leaf disk to prevent the mites from escaping.
3. Using a clean paint brush (size 20) we gently placed at least 10 gravid adult spider mite females on each leaf disk.
4. Each Petri dish was appropriately labelled for the replicate and the dose of acaricide tested.
5. Using a Potter precision spray tower, we sprayed 2 ml of each concentration of the acaricide.
6. After 24 h, the number of live and dead mites were counted.

7. If possible, we calculated the LC50 (lethal concentration required to kill 50% of a population), the 95% confidence interval, the slope of the dose response curve, Chi squared, degrees of freedom, and, if possible, a resistance ratio. The dose-mortality response was adjusted with the control treatment using Abbot's formula. Probit analysis was used to estimate LC50 values, slopes, and 95% confidence interval (POLO Probit 2014). The statistical analysis of LC50 values was performed according to non-overlapping of 95% CI (Table 4) on the laboratory susceptible population.

Three alternative acaricides were tested. These included:
1. Cinnerate. It contains 60% cinnamon oil as its active ingredient.
2. Mighty Mint Oil. It contains peppermint and spearmint oils.
3. TetraCURB. It contains 50% rosemary oil.

The mites tested in these initial bioassays came from our susceptible lab colony.

Results and Discussion. Mighty Mint Oil and TetraCURB performed well (Table 2 & 3). Efficacy at the rates recommended on the label for both of these alternative acaricides resulted in significant mortality. Cinnerate did not perform well in these bioassay tests. Data is presented as the percent (%) of the maximum recommended label rates for each of these alternative acaricides that is required to kill 50% of the candidate mite population

Table 2. Response of acaricide-susceptible spider mite populations to exposure to candidate alternative acaricides.

Susceptible population

Population	Product	% Mortality[a]	N	LC50	95% Cl	Slope ± SEM	X^2
Susceptible	Mighty Mint	85.0%	400	44.76	39-51	2.74±0.27	26.82
Susceptible	Cinnerate	12.5%	400	Did not calculate			
Susceptible	TetraCURB	92.5%	400	48.15	38-58	2.79±0.13	56.59

[a]Mortality at the labelled rate

Subsequently 3 populations of mites were collected from commercial peppermint fields and placed in colony in the laboratory. These populations were subsequently subjected to bioassay as detailed above and the results of these Bioassays are detailed in Table 5.

Table 3. Response of field-collected and acaricide-susceptible spider mite populations to exposure to candidate alternative acaricides.

Population	Product	% Mortality[a]	N	LC50	95%	Slope ± SEM	X^2	RR
Susceptible	Mighty Mint	87.0%	400	44.76	39-51	2.74±0.27	26.82	1.00
Granger	Mighty Mint	72.5%	200	62.69	43-88	2.17±0.36	21.68	1.40
Royal City	Mighty Mint	77.5%	200	48.45	21-78	1.85±0.33	36.10	1.08
Toppenish	Mighty Mint	100%	200	21.97	13-28	3.17±0.73	7.95	0.49
Susceptible	TetraCURB	90.0%	400	48.15	38-58	2.79±0.13	56.59	1.00
Granger	TetraCURB	95.0%	200	22.12	9-33	2.12±0.47	15.81	0.46
Royal City	TetraCURB	87.5%	200	28.46	15-40	2.08±0.40	25.53	0.64
Toppenish	TetraCURB	92.5%	200	15.89	5-25	1.84±0.44	17.24	0.36
Susceptible	Cinnerate	15.0%	400	Did not calculate				
Granger	Cinnerate	12.5%	200	Mortality < 50% at 200% label rate				
Royal City	Cinnerate	25.0%	200	Mortality < 50% at 200% label rate				
Toppenish	Cinnerate	10.0%	200	Mortality < 50% at 200% label rate				

[a]Mortality at the labelled rate

Resistance ratios (RRs) were calculated by dividing the LC_{50} of the candidate field population by the LC50 of the susceptible lab colony. As a general rule a population is considered susceptible if the RR is less than 10. Resistance is a concern when the RR ranges between 10 and 100. A population would be considered resistant if the RR exceeds 100. The resistance ratios detailed in Table 5 are inconsequential. Both Mighty Mint Oil and TetraCURB function as smotherants and with these types of acaricides resistance is typically not a concern.

Given these positive results in these bioassays and in addition to the efficacy of these products in the field trials detailed under Objective 1, these alternative acaricides could play a substantial role in spider mite IPM. Good spray coverage would be essential for good performance of these products in the field.

For Objective 3, *Develop a sensitive, rapid, and cost-effective method to predict multiple acaricide resistance on a portable platform*, two spotted spider mites (TSSM) were collected from 4 peppermint fields. One field was located near Royal City, 2 fields were near Granger, and one field was near Toppenish. From each respective location, mite populations were brought back to the Walsh laboratory and raised on beans to establish colonies. Mites from each colony were shipped to Peen State University where a transcriptomic study was carried out in 2023 using four mite populations (a susceptible population from mint, and an abamectin resistant and two bifenthrin resistant populations from hops). Differential gene expression analysis uncovered a notable disparity, with a significant higher number of downregulated genes observed compared to upregulated genes. Gene ontology enrichment analysis revealed a striking consistency among all three resistant populations with downregulated genes predominately associated with chitin metabolism. While upregulated genes in the resistant populations are found to be associated with cellular lipid metabolism. These findings offer valuable insights into the molecular mechanisms underlying acaricide resistance in TSSM. This knowledge can be leveraged to develop innovative pesticides and molecular diagnostic tools that aid in monitoring and managing resistant TSSM populations effectively. Work is ongoing at Penn State where a new post doc will continue to study the mites collected from hops and mint in Washington State.

For Objective 4) Complete augmentative releases of the predatory mites *Neoseiulus fallacis* and *Galendromes occidentalis*. We conducted augmentative releases of two predatory mite species in a commercial peppermint field near Granger in four 0.25 acre plots. Following release, populations of *Gallendromes occidentalis* were able to establish at low population densities and were detectable by hand lens surveys completed in early summer. Populations of pest mites was quite low in this peppermint field and we doubt that the *G. occidentalis* released significantly contributed to the bioregulation of the endemic two-spotted mite population. Unfortunately, in plots where we released *Neosiulus fallacis* we were unable to detect any successful colonization in the mint field. We contacted several commercial insectaries regarding a donation of *Stethorus punctillum* for commercial release in hopyards and mint fields, but there was a supply issue with these predatory beetles. Even when we offered to purchase some we were told they were unavailable. They were sold out.

For mite management conservation biological control is the most cost-effective method for controlling mites in mint field.

Acknowledgements: Funds for this research were provided by the Mint Industry Research Council, the Washington Mint Commission, and the Washington State Commission on Pesticide Registration.

2023 WA Mint Research Final Report

Project Title: Weed Control and Nitrogen Rate Trial on Native Spearmint

Principal Investigators:

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Statement of Purpose:

This project combined an herbicide efficacy trial and a nitrogen rate trial on the same established spearmint field. The purpose is to compare the new herbicide tiafenacil with other registered herbicides used in mint for weed control efficacy and to help revise the nitrogen application rates, as well as evaluate the mint oil production for each treatment.

2023 Summary of Research Goals and Objectives:

1) Evaluate new herbicide tiafenacil use in mint, including stand-alone or in tank-mixtures with other registered herbicides.

2) Quantify the spearmint hay yield and oil yield responses in relation to applied nitrogen at three different timings/application splits.

Summary of Results:

1. ***Herbicide trial:***

The herbicide trial was conducted at an established (since 2018) double-cut native spearmint field at the Irrigated Agriculture Research and Extension Center in Prosser, WA. The experiment used a complete block design with 4 replications. Plots are 10*30 ft. Herbicide treatments were applied by a bicycle sprayer that delivers 20 GPA solution at 40 PSI.

The dormant treatments were applied on 2/27/2023. Visual control (%) on weeds and mint injury (%) were recorded 7 days after application and 14, 21, and 28 days after mint green-up (3/27/2023). Weed species include rattail fescue, prickly lettuce, dandelion, and salsify.

The first harvest of mint was on 6/28/2023. Mint hay fresh yield was recorded by weighing three bags of 7 lb/bag hay, plus the leftover hay in the plot, harvested by a 5 ft-wide cutter. Samples were placed on a rack to air-dry for 7 days. Hay samples were distilled for oil using standardized mini-stills at WSU-IAREC in Prosser, WA. The first cutting samples were distilled on the week of 7/12/2023. Mint oil yield was recorded.

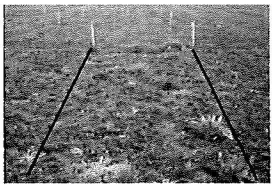
After 1st cutting, two Reviton treatments were applied on the same plots on 8/1/2023. Visual control (%) on weeds and mint injury (%) were recorded 7, 14, and 21 days after herbicide application. Mint 2nd harvest was on 9/6/2023. Samples were dried for 10 days and were distilled on the week of 9/18/2023.

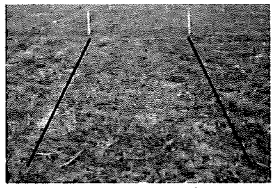
Herbicide trial results:

Due to maintenance herbicide been applied to the rest of the field. Only the MIRC multi-state herbicide treatments were tested. A dose-response study of Reviton herbicide was tested after mint first cutting. Observations are still ongoing. Below are results from the multi-state trial.

Data on spearmint injury %, hay (lb/a) and oil (fl oz/a) were summarized in Table 1. Minor spearmint injury (4-7%) was observed for Reviton at 4 fl/ oz (trt 4) and Sharpen + Zidua (trt 5) treatments at 0.09 oz/a at 14,21 and 28 days after mint green up in April 2023. Hay yield from herbicide-treated plots ranged from 3012 to 6490 lb/a, significantly higher than non-treated check (2361 lb/a). There was no significant difference among herbicide treatments for hay yield. Mint oil yield from herbicide-treated plots ranged from 110 to 315 fl oz/a, significantly higher than the non-treated check (28 fl oz/a). Sharpen+ Zidua (trt 5) had the highest oil production (315 fl oz/a). Hay yield from 2nd cutting was not enough for oil distillation, therefore, data was not present in table 1.

Data on weed control % was presented in Table 2. The dominant weed species were rattail fescue, prickly lettuce, dandelion, salsify, and flixweed. All herbicide treatments provided moderate to excellent control on prickly lettuce and flixweed at 14, 21, and 28 days after spearmint green-up. Reviton at lower rate (2 fl oz/a) did not provide good control on rattail fescue. However, at a higher rate (4 fl oz/a), control % improved significantly.


Check


Reviton 2 fl oz/a


Reviton 4 fl oz/a


Gramoxone, 32 fl oz/a


Zidua + Sharpen 0.09 fl oz/a

Figure 1. Plots on April 10. 2023, 14 days after spearmint green up.

Table 1 Spearmint injury, hay, and oil yield

No.	Herbicide Treatment	Rate (fl oz/a)	Injury (%)	Injury (%)	Injury (%)	1st cutting yield (lb/a)	2nd cutting yield (lb/a)	1st Cutting oil yield (fl oz/a)
			4/10/2023	4/17/2023	4/25/2023			
1	Check	-	0	0	0	2360	62	28 b
2	Gramoxone	32	0 c	0 b	0 b	3522	396	132 ab
3	Reviton	2	0 c	0 b	0 b	3716	165	165 ab
4	Reviton	4	5 b	5 a	4 a	3012	91	110 ab
5	Sharpen + Zidua	0.09	7 a	6 a	4 a	6490	1100	315 a

Different letters within a column indicate significant difference (p<0.05)

Table 2 Weed control in 2023 season

No.	Herbicide Treatment	Rate (fl oz/a)	Rattail fescue	Rattail fescue	Rattail fescue	Rattail fescue	Prickly Lettuce	Prickly Lettuce	Prickly Lettuce	Prickly Lettuce
			3/6	4/10	4/17	4/25	3/6	4/10	4/17	4/25
1	Check	-	0	0	0	0	0	0	0	0

2	Gramoxone	32	44 a	71 a	64 a	60 a	99	100 a	100	100 a
3	Reviton	2	10 b	8 b	5 b	3 b	95	75 b	80	71 b
4	Reviton	4	86 a	99 a	86 a	83 a	98	88 ab	84	86 ab
5	Sharpen + Zidua	0.09	70 a	91 a	81 a	84 a	90	98 a	94	91 ab

Different letters within a column indicate significant difference (p<0.05)

Table 2 Weed control in 2023 season (Continued)

No.	Herbicide Treatment	Rate (fl oz/a)	dandelion	dandelion	dandelion	dandelion	Salsify	Salsify	Salsify	Salsify
			3/6	4/10	4/17	4/25	3/6	4/10	4/17	4/25
1	Check	-	0	0	0	0	0	0	0	0
2	Gramoxone	32	84	1	23	60	80 b	97 a	88 ab	85 a
3	Reviton	2	90	16	34	41	100 a	22 b	55 b	54 b
4	Reviton	4	70	2	23	32	85 b	100 a	100 a	97 a
5	Sharpen + Zidua	0.09	75	10	10	30	100 a	17 a	74 ab	78 ab

Different letters within a column indicate significant difference (p<0.05)

Table 2 Weed control in 2023 season (Continued)

No.	Herbicide Treatment	Rate (fl oz/a)	flixweed	flixweed	flixweed	flixweed
			3/6	4/10	4/17	4/25
1	Check	-	0	0	0	0
2	Gramoxone	32	100	100	100	96
3	Reviton	2	100	100	100	100
4	Reviton	4	78	100	100	100
5	Sharpen + Zidua	0.09	100	100	98	98

2. *Nitrogen rate trial*

A total of 18 treatments consisting of a combination of six N rates and three N application timing were tested on the same spearmint field at IAREC, Prosser, WA. The experimental design is a randomized complex block with three replicates. There will be 54 plots (3 timings x 6 rates x 3 replications). Each plot has a size of 20 ft x 30 ft. Ammonium sulfate was used as the N source.

N timings:

(T1) all N in the spring and none after the first cutting,

(T2) ½ of N in the spring and ½ after the first cutting, and

(T3) 2/3 of N in the spring and 1/3 after the first cutting.

N application rates:

(R1) 250 lbs/acre; (R2) 200 lbs/acre; (R3) 150 lbs/acre,

(R4) 100 lbs/acre; (R5) 50 lbs/acre, and; (R6) 0 lbs/acre.

Additionally, within the non-fertilization plots, we split a small portion (with a dimension of 5 ft x 30 ft) for additional N fertilization tests to compare the effect of different fertilization on mint growth and production. Three type of fertilization was conducted including SuperU (46-0-0), Multi-cote (41-0-0), and UAN32 (liquid). The fertilization was based on a N rate of 100 lbs/ac. SuperU and Multi-cote were applied in spring, while UAN32 is being applied 5 times throughout the crop season.

In addition, we are evaluating the leaf nutrient content, soil nutrient content, and leaf greenness, as well as observe mint growth throughout the crop season. By combining the hay yield and oil yield data, we expect to provide the critical leaf and soil nutrient level which is related to the best hay and especially oil production.

2. *Nitrogen rate trial results:*

1) ***<u>Mint hay yield:</u>*** The hay yield at 1st cutting and 2nd cutting results are shown in Fig. 2. At first cutting when nitrogen was all applied in the spring (T1), higher hay yield was observed when higher nitrogen was applied (R1, 250 lb/a vs. R6, 0 lb/a). However, when N was applied half in the spring and half after the first cutting, no significant difference was observed for hay yield. A similar trend is observed for T3, 2/3 of N in the spring, and 1/3 after the first cutting. Hay yield from 2nd cutting is lower than 1st cutting overall due to cooler temperatures and shorter days for biomass accumulation.

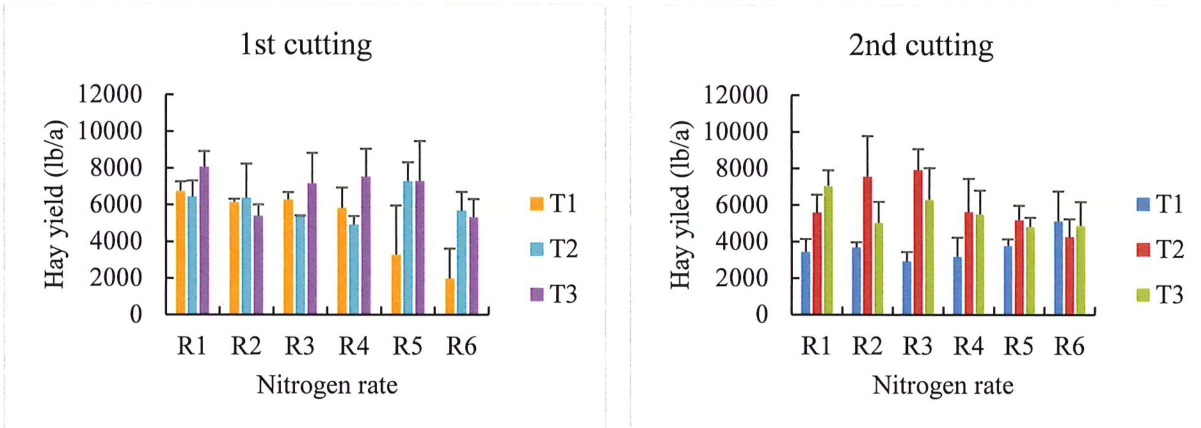


Figure 2. The hay yield under the different N fertilization methods (T1- all N in the spring and none after the first cutting; T2- ½ at 1st cutting and 2nd cutting; T3-2/3 of N in the spring and 1/3 after the first cutting) and rate (R1- R6, 0-250 lbs/ac).

2) ***Mint oil production***: Mint oil production results are shown in Figure 3. Overall, mint oil production from the 1st cutting was more than from the 2nd cutting. When all N were applied in the spring, oil production is associated with the amount of N applied, however, no significant difference were found among all six nitrogen rates. Similar trend was observed in T3, 2/3 of N in the spring and 1/3 after the first cutting. On the contrary, for T2, ½ at the first cutting and ½ 2nd cutting, the more N applied, the less oil was produced.

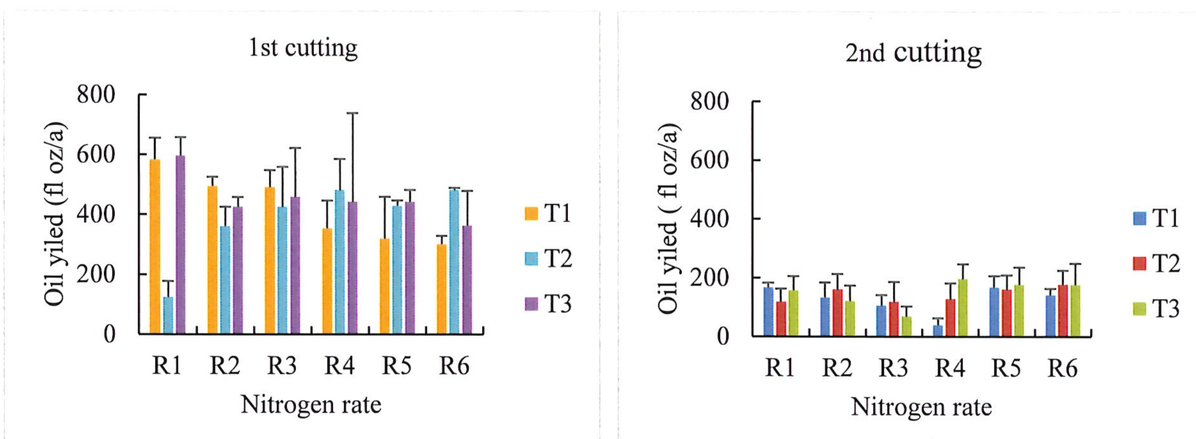


Figure 3. Mint oil production under the different N fertilization methods (T1- all N in the spring and none after the first cutting; T2- ½ at 1st cutting and 2nd cutting; T3-2/3 of N in the spring and 1/3 after the first cutting) and rate (R1- R6, 0-250 lbs/ac).

3) Mint leaf greenness: The mint leaves were taken 3 times before the first cutting. The leaf greenness was also measured 3 times. The data showed that the leaf greenness decreased with the lower N rate, especially during the late growing stage, regardless of the fertilization methods (Fig. 4).

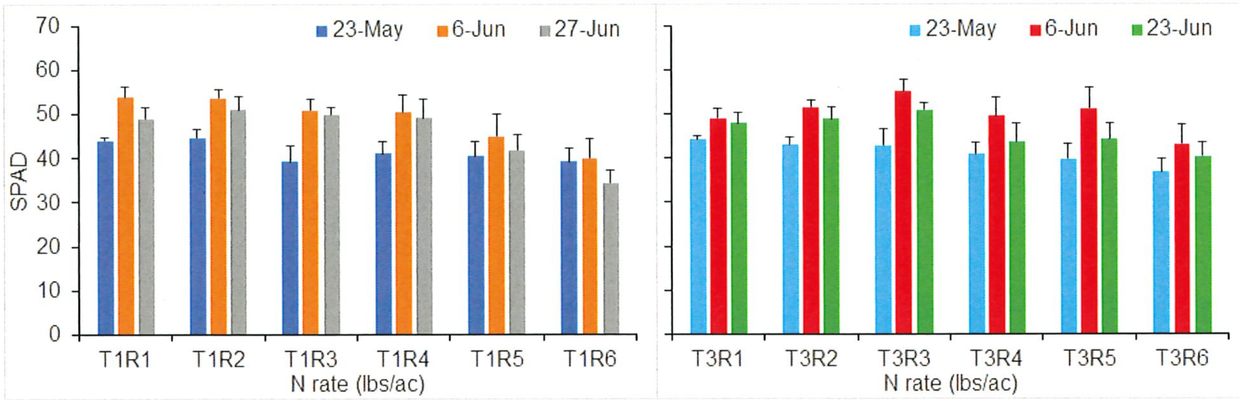


Figure 4. The leaf greenness under the different N fertilization methods (T1: 100% application in spring vs T3: 2/3 N in spring +1/3 N in fall) and rate (0-250 lbs/ac).

2)

2023 Report: Best Management Practices for Profitable Distillation of High-Quality Mint Oil

Principal Investigator(s):
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Statement of Purpose:
Mint distillation can be a complex process with lots of equipment to maintain and decisions to be made. Mint stills and distillation processes are as different and varied as the growers that built them. It would be helpful to have generalized guidance to help growers understand in an easily digestible and accessible format some guidelines for the more profitable and energy efficient distillation processes. This included still designs and a better understanding of the distillation process and variables that can affect profitability and mint oil quality.

Summary of Objectives:
We worked with three different producers to characterize the mint oil distillation methods and practices. The data collected included break-through times. Also, mint oil production rates (in lbs/min) and oil samples were collected every 5-10 minutes. These oil samples were submitted to RCB International who ran them for component analysis.

Actions Taken to Date:

- Worked with two grower cooperators to collect data from their first harvest (for double-cut mint) of native spearmint in July.
- Worked with another grower during their second harvest of spearmint in September.
- Also worked with a grower during their harvest of peppermint (single cut) to collect data.
- Obtained mint oil distillation rate curves from each of the four different mint distillation events and obtained oil samples from throughout the distillation process.
- The samples from one cooperator were errantly put into incompatible plastic vials that the mint oil dissolved. Those samples were unfortunately lost.

Results:

The results from working with the three different cooperators (named here cooperator 1, 2, and 3) during four separate distillation events (3 spearmint, and 1 peppermint) are given below. The total distilled oil, the distillation rate, and the oil component analysis and how that changed over the course of the distillation (when available) are given in the charts below (Figures 1-4).

Cooperator 1. Spearmint.

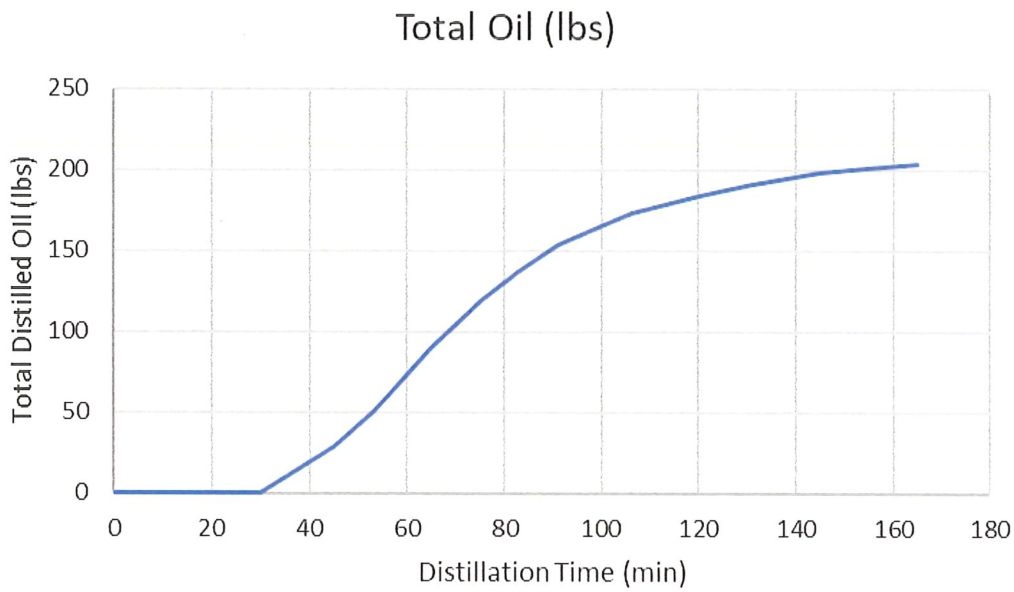

Figure 1. Total distilled spearmint oil from cooperator 1 over the distillation time in minutes.

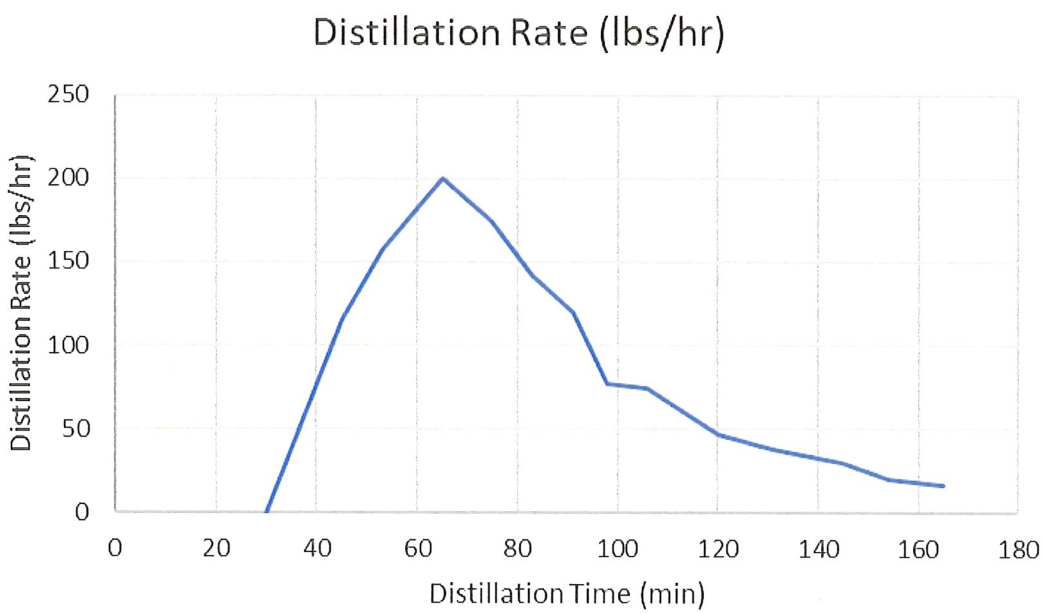

Figure 2. Spearmint oil distillation rate from cooperator 1 (oil distilled divided by the time it took to distill it).

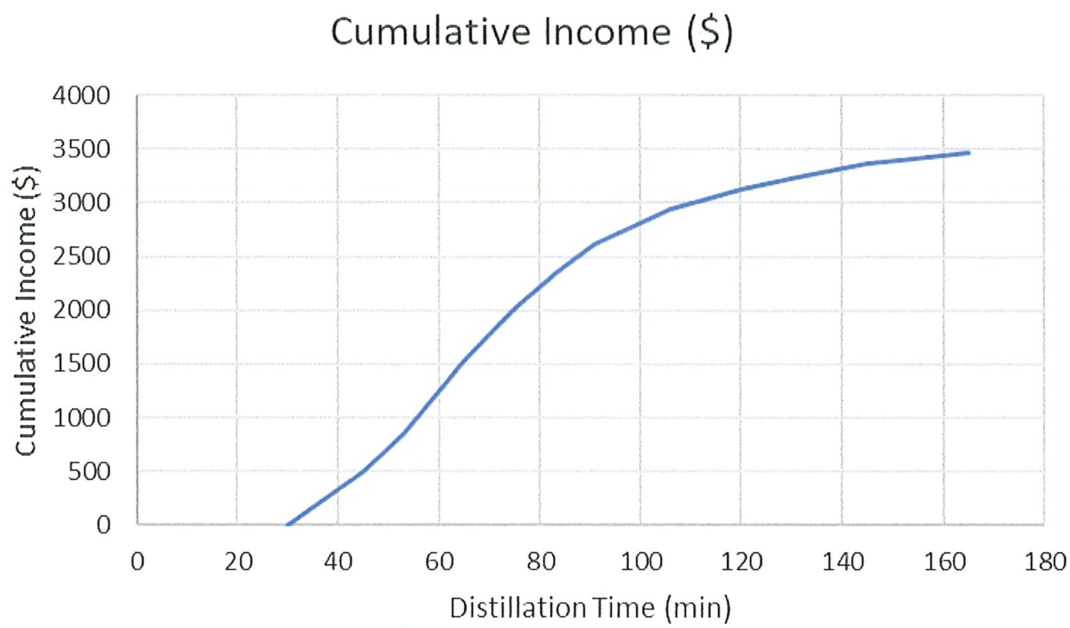

Figure 3. Estimated cumulative income from cooperator 1 over the distillation time in minutes. This is essentially the data from Figure 1 multiplied by an estimated oil price of $17/lb.

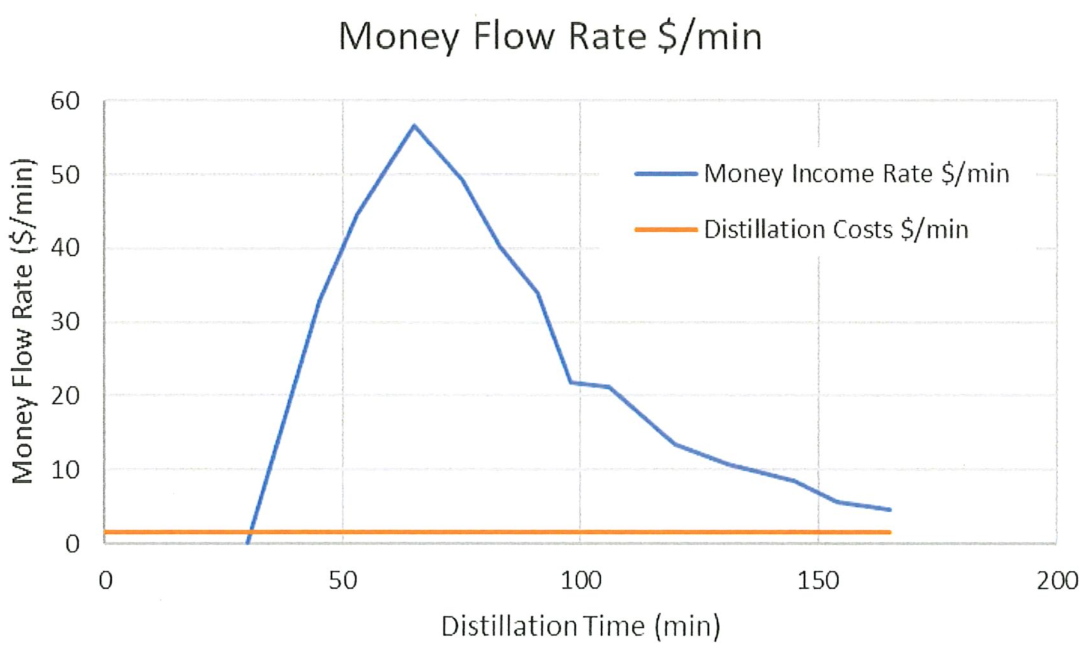

Figure 4. Example money income from oil vs outflow to distillation costs for cooperator 1. This used a series of assumptions regarding the mint oil prices, fuel costs, use rate, and the labor and still costs amortized over the run time of the distillation event.

Oil samples were collected for oil component analysis. Unfortunately, the vials used to contain the samples were the wrong sort of plastic and were dissolved by the mint oil resulting in the loss of these samples.

Cooperator 2. Spearmint.

We collected data from a spearmint distillation event from cooperator 2. These results are shown in Figures 5-10.

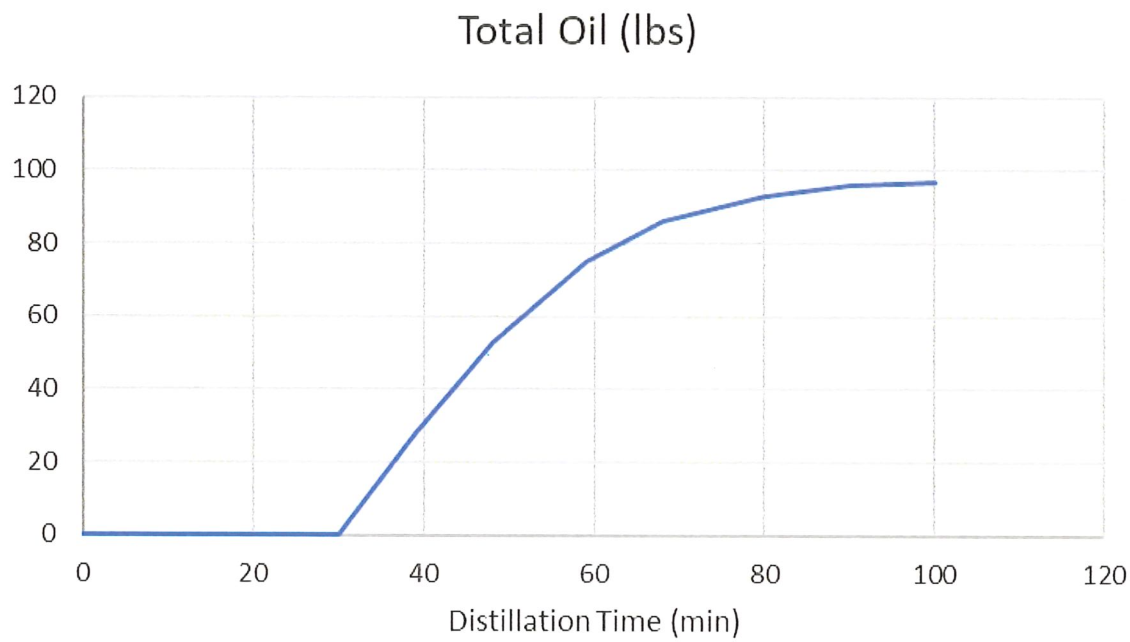

Figure 5. Total spearmint oil distilled from cooperator 2 as a function of distillation time.

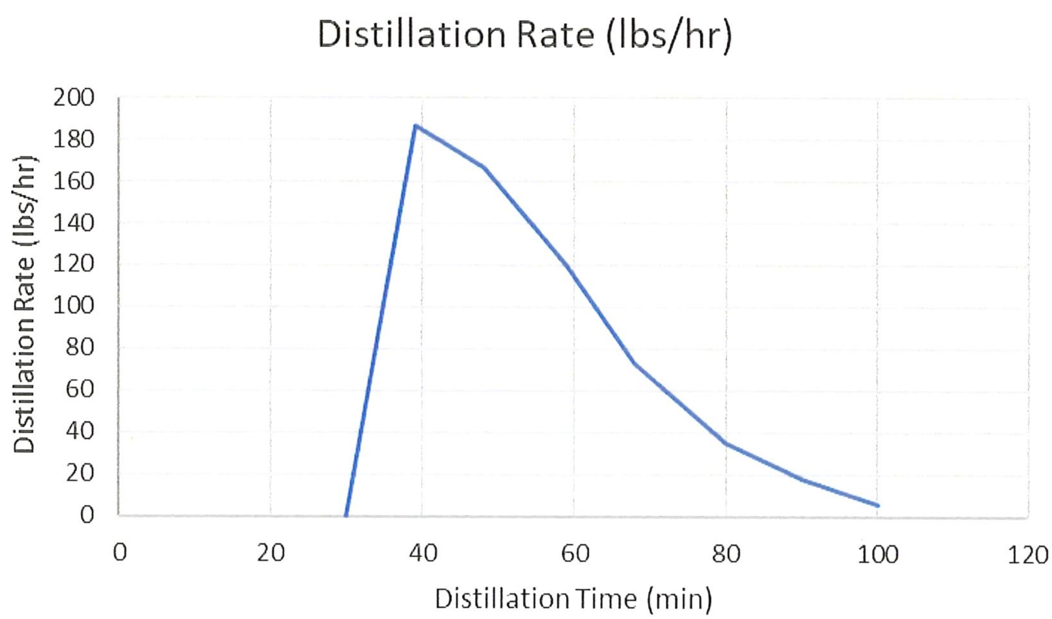

Figure 6. Spearmint oil distillation rate from cooperator 2 in pounds per hour.

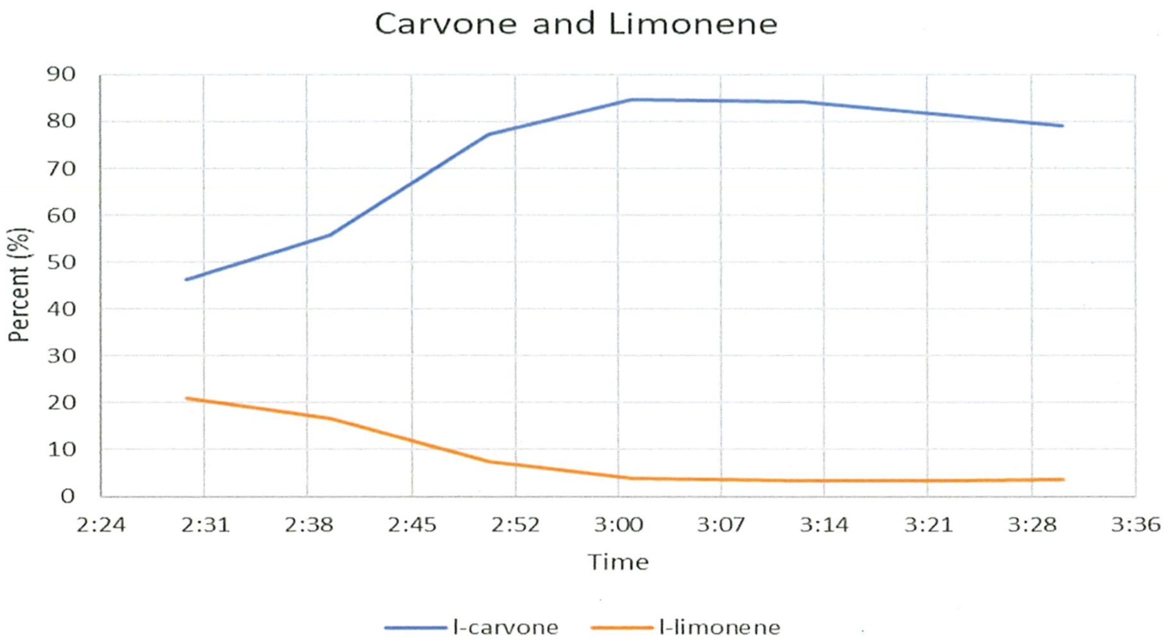

Figure 7. The carvone and limonene contents of the distilled oil from cooperator 2 as a percentage of the total oil mass as a function of the distillation time.

The carvone content increases over time (Figure 7) but peaked about 40 minutes into the distillation event and decreased after that. Limonene content steadily decreased over the distillation time.

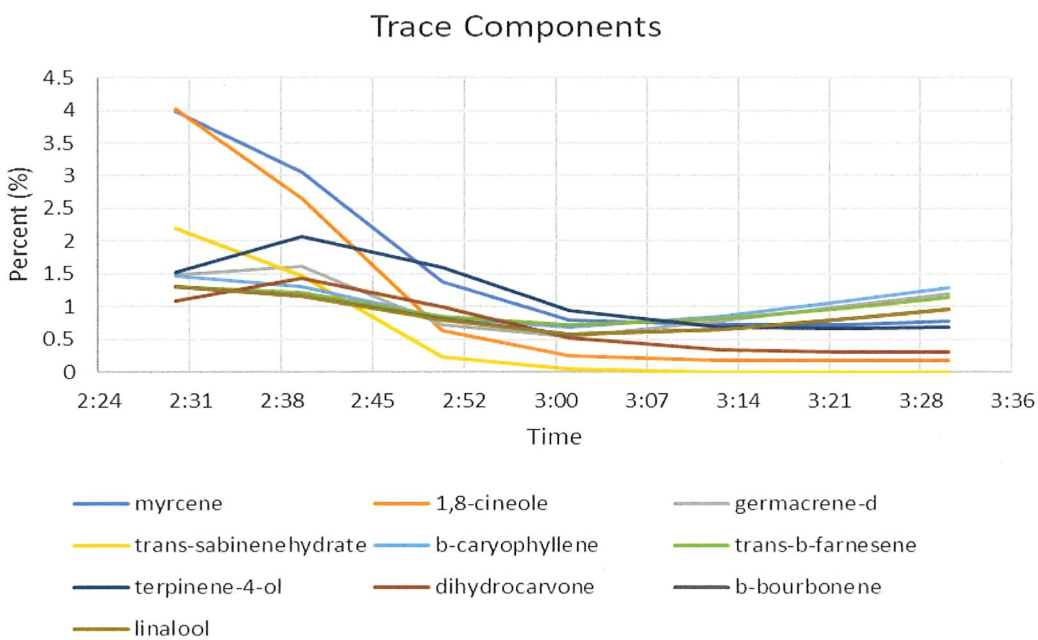

Figure 8. Other trace component contents of the distilled spearmint oil from cooperator 2 as function of the distillation time. Many of these also increased after about 40 minutes into the distillation time.

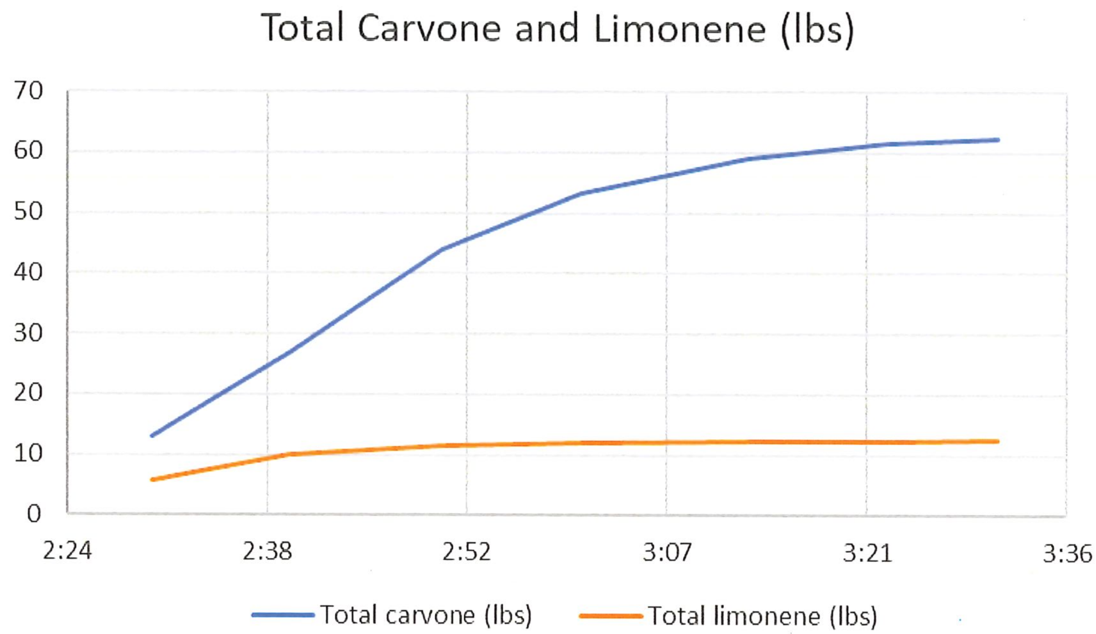

Figure 9. Total carvone and limonene distillation rates (in total pounds) in the spearmint oil distillation of cooperator 2.

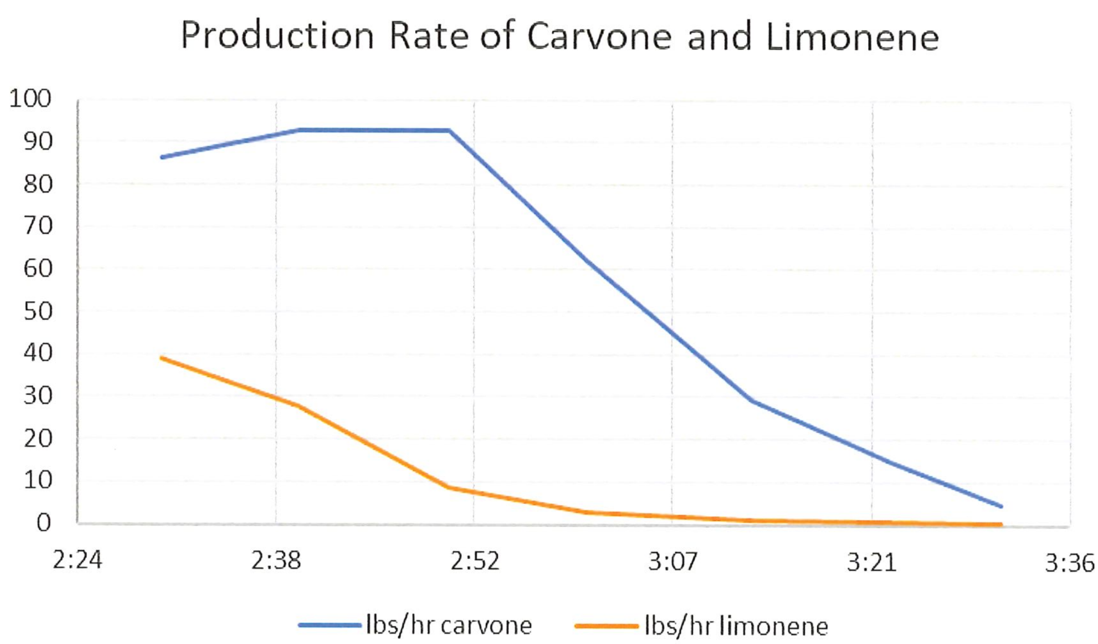

Figure 10. The oil production rate multiplied by the percentage components to show the production rate of carvone and limonene as a function of the oil distillation time showing that overall carvone production rates peak about 30 minutes into the cook, while limonene drops steadily.

Cooperator 2, Peppermint.
Data was also collected from cooperator 2 during the peppermint harvest (single cut peppermint). The results are shown in Figures 11-15.

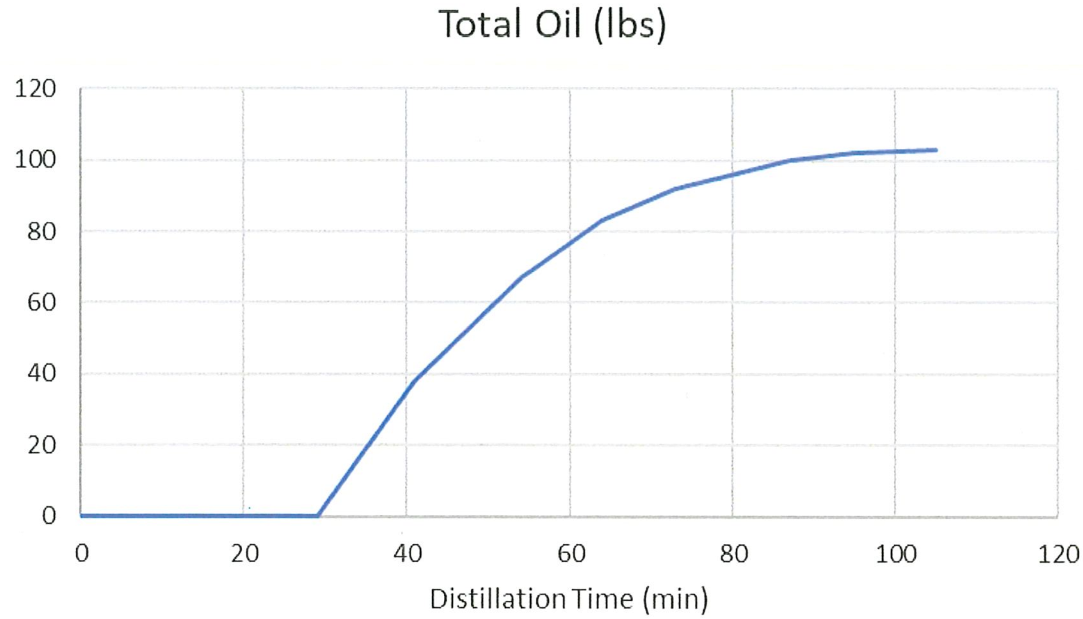

Figure 11. Total peppermint production rate as a function of distillation time for cooperator 2.

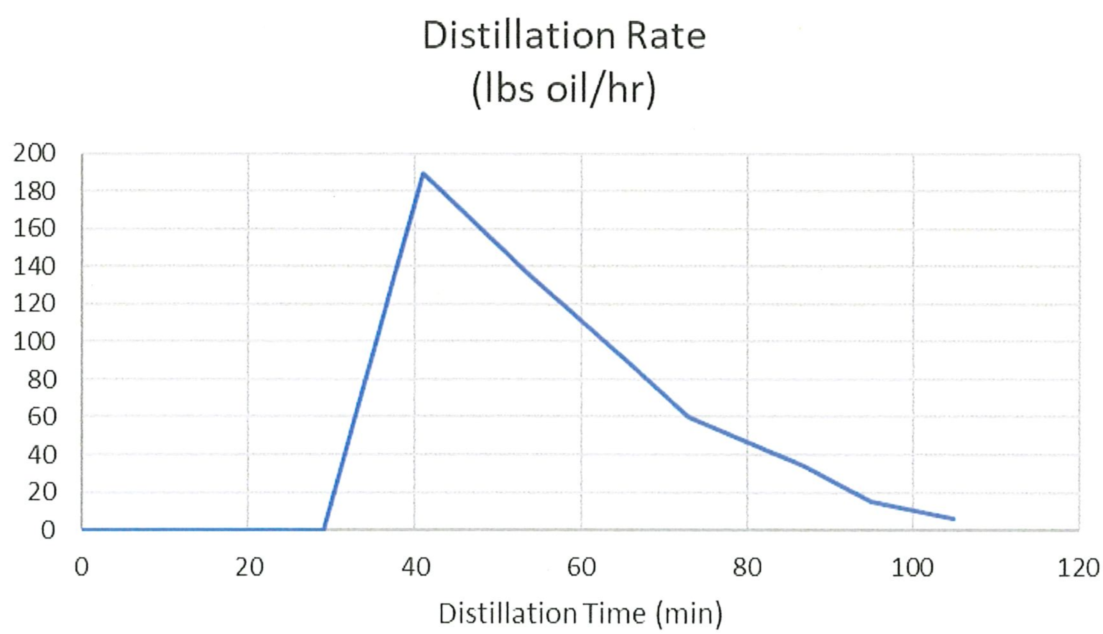

Figure 12. Peppermint oil distillation rates as a function of distillation time for cooperator 2.

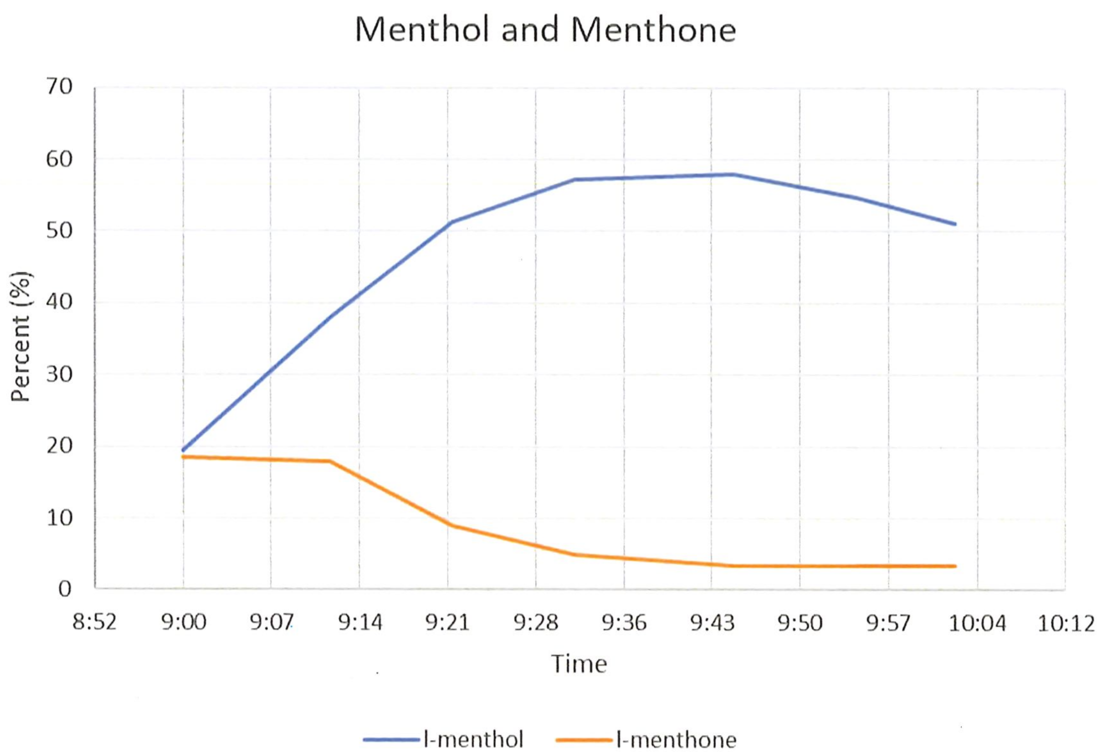

Figure 13. Menthol and Menthone components of the distilled peppermint oil from cooperator 2. Similar to carvone in spearmint, the menthol concentration in the distilled oil peaked about 40-50 minutes into the distillation time and then decreased after that.

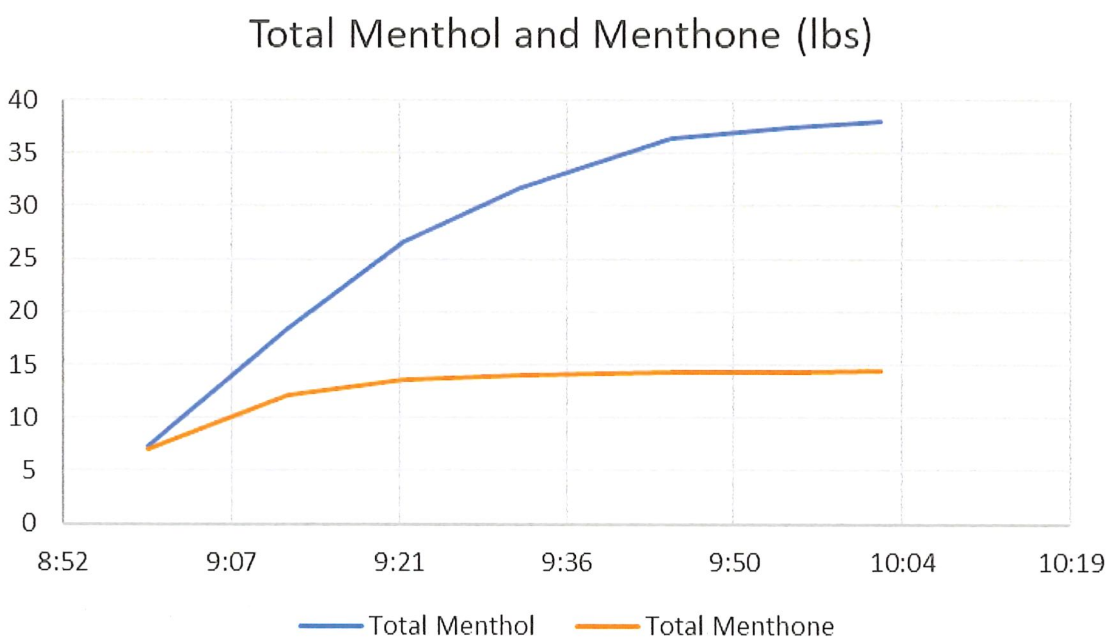

Figure 14. Total menthol and menthone production rates (total oil production rate multiplied by the oil component percentage) as a function of distillation time during the peppermint oil distillation from cooperator 2.

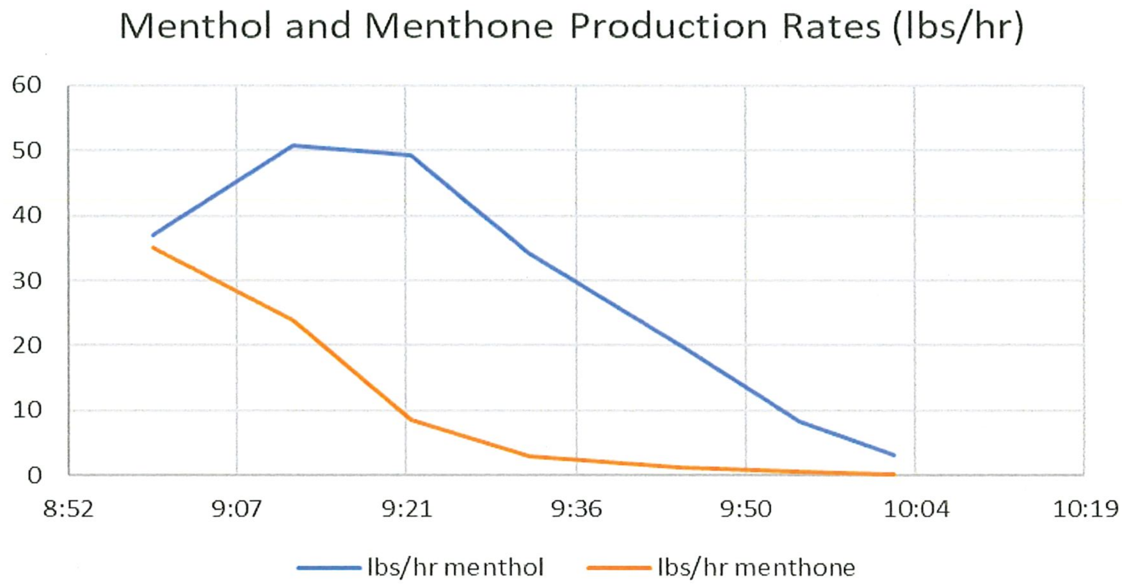

Figure 15. The menthol production rate in lbs/hour in peppermint distillation for cooperator 2 peaks a few minutes after breakthrough, while it steadily declines for menthone.

Cooperator 3. Spearmint.

The data from the distillation of the spearmint oil from cooperator 3 behaved in a strange manner with two rates. This may have been due to adjustments being made to the boiler and steam flow rates for the other tubs at the time of the distillation.

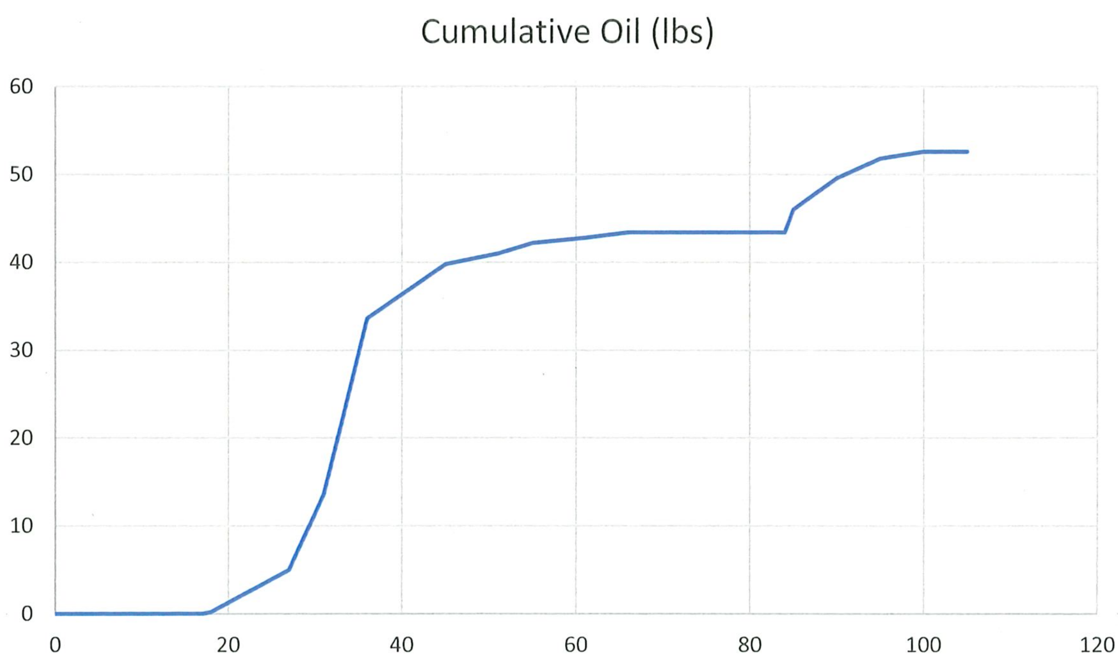

Figure 16. Total spearmint oil distilled by cooperator 3. This may have been due to adjustments to the boiler steam flow during the distillation process.

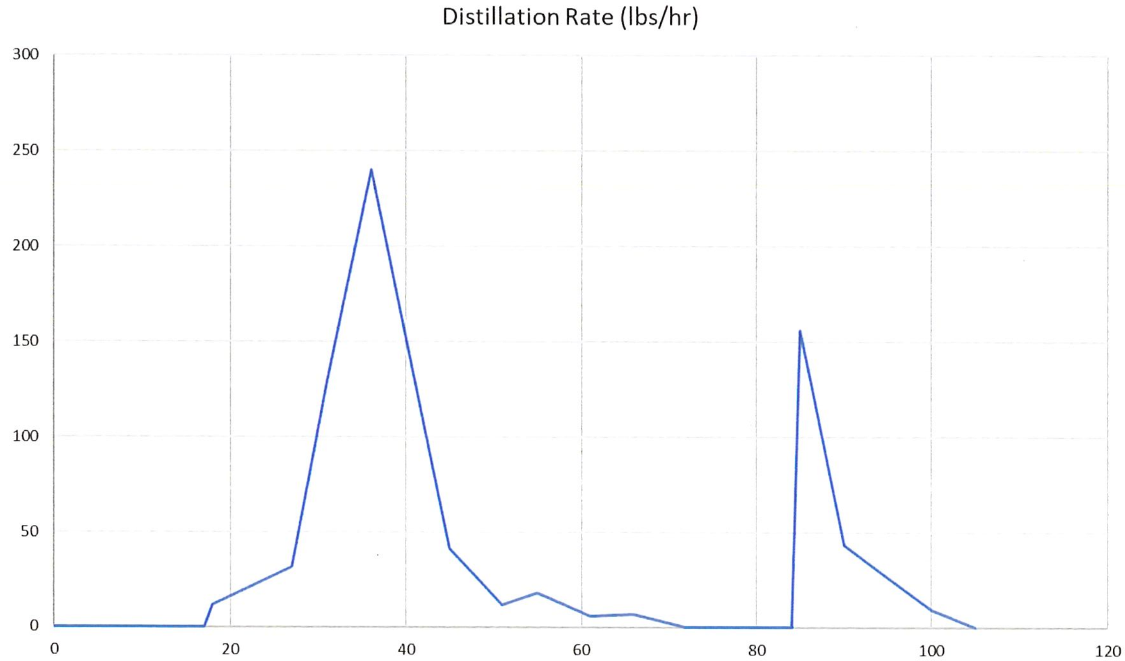

Figure 17. A bi-modal spearmint oil distillation rate from cooperator 3. This may have been due to adjustments to the boil steam flow during the distillation process.

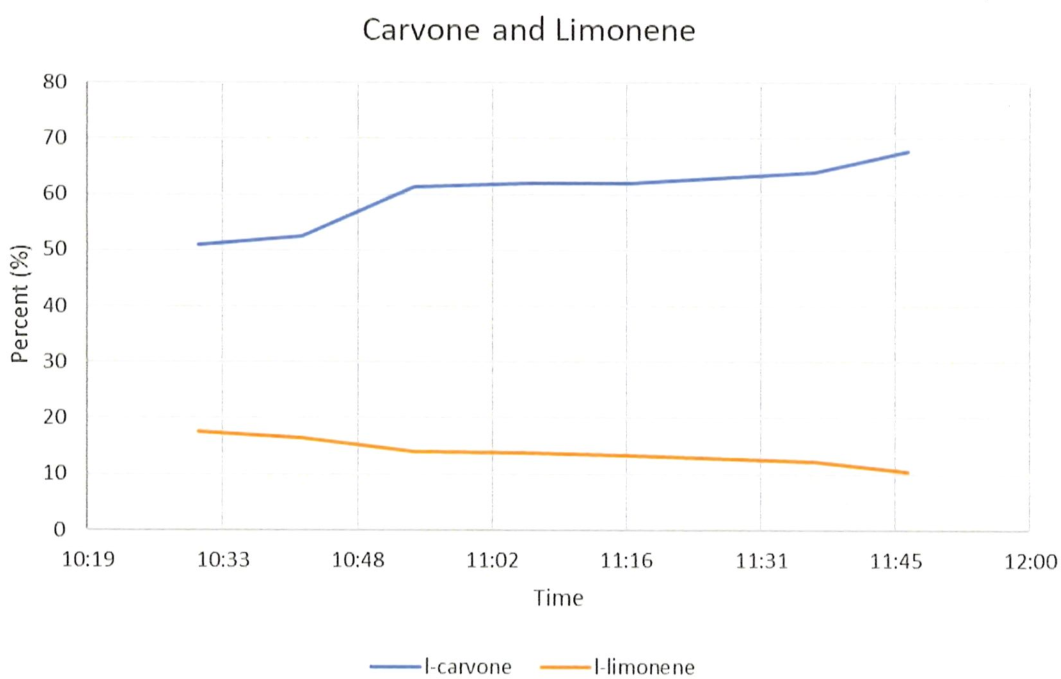

Figure 18. Carvone and limonene contents of the distilled spearmint oil from cooperator 3 as a function of the distillation time.

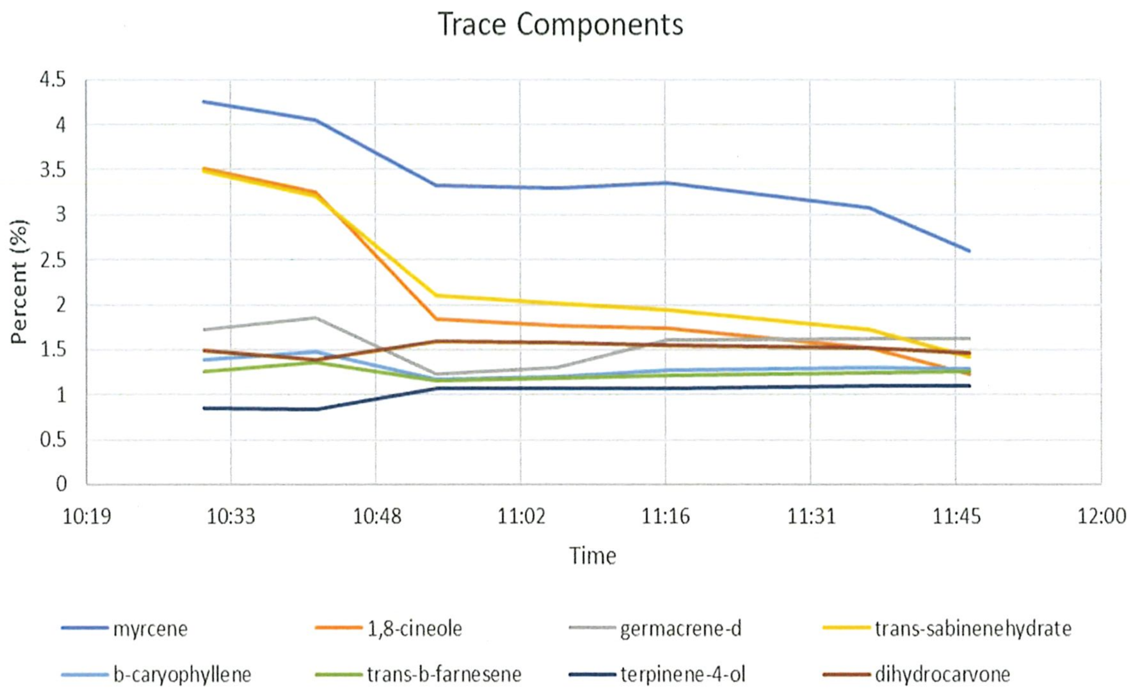

Figure 19. The minor, or trace components of the distilled spearmint oil from cooperator 3 as a function of distillation time.

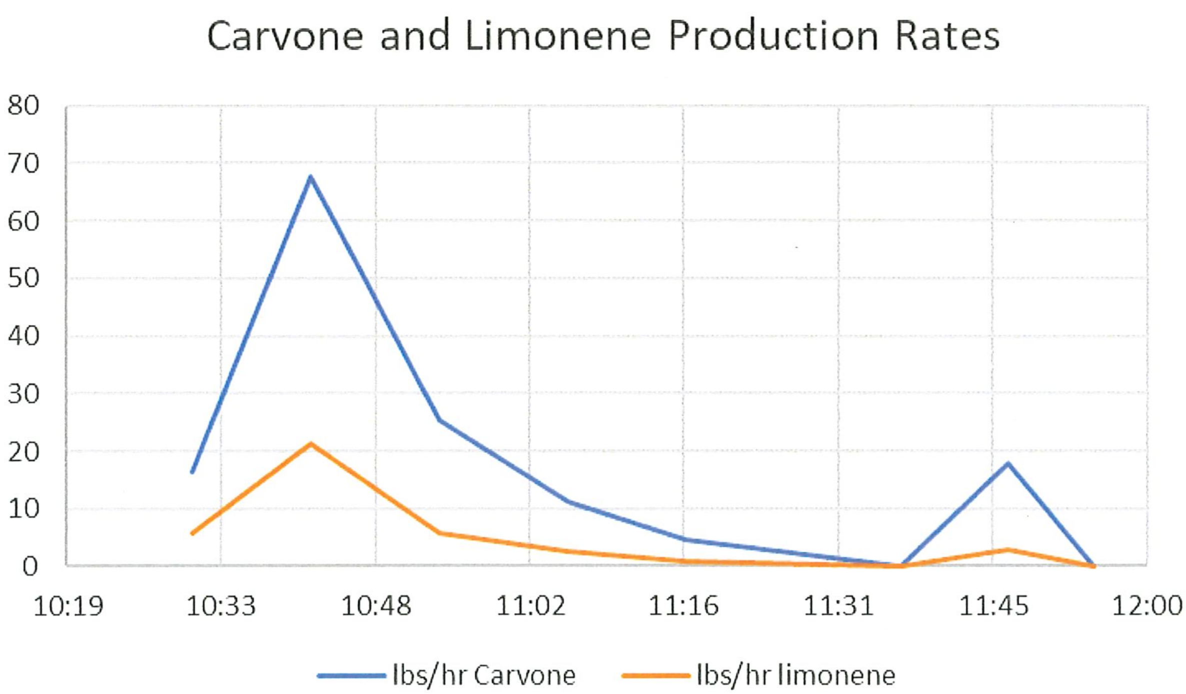

Figure 20. Carvone and limonene production rates for cooperator 3 as a function of distillation time.

Conclusions:

- We worked with three different cooperators during four different mint oil distillation events. We collected mint oil distillation rate data for one tub during that distillation event. We also collected mint oil samples that were then submitted to RCB International, who analyzed the samples to give the percent concentration of the various components over time.
- There is a lag between the time that the steam is connected to the tubs and the time before mint oil begins to be distilled. This is due to the time required to fill the tubs with steam and get the steam back to the condenser.
- After mint oil first begins to be distilled, the oil distillation rate is the highest, but then slowly decreases over time until it is no longer economical to distill.
- A preliminary estimate of the costs of distillation vs. the return from total distilled oil indicates that it may be economical to run them a bit longer than is being currently done. However, these results will change dramatically depending on the costs of running a particular still, labor costs, number of people involved in distilling, the efficiency of the distillation process, and the price of oil.
- Spearmint oil is composed primarily of two components: carvone and limonene. The carvone content increases over time but peaked about 40 minutes into the distillation event and decreased after that. Limonene content steadily decreased over the distillation time.
- Peppermint oil is composed primarily of two components: menthol and menthone. The menthol content increases over time but peaked about 45-50 minutes into the distillation event and decreased after that. The menthone content steadily decreased over the distillation time.
- An extension education paper on best practices from mint oil distillation is still being developed.

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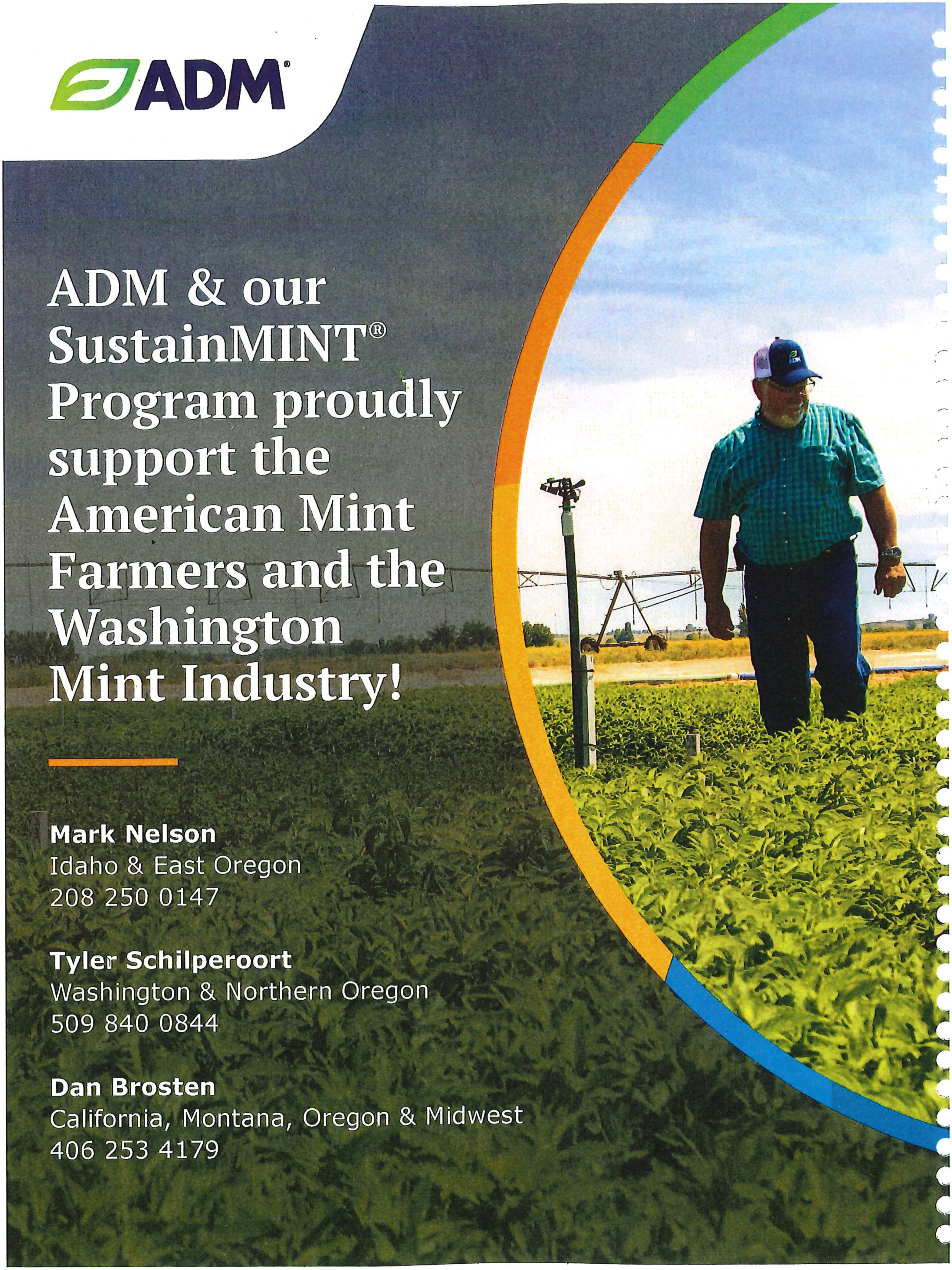
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