OREGON MINT COMMISSION
UPDATE
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Weed Control in Peppermint

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Six herbicide evaluation research studies were conducted in western Oregon by the OSU Weed Science Program. Some results from these studies are discussed below. For more detailed information regarding currently labeled herbicide applications, weed control efficacy and crop rotation restrictions associated with some herbicide applications always refer to specific herbicide labels, the Weed Management in Mint Extension Publication (EM 8774, Revised 2008, http://extension.oregonstate.edu/catalog/index.php) and to the Mint Chapter in the 2009 Pacific Northwest Weed Management Handbook (http://pnwpest.org/pnw/weeds).

Field Bindweed Control in Peppermint

Thirty-two years after we conducted the first field trial with Thistrol (MCPB) on peppermint, it appears that a registration for use in mint may be imminent. In subsequent years we have not found a superior herbicide for field bindweed control in actively growing peppermint. We have previously shown that Aim (carfentrazone) and Starane (fluroxypyr) can provide partial control of field bindweed, but mint safety is sometimes marginal. This study was conducted to evaluate reduced rates of Aim and Starane tank mixed with Thistrol for the control of field bindweed in an established stand of peppermint. These combinations might also prove beneficial for control of other weed species.

Thistrol was applied alone at two rates on two dates in 2008 and in combination with Starane and Aim at the lower rate on the second application date. Aim and Starane were also applied alone. Visual evaluations of crop injury and field bindweed control were conducted periodically and biomass was collected from three square yards in each plot on August 7 (Table 1). The foliage was air dried and distilled to estimate oil yield.

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Table 1. Field Bindweed Control in Peppermint with Thistrol, Aim and Starane

				FIELDS				
Rating Date			Mint 6/30/08	Bindweed 6/30/08	Mint 7/15/08	Bindweed 7/15/08	Mint 8/7/08	
Rating Type			Injury	Control	Injury	Control	Oil Yield	
Rating Unit			%	%	%	%	lb./acre	
Treatment Name		Rate oz/acre	Appl Date	3	4	5	6	7
1	Check	0		0.0	0.0	0.0	0.0	54 a
2	Thistrol	16	May 29	5.0	63.3	0.0	53.3	55 a
3	Thistrol	32	May 29	18.3	83.3	6.7	76.7	71 a
4	Thistrol	16	June 20	0.0	33.3	0.0	76.7	55 a
5	Thistrol	32	June 20	0.0	53.3	13.3	80.0	67 a
6	Aim	0.77	June 20	10.0	70.0	1.7	40.0	55 a
7	Starane	6	June 20	0.0	46.7	3.3	70.0	57 a
8	Aim Thistrol	0.77 16	June 20 June 20	16.7	80.0	0.0	53.3	49 a
9	Starane Thistrol	6 16	June 20 June 20	0.0	56.7	6.7	83.3	60 a

Means followed by the same letter do not significantly differ (P= .10)

Field bindweed control at the final rating on July 15 was approximately equal in plots treated on May 29 with the higher rate of Thistrol and on June 20 with both rates of Thistrol. The addition of Starane to Thistrol had little effect on bindweed control, but it appeared that Aim may have been antagonistic. Variability in mint oil yield precluded detecting differences between treatments, but all means were approximately the same or greater than the untreated check.

Redroot Pigweed Control with Post-emergence Herbicides

An exploratory study was conducted to compare the efficacy of control of 20-inch tall redroot pigweed plants. Thistrol (MCPB) and Basagran (bentazon) were applied alone, as tank mix partners and in combination with low rates of Aim (carfentrazone) and Starane (fluroxypyr). Treatments were applied on July 24, 2008. Aim plus Thistrol was clearly the best treatment providing 63 percent control of the large pigweed. This treatment provided a great deal of defoliation on the large pigweed plants and probably would have been more effective on smaller pigweed plants. The other treatments were approximately equal in their effect on the large plants, but were less effective in general. An application timing study will be conducted in the future to determine the growth stage of pigweed when maximum post-emergence control with these treatments can be obtained.

First Year Peppermint Tolerance to Treflan and Prowl H_2O Timings

Control of summer annual weeds continues to be a significant production problem for peppermint growers. The recent registration of Treflan (trifluralin) for soil incorporation by irrigation or rainfall provides another option where mechanical soil incorporation is not practical. Treflan is currently labeled for use only on dormant and semi-dormant mint in the spring and post harvest. In this study Treflan was applied on four dates in late winter and spring to evaluate the safety of this application method on fall planted peppermint. 'M85' mint rhizomes, donated by Richard Funke, were hand planted in November 2007. The February application was a pre-emergence application; the other timings, which are not currently registered timings, were post-emergence applications. The related herbicide Prowl H_2O (pendimethalin) was included at each application timing for comparison. The entire trial area was treated with Sinbar

Table 2. First Year Peppermint Tolerance to Treflan and Prowl H_2O Timings

			Mint		
Rating Date Rating Type Rating Unit			7/15/08 Injury %	8/12/08 Fresh wt. lb./3yd²	9/8/08 Oil yield lb./acre
Treatment	Rate oz/acre	Application Date	1	2	3
1 check	0		0.0	7.48	43
2 Treflan	20	Feb 27	0.0	10.05	46
3 Prowl H_2O	32	Feb 27	0.0	8.40	44
4 Treflan	20	March 20	0.0	9.40	51
5 Prowl H_2O	32	March 20	0.0	9.93	52
6 Treflan	20	April 9	0.0	9.03	51
7 Prowl H_2O	32	April 9	0.0	7.58	44
8 Treflan	20	May 19	5.0	10.15	54
9 Prowl H_2O	32	May 19	5.0	8.30	45
LSD (P = .10)				NS	NS
CV				27.16	28.46

Table 3. Herbicide Screening in a New Planting of Peppermint

				Mint			
Rating Date Rating Type Rating Unit			5/5/08 Injury %	6/3/08 Injury %	7/15/08 Injury %	8/12/08 Fresh wt lb./3 yd²	9/15/08 Oil Yield lbs./acre
Treatment	Rate	Application Date	1	2	3	4	5
	oz/acre						
1 check	0		0.0	0.0	0.0	11.7 ab	45.9 bc
2 KIH-485	1.73	Nov 14	16.7	16.7	0.0	7.2 bc	41.7 c
3 KIH-485	3.47	Nov 14	26.7	56.7	30.0	6.0 c	36.4 c
4 KIH-485	1.73	Feb 22	6.7	13.3	0.0	9.1 abc	47.5 bc
5 KIH-485	3.47	Feb 22	20.0	46.7	30.0	7.5 bc	40.1 c
6 KIH-485	1.73	April 16	0.0	0.0	0.0	10.2 abc	54.1 abc
7 KIH-485	3.47	April 16	3.3	0.0	0.0	11.5 ab	69.1 a
8 Nortron	16	April 16	0.0	0.0	0.0	9.7 abc	57.3 abc
9 Nortron	32	April 16	0.0	0.0	0.0	12.5 a	55.8 abc
10 Nortron	48	April 16	3.3	0.0	0.0	12.0 ab	62.6 ab
11 DPX-KJM44	2.5	April 16	76.7	95.0	95.0	0.0 d	0.0 d
12 DPX-KJM44	5.0	April 16	76.7	100.0	100.0	0.0 d	0.0 d
CV						36.6	30.6

Means followed by the same letter do not significantly differ (P= .10)

Table 4. Peppermint Tolerance to Nortron

		Mint			
Rating Date Rating Type Rating Unit		4/29/2008 Injury %	5/20/2008 Injury %	8/5/2008 Fresh Wt lb./3 yd^2	9/5/2008 Oil Yield lb./acre
Treatment	Rate	1	2	3	4
1 check	0	0.0	0.0	15.2	30.5
2 Nortron	32 oz/acre	0.0	10.0	16.9	46.7
LSD (P = .10)				NS	NS
CV				63.4	23.0

(terbacil) on February 6 and was hand weeded to minimize weed competition that might interfere with crop injury evaluations.

The three earliest application timings were scheduled when rain was predicted. The May application timing was followed by sprinkler irrigation the same day. A symphilid infestation that was only partially controlled by Lorsban increased variability in peppermint growth throughout the trial area, but the application of Treflan or Prowl H_2O caused little injury to the mint at any timing (Table 2). Neither the peppermint foliage fresh weights nor the oil yields differed between treatments and applications timings.

Herbicide Screening in a New Planting of Peppermint

A field trial was established at the Hyslop research farm to evaluate herbicides for use in newly planted peppermint. These types of trials are conducted annually to develop data packages that are eventually useful to develop labeled uses for these herbicides in peppermint. KIH-485 (pyroxasulfone), Nortron (ethofumesate) and DPX-KJM 44 (aminocyclopyrachlor) were the herbicides included in the study. KIH-485 is an experimental herbicide we are also testing for use in wheat and grasses grown for seed. This herbicide routinely provides pre-emergence control of many annual broadleaf weeds and grasses. We have been evaluating DPX-KJM 44 in our grass grown for seed trials for control of wild carrot and other broadleaf weeds in recent years. Nortron provides some residual control of certain annual grasses and broadleaf weeds.

Mint rhizomes were donated by Richard Funke and were hand planted in November 2007. Sinbar was applied over the entire study area in March and the plots were hand weeded to eliminate competition so that crop injury from the applied herbicides could be evaluated. KIH-485 was applied at two rates in November, pre-emergent to mint, in February, when the mint was 1/4 inch, and in April, when the mint was two inches, to evaluate potential application timings for this new compound. Nortron and DPX-KJM 44 were applied in April. Visual evaluations of crop injury were conducted periodically (Table 3) and the mint was hand harvested in August. The biomass from three square yards of each plot was weighed, air dried and distilled. The study area was infested with symphilids which were only partially controlled by Lorsban. This infestation weakened the mint and increased variability in the peppermint growth. Mint stunting from applications of KIH-485 was greatest at the higher rate in the first two timings; these two timings reduced biomass and oil yield. Both rates of KIH-485 in the April timing and all three rates of Nortron increased oil yield over the weed free check. This trend toward higher yields resulted from an increase in the oil concentration in the mint foliage and not from an increase in biomass compared to the check. DPX-KJM 44 was not selective in peppermint and is likely too persistent in the soil to be used in peppermint culture.

Table 5. Redroot Pigweed Control with Nortron and KIH-485

			Redroot pigweed	
Rating Date Rating Type Rating Unit			7/16/2008 Control %	8/21/2008 Control %
Treatment Name	Rate	Application Date		
	oz/acre			
1 check	0	May 6	0.0	0.0
2 Nortron	16	May 6	50.0	20.0
3 Nortron	32	May 6	60.0	0.0
4 Sinbar	16	May 6	95.0	60.0
5 KIH-485	0.38	May 6	80.0	10.0
6 KIH-485	0.75	May 6	95.0	82.5
7 Nortron	16	June 16	25.0	35.0
8 Nortron	32	June 16	30.0	30.0
9 Sinbar	16	June 16	100.0	75.0
10 KIH-485	0.38	June 16	65.0	57.5
11 KIH-485	0.75	June 16	52.5	86.3
LSD (P = .10)			36.8	26.3
CV			51.7	52.9

Peppermint Tolerance to Nortron

Nortron (ethofumesate) was applied to an established stand of three-inch tall peppermint on April 17, 2008 to evaluate crop tolerance to this herbicide in a production field. The trial area was infested with *verticillium* wilt, but the application of Nortron did not reduce mint oil yield compared to the untreated check

A slight stunting of mint growth was observed a month after application (Table 4), but fresh weight biomass collected on August 5 was comparable to the untreated plots. Further work in peppermint with this herbicide is warranted because there appears to be adequate crop safety on both established and new plantings.

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Redroot Pigweed Control with Nortron and KIH-485

Summer annual broadleaf weeds continue to be a significant problem in peppermint production especially where Sinbar resistant weeds are present. Two rates of Nortron (ethofumesate) and KIH-485 (pyroxasulfone) were evaluated for the control of redroot pigweed at two timings in a non-crop study. Most soil residual herbicides that are currently registered for use in mint must be applied in the dormant season to avoid injury to the crop. KIH-485 and Nortron have been reasonably safe on actively growing peppermint in our research plots at application rates higher than those used in this study. Sinbar was included as a standard at both timings. Non-Sinbar resistant redroot pigweed seed was planted in each plot to insure an adequate population for evaluation. Sprinkler irrigation was applied after each herbicide timing and on a regular basis throughout the duration of the study.

The May 6 application timing of KIH-485 applied at the higher rate, which was applied pre-emergence to the pigweed, provided control comparable to that of Sinbar through the mid-July evaluation date, and control was somewhat better than Sinbar when evaluated near the end of August (Table 5, page 3). Following the June 16 application, after some of the pigweed had reached the six leaf stage, Sinbar controlled all of the emerged pigweed, but KIH-485 provided better control of later emerging pigweed.

Nortron did not provide acceptable pigweed control at either timing. This herbicide often performs poorly when applied to dry soil, which was the case at both timings. Pre-irrigation or application in the irrigation water may be better approaches with this compound.

Progress on Transgenic Peppermint

Rod Croteau, Washington State University

Our 2008 field trials with genetically enhanced peppermint plants that express the menthofuran synthase antisense (MFSA) gene in combination with the DXR gene from the precursor supply pathway have provided several new lines that give 70 percent oil yield gain over controls and with excellent oil quality. To reach our goal of doubling oil yield in "super mint" we have been test stacking candidate genes from the menthol biosynthetic pathway but these genes, with the exception of MFSA, have provided only modest additional oil yield gain (10-15 percent). To achieve the additional 30 percent yield gain that we seek it is now absolutely essential to test all of the other six genes from the precursor supply pathway for additional yield gain by stacking them individually into our DXR-enhanced plants and evaluating additive effects with DXR. All of the required gene constructs have been prepared, the transformation-regeneration work is in progress, and we have started large-scale yield evaluation of greenhouse plants. We expect this work to lead to the generation of new, elite lines based on MFSA and containing both DXR and an additional yield gene, but we do not plan on taking these new lines to field trial until we are able to install the marker gene (see below). Screening the precursor supply pathway for additional yield genes represents a major undertaking and is the final set of genes to be tested for this purpose. It should be noted that each of these stacking candidate genes was prepared in a construct containing the 35S promoter and antibiotic (hygromycin) resistance for selection because the MFSA-DXR host plants already contain the BAR gene and kanamycin resistance. More importantly, these 35S:hygromycin resistance constructs should be free of operating restrictions and can be used "as is" for preparing super mint. It should also be noted that because of regulatory issues the BAR gene, which confers resistance to the broad spectrum herbicide glufosinate, is unlikely to be approved for use in mint so we are seeking alternate selection genes for this purpose.

In order to identify the essential oil from genetically enhanced peppermint it is necessary to express a marker gene that will add a component to be carried through the steam distillation process. Such a marker must be virtually impossible to remove and be readily detectable but not impact the organoleptic properties of the oil. For this purpose, we are employing a mutant gene of limonene synthase which expresses a synthase that produces (+)-limonene, (+)-linalool and (+)-*a*-terpineol (these are the opposite three-dimensional forms of the major (–)-isomers contained in peppermint oil and both (+)- and (–)-isomers can be readily detected by existing analytical methods). However, refined analytical data from the oil buyers indicate that both (+)- and (–)-isomers are naturally present in peppermint oil at relatively low levels. Thus, for our marker gene strategy to be effective we must skew the (+)-isomer content sufficiently to permit unambiguous verification of the marker. In our initial attempts to do this we employed weak to moderate promoters to control marker gene expression but this proved to be insufficient to drive the (+)-isomer content high enough for analytical confirmation. We have now prepared a new construct using the strong 35S promoter coupled to the marker gene, with antibiotic (hygromycin) resistance for selection, and are now generating transformed plants for analysis. Our plan is to carry out greenhouse-level testing of these plants and to move the best selections to 2009 field trials with the intent of generating larger scale oil samples from field grown material for evaluation by the oil buyers. Our present goal is to gain "proof of concept" by expression of the marker gene in wildtype Black Mitcham. For ultimate use of the marker gene in super mint we plan to substitute a strong oil gland-specific promoter for the 35S promoter in order to gain more precise control of expression. Promoter isolation is also in progress.

Affect of Headline Fungicide on Baby and Established Peppermint Oil Yields in Northeast Oregon

Bryon Quebbeman, Quebbeman's Crop Monitoring, LaGrande, Oregon

Anecdotal evidence and some simple trials done the past few years in Idaho indicated that the Strobulirin type fungicides can increase mint oil yields even in the absence of any visual diseases. Headline fungicide (Pyraclostrobin) costs approximately $22.50/acre for the maximum rate of 12 oz/acre. If mint oil was valued at $15.00/lb. it would take approximately 1.5 lbs./acre oil to pay for a single application of Headline. The application cost would be in addition to the costs of the materials listed previously, but the application cost is often reduced because fungicides can usually be applied with other pesticides.

There is interest in this type of fungicide because it takes a relatively small yield increase to pay for the product, especially with the recent increase in new mint oil prices. Growers could realize a profit from applying Headline fungicide if this product can increase yields at least three pounds per acre.

The objective of this project is to evaluate the affect of Headline fungicide (Pyraclostrobin) applied at different dates and number of times on baby and established peppermint oil yields.

Experiment One

This was the only experiment of the four experiments to have any treatments significantly (P=0.05) increase oil yield compared to the untreated check (Table 1). The double application of Headline increased the yield 21 lbs./acre compared to the untreated check. All Headline treatments in experiment one appeared to increase the yield enough to pay for the cost of a single or double application of Headline at 12 oz/acre.

Table 1, Experiments One and Two

Oil yields of peppermint treated with Headline fungicide applied to second year, sprinkle irrigated mint, near Imbler, Oregon 2008. (Exp 1 harvested Aug. 9; Exp 2 harvested Aug. 13)

Treat.#	Treatments	Rate lb. ai/acre	App. date	Exp. 1 Mean oil yield (lbs./acre)	Exp.2 Mean oil yield (lbs./acre)
1	Untreated check	---		85 a	104
2	Headline 12 oz/a	0.2	June 9	92 ab	109
3	Headline 12 oz/a+ Headline 12 oz/a	0.2 0.2	June 9 July 4	106 c	112
4	Headline 12 oz/a	0.2	July 4	97 bc	109
	LSD			10	NS

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

Experiment Two

On the date of June 9 no powdery mildew or any other disease was observed. On June 25 a trace amount of powdery mildew was observed in all the Headline treatments as well as the untreated check.

The mean oil yields were not significantly different (P=0.05) in the treatment when compared to the untreated check (Table 1). The mean mint oil yields still were higher in all of the Headline fungicide treatments than the untreated check. The additional oil produced in all of the Headline treatments would be more than enough to pay for even the double application of the Headline.

Experiment Three

No powdery mildew or any other foliar disease was observed on any treatment before July 4. On July 26 a moderate level of powdery mildew was present on the untreated check and the late application of Headline. The early treatment and early plus late application of Headline had a low level of powdery mildew present. At harvest time no mildew was observed on any treatment.

In this experiment the early Headline treatment produced the lowest mean oil yield of all the treatments (Table 2). The early Headline treatment was statistically similar to the untreated check, but it was significantly lower than the double and late application of Headline.

The double and late Headline treatments still appeared to

Table 2, Experiments Three and Four

Oil yields of peppermint treated with Headline fungicide applied to fall planted, pivot irrigated baby mint, located near La Grande, Oregon, 2008. (Exp 3 harvested Aug. 24, Exp 4 harvested Aug. 26)

Treat.#	Treatments	Rate lb. ai/acre	App. date	Exp. 3 Mean oil yield (lbs./acre)	Exp.4 Mean oil yield (lbs./acre)
1	Untreated check	---		99 ab	82
2	Headline 12 oz/a	0.2	June 27	91 a	83
3	Headline 12 oz/a + Headline 12 oz/a	0.2 0.2	June 27 July 23	108 b	90
4	Headline 12 oz/a	0.2	July 23	103 b	92
	LSD			11	NS

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

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increase the oil yields a minimum of 4 lbs./acre compared to the untreated check.

This field had the most uneven stand of any of the four fields. It is suspected that uneven amounts of mint hay were harvested which added to the variability in the oil yields.

Experiment Four

The mean oil yields of the double treatment and the late treatment of Headline were not significantly higher than the untreated check but they were between eight to ten lbs./acre higher than the untreated check (Table 2). The early Headline treatment was very similar to the untreated check.

No mildew or any other foliar disease observed on June 27. On July 23 the mint was 10-14 inches tall and very lush. On this date it was observed that treatments one and four had a light amount of powdery mildew, which was mostly on the bottom leaves. Treatments two and three had just a trace of powdery mildew also on the bottom leaves.

No mildew was observed on any treatment when the mint was harvested on August 26.

Conclusion

In established mint all Headline treatments numerically increased the mint oil yield compared to the untreated check, but the increase was only significant (P=0.05) in one of the two experiments. The double applications of Headline showed a trend of producing higher oil yields than either the early or late Headline treatments.

In the two baby mint trials none of the Headline treatments were statistically significant compared to the untreated check. The mean oil yields of the double and late Headline applications still increased yields more than enough to pay for the cost of the Headline fungicide.

It appears that later applications are the most advantageous for increasing oil yields.

The spring weather was unusually cool in 2008 and this may have had some effect on the results. This research needs to be repeated to verify if the increased oil yields are the result of the Headline treatments or are from random variation.

It is planned to repeat this research in 2009 and to focus on the best time to apply a single application of Headline.

Production of Pharmaceutical Feedstocks in Mint

Mark Lange, Institute of Biological Chemistry, Washington State University

In July of 2008 the mint commissions of the Pacific Northwest added an exciting new program to their portfolio. The laboratory of Mark Lange, a faculty member at Washington State University's Institute of Biological Chemistry, is supported to evaluate the potential of utilizing mint as a platform for the accumulation of high-value chemicals with relevance as feedstocks in the pharmaceutical industries within the natural essential oil.

For the first year the proof-of-concept phase of the project, the feasibility of producing two specific target molecules, is evaluated: (1) (-)-perillyl alcohol, a monoterpene that has cleared Phase II trials as an anti-cancer drug; and (2) amorphadiene, a sesquiterpene that constitutes the first biosynthetic precursor of the critically important antimalarial drug, artemisinin. As a first step in this endeavor, the genes encoding the enzymes involved in the biosynthesis of the target molecules in the natural producers, namely (-)-limonene 7-hydroxylase from *Perilla frutescens* and amorphadiene synthase from *Artemisia annua*, were transferred to the peppermint genome using a process called *Agrobacterium*-mediated transformation. From these initial transformation events entire plants were regenerated, a time-consuming process that includes switching between various types of growth media.

The Lange laboratory is currently in the process of testing the first generation of these regenerated transgenic plants for the presence of the introduced gene, the appropriate expression levels and the essential oil composition. Very promising preliminary data from one of our transgenic lines indicate that the antimalarial precursor is accumulated at roughly eight percent of the total essential oil. Further analyses with the remaining transgenic lines are currently underway. In addition, optimizations of the constructs, which are the pieces of genetic information that determine how and where genes are going to be expressed in transgenic peppermint, are expected to increase the production levels of the target metabolites to >20 percent of the total essential oil by the end of this year. In early 2009 Lange started a biotechnology company, Ajuga BioSciences Inc., which will focus on developing a strategy for the commercialization of this intriguing new platform.

Evaluation of NutriSphere Nitrogen™ for Improved Nitrogen Efficiency in Established Mint in Northeast Oregon

Bryon Quebbeman, Quebbeman's Crop Monitoring, LaGrande, Oregon
Gary Kiemnec, Eastern Oregon State University

Increased costs of nitrogen and the introduction of new products that claim to improve nitrogen use efficiency have prompted questions about the cost effectiveness of these newer products. One product that is currently being used is a Simplot product called NutriSphere-N for granular nitrogen. The product data sheet states that NSN stabilizes and protects the nitrogen fertilizers urea and ammonium sulfate. In addition, the data sheet also states that NSN acts to reduce the volatilization, nitrification and denitrification of nitrogen fertilizer when applied to the soil, as well as it inhibits nitrogen leaching. Adding NSN to urea at the rate of 0.5 gallon per 2,000 lbs. increases the cost of one pound of 100 percent nitrogen by $0.10 to $0.15 (or $0.10 to 0.15 per 2.18 lbs. of urea). Some benefit should be realized for a grower using a more expensive product.

The objectives of this project are to compare oil and hay yields when peppermint is fertilized with NSN-treated urea or urea; compare oil and hay yields when peppermint is fertilized with NSN-treated urea or urea at three nitrogen rates; and compare oil and hay yields of peppermint fertilized with NSN-treated urea to urea with three, two or no split applications.

At site one there were no statistically significant differences (P = 0.05) in oil yield or hay weight for any treatments (Table 1). No conclusions can be drawn from this site except that there was adequate nitrogen available in the soil for a maximum oil yield even at the lowest nitrogen rate. The remainder of the discussion will focus on site two.

Nitrogen Rates Using NSN-Treated Urea

The highest rate of NSN-treated urea, when applied with three applications, provided significantly (P=0.05) higher oil yields compared to the 210 and 160 lbs. N/A NSN-treated urea at the same number of applications (Table 1). However, when NSN-treated urea was applied in two applications at 210 lbs. N/A, the oil yield was identical to the 260 lbs. N/A applied in three applications. In addition, this 210 lbs. N/A of NSN-treated urea applied in two applications was significantly higher than the three applications of 210 and 160 lbs. N/A of NSN-treated urea as well as significantly higher than a single application of NSN-treated urea at 210 lbs. N/A.

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Table 1, Sites One and Two.

Comparison of peppermint oil yields and dry hay weights between NSN-treated urea and standard urea, at three nitrogen rates and with applications split zero, twice or three times.

			Site one	Site two	Site one	Site two
Treatment #	**Number of splits**	**Treatment**	**Oil yields lbs./acre**	**Oil yields lbs./acre**	**Dry hay weight (tons/acre)**	**Dry hay weight (tons/acre)**
1	3	260 lbs. N/A with NSN	100	97 b	4.10	4.64
2	3	260 lbs. N/A as urea	98	89 ab	4.14	4.57
3	3	210 lbs. N/A with NSN	94	86 a	4.09	4.38
4	3	210 lbs. N/A as urea	100	87 ab	4.09	4.49
5	3	160 lbs. N/A with NSN	95	81 a	4.00	4.30
6	3	160 lbs. N/A as urea	98	90 ab	3.97	4.42
7	1	210 lbs. N/A with NSN	101	82 a	4.00	4.44
8	2	210 lbs. N/A with NSN	99	97 b	3.82	4.41
9	2	210 lbs. N/A as urea	95	87 ab	3.97	4.36
		P<0.05 LSD	NS	11	NS	NS

Site two: Oil yield: LSD = 11, P =4.53, CV=12%
Site two: Dry hay weight: LSD=0.33, P=34.5, CV=7.36
Means with the same letter are not significantly different (Petersen 1985).

Although there is a very slight numeric trend for more dry matter to be produced with the higher nitrogen rate of either nitrogen treatment, the differences were not statistically significant.

Nitrogen Rates Using Urea

There were no significant (P=0.05) differences between the oil yields of any of the nitrogen rates of urea (Table 1, page 7). The number of splits of urea also did not significantly affect the oil yields of the different nitrogen rates.

No clear conclusion can be drawn about the effect of rate on the oil yield due to the inconsistency of the yields and lack of balanced treatments to compare to.

Although there is a very slight numeric trend for more dry matter to be produced with the higher nitrogen rate of either nitrogen treatment, the differences were not statistically significant.

NSN-treated Urea Vs. Urea

Table 1 (page 7) shows that for site two there are no significant differences (P=0.05) between the NSN-treated urea and the urea at the same rate of nitrogen.

There are a total of four comparisons between the NSN-treated urea and standard urea. Two of the four comparisons show the NSN produced oil yields that were close to being significantly higher than the urea, but in the other two comparisons the NSN-treated urea produced oil yields that were either very close or less than the yields of the urea. Although two of the treatments are not quite significant at P=0.05, the numeric amount of the yield increase would provide a significant net income after paying for the extra cost of the NSN.

In this situation if NSN-treated urea cost $0.012/ lb. of nitrogen, then the extra cost of the NSN would have been $26.25/A. If mint oil prices were $15.00/lb., then it would take less than two lbs./A of oil to pay for the extra cost of the NSN.

Splits Using NSN-Treated Urea

The split application of 210 lb. N/A as NSN-treated urea provided a significantly higher yield (P=0.05) than the same rate of NSN with no split or with three splits.

It is speculated that applying all the nitrogen in one application is not as efficient as splitting the nitrogen into two or three applications, so it is not surprising that the single application of 210 lbs. N/A of NSN-treated urea produced the second lowest oil yield and was significantly lower than the 210 lbs. N/A NSN-treated urea split applied. It is surprising that the three applications of 210 lbs. N/A NSN-treated urea were significantly lower than the two applications of NSN-treated urea at the same rate.

Splits Using Urea

There were no significant differences between two and three splits of urea at the rate of 210 lbs. N/A. There was no treatment that included one application of standard urea at 210 lbs./N because this was determined to be an impractical treatment that would be too risky in most situations and should not be adapted as a grower practice.

It was anticipated that treatment seven (210 lbs. N/A as urea in one application) would physically damage the mint by burning the mint foliage. However, there was no visible burning or any kind of damage to the mint foliage from this treatment at either site. It is speculated that the retarded growth of the mint from the cool weather before and during the time of the application, and rain of 0.18 inch four days after the application at site one and two days after the application at site two, kept the NSN-treated urea from causing any visible damage to the mint.

Summary

Site One

There were no significant differences in oil yields or dry hay yields due to apparent high levels of residual soil nitrogen that masked all potential treatment effects so no conclusions can be drawn.

Site Two

The NSN-treated urea at different rates did produce some significantly different oil yield results but the results were inconsistent and no clear conclusion can be made about the rate of NSN-treated urea on oil yields. Although some of the oil yield differences were not significant at (P=0.05), the amount of increased oil yield could provide a significant increase of net income for a mint grower if the yield increase was caused by the NSN-treated urea and was not from random variation.

All rates of N as urea provided very similar oil yields that were not significantly different.

The split application of NSN-treated urea at 210 lbs. N/A provided a significantly higher oil yield than no split or a three way split at the same nitrogen rate. There were no significant differences between the two and three spilt applications of urea at the same nitrogen rate.

There were no significant differences in the amount of dry hay produced per acre between any of the treatments.

The unusual cold spring weather in 2008 may have affected the results of these nitrogen trials by reducing the total amount of nitrogen needed for the season

Microwave Production Scale Project

David Hackleman, Chemical, Biological and Environmental Engineering, Oregon State University

This report will describe progress from November 2008 through March 2009. In specific, "pilot scale" experiments were performed at a potential supplier of microwave equipment and reported at OMC and MIRC meetings in January. Modest scale (10 ton/day) production scale design and equipment cost has been the focus as well as methods to fund a full-scale study.

The purpose of this project is to experimentally confirm whether large-scale microwave excitation of mint hay for the purpose of extraction of its essential oils is practical. This is based on demonstrated performance of small-scale (in-lab) extraction units.

The pilot scale test leads us to believe that a full scale continuous feed microwave excited essential oil extraction process unit would function effectively. Unfortunately, while we were able to get some oil from our test at the microwave equipment supplier, it was not really feasible to get a quantitative analysis of the energy and oil production. This was due to several reasons:

- The hay used in the pilot scale test was material baled and stored from August through December. In spite of this storage (which conventional wisdom suggests is deleterious), good oil was extracted from the hay.
- The experiment set-up was not really able to be designed for efficiency of oil collection.
- The condenser used was transported to the site from the West Coast, as they are not in the mint extraction business, and we had no separator except gravity and time.
- Since hay was manually fed onto the track-belt, the feed mechanism could not keep up with the processing speed of the unit. Therefore, we were limited to runs of up to five minutes duration.

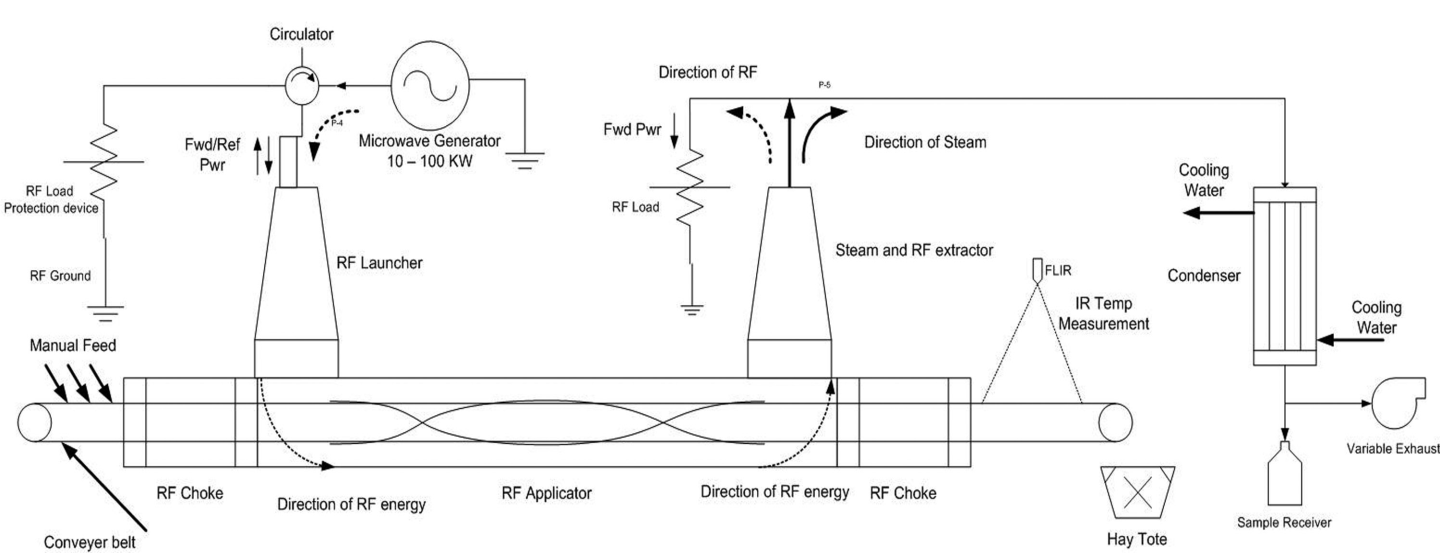
A schematic diagram of the experiment set-up is shown in Figure 1.

Results:

Roughly 0.23 KWh was required to extract transfer one pound of water/oil. This compares favorably with the estimates from the lab-scale systems and is actually better than the "rule of thumb" given to us by the microwave system supplier of 2.5 lbs. water per KWh (~ 0.4 KWh/lb.). This means that so far, we're still on track for an extraction energy cost of between \$0.60 and \$5.00 per pound of oil given electricity at \$0.10/KWh and extraction ratios similar to that found in the lab scale tests. The number \$5/lb. is based on poor extraction efficiency but until we have a study with a more efficient condenser connection, it remains within the range. The number \$0.60/lb. is based on best case observed results to date and is about 30 percent of the best case observed results with the current steam extraction technology, so much more efficient. Secondly,

(continued on page 10)

Figure 1: System layout used in study



mint hay that was processed through the extractor was tested for oil content before and after the process.

Amount of oil in hay prior to process: ~ 0.4% by mass

Amount of oil in hay post process (one pass): none detected

During the visit to the microwave system company, we proposed three types of possible "full scale" systems:

1. A full scale "batch" unit roughly the size of a mint truck.
2. A smaller scale "batch" unit roughly 3 x 4 x 5 feet in size.
3. A dual belt feed-through continuous process system.

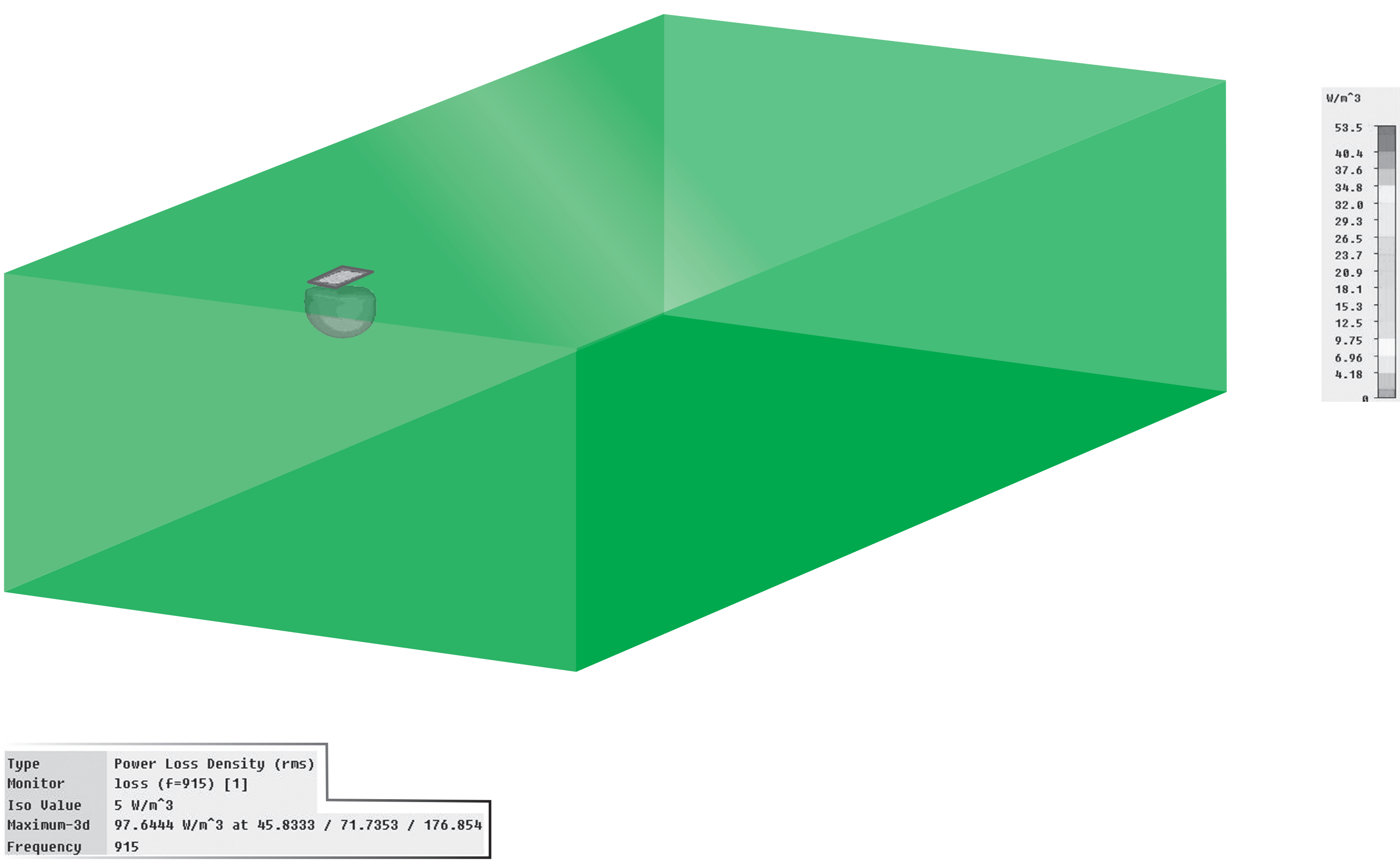
The company did some simulations for us on the batch units and reported back that they are unlikely to function effectively. As an example, Figure 2 is an energy distribution for the mint truck size unit. Similar results are seen in the small unit.

As one can see from this diagram, all the power is dissipated in a very small area right at the application point from the microwave unit. This suggests that the continuous process unit which did function effectively in the pilot scale process test is the more viable means to accomplish the extraction. Figure 3 is a diagram of how such a unit might appear.

This design is significantly different than the existing process, yet does use some of the equipment on hand at a standard mint oil extraction facility, namely the condensers and separators. The unique challenge with this type of a process is the process of feeding hay into the unit as it is vastly different from the existing process. Either chopped or un-chopped hay needs to be distributed on the belt that then transports into the extractor. The feeding of mint hay onto a belt is not done today, and may not be trivial.

The cost quote for the extractor portion of Figure 3 came in initially from the proposed supplier at a much higher amount (roughly four times) than was expected. It is possible that this cost is due to the "single unit" nature of the request and would

Figure 2: Mint Truck 90% Power Region



drop significantly if multiple units were produced, but at this time, we need to modify our expected design or find more funds before we can proceed with further development.

Next Step:

Rocky Lundy, Greg Biza and I are to visit the supplier in March and determine a path forward. We believe that we can find such a path, yet are uncertain exactly what the end result will be at this time. Therefore, we are minimizing expenditures until we complete that discussion. Grants are also being pursued through resources at the University to match funds committed by the mint industry.

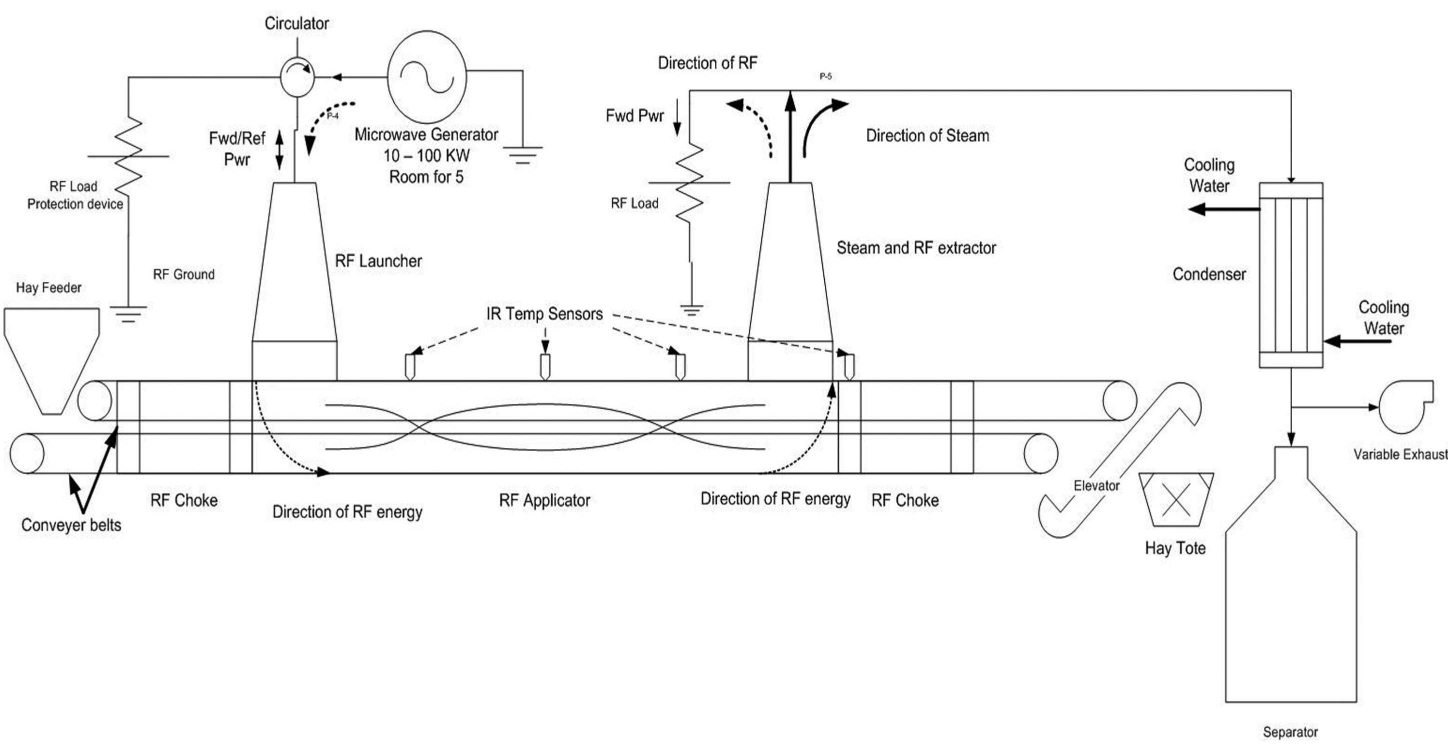
Other Business:

Allied to this work, the development of a lab-scale extractor unit that does not require drilling holes in a standard microwave oven are in progress. This is being accomplished by a student team at OSU college of Chemical, Biological and Environmental Engineering as their "senior project." This activity is autonomous to the work above, and I am only involved in advising the team on a sporadic basis. Results should be available and demonstrated at Engineering Expo on the OSU campus in May, 2009.

Acknowledgements:

The cooperative work Rocky, Greg, and Kevin have contributed to this project is greatly appreciated. In addition, Drs. Murthy and Karow at OSU have helped considerably with the program. Many of you have offered your time and ideas, all of which have been valuable and reduce cost. We all wish to use mint industry funds wisely, and as a consequence, are very conservative about allocating those monies until we believe we have a clear path forward. Thank you all for your interest and contributions to this work.

Figure 3: Full Scale Dual Belt Extractor Concept



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

Tim Butler, Chairman, Aumsville, Oregon

Plans are beginning for the 2010 Annual Convention. Be sure to mark your calendars. The dates will be January 14 & 15 at the Salishan Lodge and Golf Resort, Gleneden Beach, Oregon.

If you are interested in advertising in the 2010 Meeting Program and Directory, a mailing will be made in August. If you do not receive the mailing or would like additional information on advertising, contact Kari or Sue at the Association office at (503) 364-2944.

This publication is available in alternative formats upon request.

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