MONTANA
STATE UNIVERSITY
AGRICULTURAL
EXPERIMENT STATION

1994 MONTANA PEPPERMINT RESEARCH REPORT

RESEARCH PROJECTS FOR THE NORTHWESTERN AND WESTERN AGRICULTURAL RESEARCH CENTERS

CULTIVAR, MANAGEMENT AND CROP ROTATION STUDIES

Leon Welty and Louise Prestbye

IRRIGATION AND FERTILIZER STUDIES

Mal Westcott and Marty Knox

WEED CONTROL STUDIES

Bob Stougaard and Todd Keener

Plan to attend the Northwestern Ag Research Center Peppermint Tour on July 20, 1995

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TITLE: Evaluation of Mint Cultivars in the Presence and Absence of *V. dahliae*.

PERSONNEL: Leon E. Welty, Professor of Agronomy, MSU, Kalispell, MT
Louise S. Prestbye, Research Technician, MSU, Kalispell, MT

OBJECTIVE: Determine adaptability of existing and experimental peppermint and spearmint cultivars for pest tolerance, oil yield and quality, and stand life with and without Verticillium wilt.

PROCEDURES: Peppermint and spearmint cultivars (Tables 1 & 2) were established at the Northwestern Agricultural Research Center at Kalispell, MT in spring of 1994. The experiment was planted at two sites (one to be infected with Verticillium wilt and one to be kept free of the disease) in Creston silt loam soils.

Nuclear plants were obtained from three different sources. Black Mitcham - stem-plug was obtained from Lakes, Ronan, MT. Meristem Black Mitcham, Meristem Native and Scotch spearmint were obtained from Starkels, Ronan, MT. All other entries were provided by MIRC from Dr. Don Robert's breeding program. Nuclear plants were planted on one foot centers. Each plot consisted of four rows spaced 20 inches apart, 20 feet in length. Harvest area for hay yield was 86.7 square feet. The peppermint and spearmint experiments were arranged separately in randomized complete block designs with four replications.

During the first month after planting, plots were kept moist to insure adequate establishment. Thereafter, each nursery was sprinkler irrigated to insure maximum growth. Each experimental site was fertilized with P, K, and S prior to planting. Nitrogen was applied at a total rate of 170 lb/A in three separate applications throughout the growing season. No pesticides were applied to the cultivars in 1994. Weeds were controlled by hand.

Cultivars were evaluated for agronomic characteristics and disease on 8/17, 8/31, and 9/22/94. Dry matter yields were obtained at one site on Sept. 27. Approximately 20 pounds of green hay was air dried and later distilled. Samples were sent to A.M. Todd for quality analyses.

RESULTS AND DISCUSSION:

Interpretation of 1994 data must be done with caution because cultivars were planted at three different dates (Table 3). Legitimate comparisons can be made among Black and Murray Mitcham cultivars and experimental cultivars obtained from MIRC since they were planted on the same date.

Initial establishment and vigor was superior for Black Mitcham-plug and meristem spearmints because they were the first cultivars established. By August 17, all peppermint cultivars had covered the row except T-84-5, Murray, and M-83-7 (Table 1a). Stolon spread at this time was similar for all cultivars.

By August 31, all cultivars had covered the rows. Stolon spread was greatest for Black Mitcham - plug, Black Mitcham - meristem, and Black Mitcham - stem (Table 1b). Powdery mildew was beginning to appear, particularly for Black Mitcham - meristem.

On September 22, all cultivars had powdery mildew with the Black Mitchams having the greatest incidence of the disease (Table 1c). Also, peppermint rust was evident on the Black Mitchams. Interestingly, Black Mitcham - meristem, which is purported to be more susceptible to rust than stem tip Black Mitcham, had the least rust of all Blacks. This was probably related to stage of mint growth coinciding with rust development, since the meristem Black was the last mint planted.

Meristem spearmints were more vigorous, covered the row earlier and had more stolon spread than stem tip spearmints (Tables 2a,b,c). Whether this was due to planting date or the meristem process cannot be determined. Scotch spearmints had significant levels of powdery mildew on Aug. 31 and were severely infested by Sept. 22. Meristem Scotch had significantly more rust than stem-tip Scotch on Sept. 22.

Black Mitcham stem-tip - plug produced the highest oil yield of all peppermint cultivars (Table 3). Black Mitcham stem tip from MIRC produced the next highest oil yield which was surprising considering the condition of the nuclear plants. Meristem Black produced substantial oil considering it was planted at least two weeks after all other cultivars.

Meristem spearmint produced more oil than stem-tip spearmint regardless of species. Again, no conclusions can be drawn because of the difference in planting date.

Oil analyses showed significant differences in quality components among cultivars (Table 4). Black Mitcham was lower in menthol and higher in menthyl acetate (ester) than the other peppermint cultivars regardless of planting date. Scotch spearmint was higher than Native in total heads, limonene and carvone.

In fall 1994, two rates of *V. dahliae* were planted across all mint cultivars at one site. Cultivar response to this disease will be measured in 1995. The other site will be maintained *Vert* wilt free.

Table 1a. Agronomic characteristics of peppermint cultivars at Kalispell, MT on 8/17/94

CULTIVAR	HEIGHT	ROW COVER	STOLON SPREAD
	inches	*(1–5)*[1/]	*(1–5)*[2/]
Black Mitcham – stem (plug)	18	5.0	1.0
Black Mitcham – meristem	14	4.8	2.0
Black Mitcham – stem	16	4.8	1.3
M–83–5 – stem	14	4.8	2.0
M–83–7 – stem	13	4.0	1.8
Murray Mitcham – stem	14	3.5	1.5
T–84–5 – stem	13	4.3	2.3
mean	15	4.4	1.7
LSD(0.10)	1	0.5	0.6

Table 1b. Agronomic characteristics of peppermint cultivars at Kalispell, MT on 8/31/94.

CULTIVAR	HEIGHT	ROW COVER	STOLON SPREAD	POWDERY MILDEW
	inches	*(1–5)*[1/]	*(1–5)*[2/]	%
Black Mitcham – stem (plug)	22	5.0	5.0	6.3
Black Mitcham – meristem	18	5.0	4.3	32.5
Black Mitcham – stem	19	5.0	4.3	7.5
M–83–5 – stem	18	5.0	3.0	0.0
M–83–7 – stem	17	5.0	3.5	0.0
Murray Mitcham – stem	13	5.0	3.8	0.0
T–84–5 – stem	17	5.0	4.0	0.0
mean	18	5.0	4.0	6.6
LSD(0.10)	2	0.0	0.7	17.5

Table 1c. Agronomic characteristics of peppermint cultivars at Kalispell, MT on 9/22/94.

CULTIVAR	HEIGHT	ROW COVER	STOLON SPREAD	RUST	POWDERY MILDEW
	inches	*(1–5)*[1/]	*(1–5)*[2/]	%	%
Black Mitcham – stem (plug)	19	5.0	5.0	23.8	75.0
Black Mitcham – meristem	19	5.0	4.5	7.5	82.5
Black Mitcham – stem	21	5.0	3.8	11.3	63.8
M–83–5 – stem	17	5.0	3.5	4.0	18.8
M–83–7 – stem	16	5.0	4.0	0.8	25.0
Murray Mitcham – stem	17	5.0	4.3	4.0	17.5
T–84–5 – stem	17	5.0	4.5	0.3	12.8
mean	18	5.0	4.2	7.4	42.2
LSD(0.10)	3	0.0	NS	7.6	20.9

[1/] 1= plot area very sparsely covered; 5= plot area totally covered.
[2/] 1= no stolon spread; 5= extensive stolon spread.

Table 2a. Agronomic characteristics of spearmint cultivars at Kalispell, MT on 8/17/94.

CULTIVAR	HEIGHT	ROW COVER	STOLON SPREAD
	inches	*(1-5)[1/]*	*(1-5)[2/]*
Native - stem	17	4.0	3.5
Native - meristem	20	5.0	1.0
Scotch - stem	15	3.5	4.0
Scotch - meristem	19	5.0	1.5
mean	18	4.4	2.5
LSD(0.10)	1	0.3	0.6

Table 2b. Agronomic characteristics of spearmint cultivars at Kalispell, MT on 8/31/94.

CULTIVAR	HEIGHT	ROW COVER	STOLON SPREAD	POWDERY MILDEW
	inches	*(1-5)[1/]*	*(1-5)[2/]*	%
Native - stem	19	4.8	2.5	0.0
Native - meristem	21	5.0	4.3	0.0
Scotch - stem	21	4.3	2.0	23.8
Scotch - meristem	21	5.0	3.3	38.8
mean	20	4.8	3.0	15.6
LSD(0.10)	NS	0.4	0.8	22.2

Table 2c. Agronomic characteristics of spearmint cultivars at Kalispell, MT on 9/22/94.

CULTIVAR	HEIGHT	ROW COVER	STOLON SPREAD	RUST	POWDERY MILDEW
	inches	*(1-5)[1/]*	*(1-5)[2/]*	%	%
Native - stem	20	5.0	3.0	0.0	0.0
Native - meristem	22	5.0	4.5	0.3	0.0
Scotch - stem	23	5.0	2.0	0.0	83.8
Scotch - meristem	22	5.0	3.8	11.3	91.3
mean	22	5.0	3.3	2.9	43.8
LSD(0.10)	2	0.0	1.1	NS	7.6

[1/] *1= plot area very sparsely covered; 5= plot area totally covered.*
[2/] *1= no stolon spread; 5= extensive stolon spread.*

Table 3. Hay yield, oil content, and oil yield for mint cultivars at Kalispell, MT in 1994.

CULTIVAR	PLANTING DATE	BRANCHING	HAY YIELD	OIL CONTENT	OIL YIELD
		(0–5)[1/]	*tons DM/a*	*ml/lb*	*lbs/a*
Peppermint					
Black Mitcham (stem – plug)	5/18	1.2	2.62	6.5	64.5
Black Mitcham (meristem – bare root)	6/13	1.5	1.76	7.1	47.8
Black Mitcham (stem – bare root)	5/26	1.3	2.30	6.7	58.2
M–83–5 (stem – bare root)	5/26	3.0	1.65	7.4	46.2
M–83–7 (stem – bare root)	5/26	2.1	1.32	7.8	38.7
Murray Mitcham (stem – bare root)	5/26	2.0	1.47	5.5	30.6
T–84–5 (stem – bare root)	5/26	2.0	1.54	7.1	40.6
mean		1.9	1.81	6.8	46.6
LSD(0.10)		1.0	0.38	0.7	11.1
Spearmint					
Native (meristem – bare root)	5/18	1.8	3.93	3.1	46.0
Native (stem – bare root)	5/26	1.9	2.75	2.9	30.0
Scotch (meristem – bare root)	5/18	1.9	2.11	5.5	44.1
Scotch (stem – bare root)	5/26	2.5	1.84	4.4	30.9
mean		2.0	3.34	3.0	38.0
LSD(0.10)		NS	0.27	0.5	5.5

All cultivars harvested on Sept. 27.

[1/] 0=no branching; 5=extensive (long & numerous) branches
Based on average of all shoots in sample

Table 4. Oil quality components for mint cultivars at Kalispell, MT in 1994.

CULTIVAR	HEADS	MENTHOL	MENTHO-FURAN	ESTER	MENTHONE	PULEGONE
	%					
Peppermint						
Black Mitcham (stem – plug)	9.5	48.1	2.5	15.4	4.5	0.0
Black Mitcham (meristem – bare root)	8.6	48.5	3.0	17.2	4.2	0.0
Black Mitcham (stem – bare root)	10.6	48.1	2.7	13.3	5.8	0.0
M–83–5 (stem – bare root)	10.2	51.3	2.5	11.9	6.0	0.0
M–83–7 (stem – bare root)	9.7	50.8	3.0	12.0	6.5	0.0
Murray Mitcham (stem – bare root)	10.1	50.8	2.2	12.4	6.0	0.0
T–84–5 (stem – bare root)	9.8	51.6	3.2	11.9	6.5	0.0
mean	9.8	49.9	2.7	13.4	5.6	0.0
LSD(0.10)	0.7	1.1	0.2	0.9	0.7	0.0

	HEADS	LIMONENE	CARVONE
	%		
Spearmint			
Native (meristem – bare root)	18.6	7.1	37.1
Native (stem – bare root)	19.5	7.7	31.9
Scotch (meristem – bare root)	22.7	16.5	54.4
Scotch (stem – bare root)	21.2	16.2	49.0
mean	20.5	11.9	43.1
LSD(0.10)	1.8	1.4	4.5

TITLE: Meristem 'Black Mitcham' Peppermint Double Cut Study

PERSONNEL: Leon E. Welty, Professor of Agronomy, MSU, Kalispell, MT
Louise S. Prestbye, Research Technician, MSU, Kalispell, MT

OBJECTIVE: Determine the effect of double cutting on oil yield, quality, and stand life of meristem Black Mitcham peppermint compared to a traditional single harvest at 10% bloom.

PROCEDURES: At the Northwestern Agricultural Research Center at Kalispell, MT in spring of 1994, plots 10' wide by 15' long were delineated within a third year stand of meristem derived Black Mitcham peppermint (root source - Glacier Mint). Four replicates of 12 plots representing 11 double cut harvests and a single cut control (Table 1) were assigned in a randomized complete block design.

Harvest area was approximately 70 square feet. The area was irrigated with 0.6 to 1.6 inches per week, for a total of 18 inches over the season. In the fall of 1993, 20 lbs/a N, 104 lbs/a P_2O_5 and 120 lbs/a K_2O were applied. In 1994, 50 lbs/a S and 410 lbs/a N was applied through the sprinkler during the growing season. Sinbar was applied at 0.5 lb/a on 4/12, Poast at 2 pt/a on 4/27 and Basagran at 2 pt/a on 5/3/94. Orthene, at 0.5 lb/a, was sprayed on 8/11 for cutworm control.

Growth stage, height, and lodging were noted on the prescribed harvest dates for each plot and dry matter yields obtained. Approximately 20 pounds of green hay was air dried and later distilled. Samples were sent to A.M. Todd for quality analyses.

RESULTS AND DISCUSSION:

Oil yields (Table 2) increased as the first harvest was delayed until July 19. The breakpoint for significant oil increase occurred on July 12, which was when the meristem Black started to have significant lodging. The single harvest on Aug.1 produced oil yields which would be considered unacceptable to peppermint producers. Interestingly, after July 12 the peppermint continued to get taller and accumulate biomass without a corresponding increase in oil yield.

Plots were harvested again on Sept. 1 (Table 3a). As expected, oil yields were greater for the earlier first harvests. The highest total oil per acre was received from the July 12 + Sept.1 harvests (99.3 lbs/a - Table 4b).

Harvesting on Sept. 27 for the second time resulted in a reduction in oil yield compared to the Sept. 1 harvest (Table 4b). We anticipated that the additional 26 days of growth would increase or at least maintain yields, but this did not occur. We don't think the reduction in oil yield from Sept.1 to Sept. 27 was the result of weather, because only 4 mild frosts were observed in September. We think the oil yield reduction was due to leaf drop and rot resulting from lodging. The reduction was most severe for the June harvests which had the longest time for regrowth.

Oil analyses showed significant differences in quality components among first harvest dates (Table 5a) which were related to plant maturity. The single harvest control (8/1), which had just started to bloom, was highest in heads, menthol, menthofuran and ester, and lowest in menthone. Oil from the second cuttings was generally higher in the levels of the components shown except menthone (Table 5b), and the 9/27 cutting was higher than the 9/1 cutting (Table 5c). Menthol levels of all the 9/27 treatments were similar regardless of first harvest date. Menthol levels for June and early July harvests were below what oil buyers prefer. It must be noted, however, that early harvest oil from production fields in 1994 was marketed without any price discount. This will, of course, vary with supply and demand. If oil supplies are abundant, discounts on early cut peppermint oil could be a reality.

Double cutting was very successful in 1994. However, we all know that 1994 was a good year for this practice. Growing degree days (GDD) as measured at the NWARC are presented in Tables 6 and 7. GDD were 9% higher in 1994 than the 46-year average. If 1994 was a perfect year for double cutting then 1993 would have been one of the worst. However, even in 1993 we obtained 8 inches of regrowth from our Aug.1 harvest. The unanswered question concerning double-cutting is the effect on peppermint vigor and stand life. This experiment will be continued so that determination can be made.

Table 1. Harvest treatments for peppermint double cut at Kalispell, MT in 1994.

	First Harvest	Second Harvest
1.	6/21	9/1
2.	6/21	9/27
3.	6/28	9/1
4.	6/28	9/27
5.	7/5	9/1
6.	7/5	9/27
7.	7/12	9/1
8.	7/12	9/27
9.	7/19	9/1
10.	7/19	9/27
11.	8/1	9/27
12.	8/1	----

Table 2. Harvest data from the first cuttings of the peppermint double cut study at Kalispell, MT in 1994.

Harvest Date	Growth Stage	Height inches	Lodging %	Hay Yield DM t/a	Oil Yield lbs/a	Oil Content ml/lb
6/21	vegetative	19	0	2.84	24.8	2.4
6/28	vegetative	24	0	3.64	34.6	2.6
7/5	vegetative	27	3	3.70	39.3	2.8
7/12	vegetative	29	15	4.00	45.8	3.1
7/19	mid bud	32	44	4.98	48.6	2.6
8/1	1st bloom	36	80	4.95	51.2	2.8
	LSD(0.05)	2	2	0.47	10.9	NS

Table 3a. Harvest data from the 9/1 cuttings of the peppermint double cut study at Kalispell, MT in 1994.

First Harvest Date	Second Harvest Date	Growth Stage	Height inches	Hay Yield DM t/a	Oil Yield lbs/a	Oil Content ml/lb
6/21	9/1	prebloom	30	2.11	61.2	7.7
6/28	9/1	mid bud	24	2.18	57.9	7.0
7/5	9/1	early bud	22	1.98	52.5	7.0
7/12	9/1	prebud	19	1.83	53.5	7.7
7/19	9/1	vegetative	15	1.39	41.8	8.0
		LSD(0.05)	5	0.39	7.3	1.2

Table 3b. Harvest data from the 9/27 cuttings of the peppermint double cut study at Kalispell, MT in 1994.

First Harvest Date	Second Harvest Date	Growth Stage	Height inches	Hay Yield DM t/a	Oil Yield lbs/a	Oil Content ml/lb
6/21	9/27	mid bloom	27	2.41	46.0	5.1
6/28	9/27	early bloom	26	2.43	45.4	5.1
7/5	9/27	mid bloom	24	2.37	45.2	5.1
7/12	9/27	prebud	25	2.19	41.6	5.0
7/19	9/27	vegetative	20	1.85	32.8	4.6
8/1	9/27			1.42	19.3	3.6
		LSD(0.05)	5	0.39	7.3	1.2

Table 4a. Total season hay yields from the peppermint double cut study at Kalispell, MT in 1994.

First Harvest Date	DM Yield t/a	Second Harvest Date	DM Yield t/a	Total Yield t/a	Second Harvest Date	DM Yield t/a	Total Yield t/a
6/21	2.84	9/1	2.11	4.95	9/27	2.41	5.25
6/28	3.64	9/1	2.18	5.82	9/27	2.43	6.07
7/5	3.70	9/1	1.98	5.68	9/27	2.37	6.07
7/12	4.00	9/1	1.83	5.83	9/27	2.19	6.19
7/19	4.98	9/1	1.39	6.37	9/27	1.85	6.83
8/1	4.95		--	--	9/27	1.42	6.37
LSD(0.05)	0.47		0.30	0.43		0.52	0.43

Table 4b. Total season oil yields from the peppermint double cut study at Kalispell, MT in 1994.

First Harvest Date	Oil Yield lbs/a	Second Harvest Date	Oil Yield lbs/a	Total Yield lbs/a	Second Harvest Date	Oil Yield lbs/a	Total Yield lbs/a
6/21	24.8	9/1	61.2	86.0	9/27	46.0	70.8
6/28	34.6	9/1	57.9	92.5	9/27	45.4	80.0
7/5	39.3	9/1	52.5	91.8	9/27	45.2	84.5
7/12	45.8	9/1	53.5	99.3	9/27	41.6	87.4
7/19	48.6	9/1	41.8	90.4	9/27	32.8	81.4
8/1	49.3		--	--	9/27	19.3	68.6
LSD(0.05)	10.9		7.5	13.9		6.8	13.9

Table 5a. Oil quality components from the first harvests of the peppermint double cut study at Kalispell, MT in 1994.

First Harvest Date	Heads	Menthone	Mentho-furan	Ester	Menthol	Pulegone
			%			
6/21	7.1	25.1	0.8	3.5	38.6	0.2
6/28	7.0	27.7	0.7	2.7	37.3	0.1
7/5	7.5	25.8	0.7	2.7	38.1	0.1
7/12	7.6	24.6	0.7	2.6	38.8	0.1
7/19	8.2	23.3	0.8	2.5	40.2	0.2
8/1	8.6	19.9	2.9	3.5	40.3	0.8
LSD(0.05)	0.7	2.8	0.3	0.7	2.2	0.3

Table 5b. Oil quality components from the 9/1 harvest of the peppermint double cut study at Kalispell, MT in 1994.

First Harvest Date	Heads	Menthone	Mentho-furan	Ester	Menthol	Pulegone
			%			
6/21	8.8	20.1	2.6	3.4	44.5	0.3
6/28	8.7	15.3	2.9	4.7	47.1	0.2
7/5	8.8	19.7	1.9	3.6	45.5	0.1
7/12	8.1	26.0	2.0	2.9	41.3	0.1
7/19	7.8	29.4	2.2	3.0	39.0	0.1
LSD(0.05)	NS	2.9	0.5	0.9	2.6	0.1

Table 5c. Oil quality components from the 9/27 harvest of the peppermint double cut study at Kalispell, MT in 1994.

First Harvest Date	Heads	Menthone	Mentho-furan	Ester	Menthol	Pulegone
			%			
6/21	7.7	16.0	3.3	7.2	49.9	0.0
6/28	9.8	9.2	3.1	8.4	50.0	0.0
7/5	9.1	10.8	2.6	7.9	50.4	0.0
7/12	9.6	11.1	2.3	7.8	50.2	0.0
7/19	9.0	13.3	2.2	7.3	50.0	0.0
8/1	8.8	15.0	2.2	6.9	49.5	0.0
LSD(0.05)	0.9	2.3	0.3	0.8	NS	0.0

Table 6. Summary of growing degree day (GDD) data for mint at the Northwestern Agricultural Research Center May 1, 1949 through September 15, 1994.

GDD = Temp Max + Temp Min÷2 − 50

Min Temp < 50F substituted with 50

Average growing degree days by month and year.

YEAR	MAY	JUNE	JULY	AUG.	SEPT.	TOTAL
1949	314.0	356.5	473.0	525.0	170.0	1838.5
1950	208.0	308.0	460.5	466.0	196.5	1639.0
1951	223.0	251.5	516.0	421.5	135.5	1547.5
1952	243.5	309.0	465.0	476.0	155.0	1648.5
1953	194.5	252.5	527.0	468.5	212.5	1655.0
1954	270.5	255.0	479.0	387.0	149.0	1540.5
1955	165.0	375.5	451.5	509.5	213.0	1714.5
1956	282.0	354.0	502.0	443.0	183.0	1764.0
1957	312.5	350.5	519.0	470.5	191.0	1843.5
1958	430.5	401.0	514.0	583.5	208.5	2137.5
1959	187.0	371.0	524.5	419.0	158.0	1659.5
1960	202.5	380.5	621.0	386.5	189.0	1779.5
1961	248.0	491.5	548.0	589.0	127.5	2004.0
1962	201.0	370.5	460.0	444.5	144.0	1620.0
1963	265.0	335.5	472.0	531.0	210.5	1814.0
1964	219.5	324.5	490.0	357.0	109.0	1500.0
1965	222.0	329.5	495.0	462.5	82.0	1591.0
1966	307.5	291.0	500.0	452.5	215.0	1766.0
1967	255.0	354.5	557.0	586.5	237.5	1990.5
1968	207.5	349.0	522.0	410.5	163.0	1652.0
1969	293.5	339.5	461.5	522.0	201.5	1818.0
1970	281.5	402.0	483.5	483.0	117.5	1767.5
1971	259.0	263.0	442.5	604.0	141.0	1709.5
1972	228.5	350.0	427.5	529.0	159.5	1694.5
1973	259.5	322.5	538.0	523.0	179.0	1822.0
1974	152.5	407.5	489.5	436.5	145.0	1631.0
1975	180.0	283.5	604.5	363.0	156.0	1587.0
1976	251.0	249.5	467.5	401.0	165.5	1534.5
1977	184.0	422.5	436.0	438.5	159.0	1640.0
1978	131.0	349.5	446.5	379.0	144.0	1450.0
1979	225.5	370.5	505.0	518.0	164.5	1783.5
1980	268.0	290.0	442.0	361.0	159.5	1520.5
1981	209.0	210.5	447.0	556.0	199.5	1622.0
1982	195.0	370.0	406.5	480.5	159.5	1611.5
1983	259.5	315.5	358.5	530.0	136.0	1599.5
1984	162.0	295.5	529.0	526.5	129.5	1642.5
1985	294.5	350.5	604.0	395.0	110.5	1754.5
1986	252.0	462.5	363.0	544.5	105.0	1727.0
1987	287.5	406.5	446.5	390.0	211.5	1742.0
1988	218.5	400.5	466.5	524.0	206.0	1815.5
1989	178.5	350.5	530.0	401.0	122.5	1582.5
1990	165.5	297.0	492.5	475.5	233.5	1664.0
1991	175.0	243.0	465.5	509.5	179.5	1572.5
1992	277.0	414.5	375.0	456.5	120.0	1643.0
1993	306.0	273.5	260.0	383.0	153.5	1376.0
1994	261.5	316.0	539.0	567.0	159.5	1843.0
MEAN	237.3	338.4	480.9	471.4	164.5	1692.6

TABLE 7. MINT GDD AT NWARC BY DAY IN 1994.

May	MAX	MIN	GDD
1	64	38	7.0
2	56	36	3.0
3	60	36	5.0
4	63	33	6.5
5	57	39	3.5
6	67	33	8.5
7	73	38	11.5
8	77	44	13.5
9	78	42	14.0
10	80	50	15.0
11	75	43	12.5
12	79	53	16.0
13	79	46	14.5
14	64	35	7.0
15	65	45	7.5
16	65	45	7.5
17	62	39	6.0
18	52	44	1.0
19	65	44	7.5
20	57	44	3.5
21	56	45	3.0
22	58	37	4.0
23	64	39	7.0
24	71	41	10.5
25	75	44	12.5
26	80	45	15.0
27	79	48	14.5
28	64	42	7.0
29	64	45	7.0
30	58	36	4.0
31	63	33	6.5

AV MAX	AV MIN	GDD
66.8	41.4	261.5

June	MAX	MIN	GDD
1	69	44	9.5
2	55	42	2.5
3	69	40	9.5
4	78	49	14.0
5	64	39	7.0
6	73	47	11.5
7	65	44	7.5
8	59	37	4.5
9	59	37	4.5
10	63	37	6.5
11	69	43	9.5
12	73	53	13.0
13	70	54	12.0
14	63	45	6.5
15	58	45	4.0
16	58	34	4.0
17	59	40	4.5
18	68	37	9.0
19	73	37	11.5
20	74	39	12.0
21	84	49	17.0
22	88	49	19.0
23	85	52	18.5
24	85	56	20.5
25	76	40	13.0
26	80	50	15.0
27	63	49	6.5
28	72	43	11.0
29	84	45	17.0
30	81	47	15.5

AV MAX	AV MIN	GDD
70.6	44.1	316.0

July	MAX	MIN	GDD
1	85	47	17.5
2	82	55	18.5
3	68	45	9.0
4	66	50	8.0
5	74	40	12.0
6	73	44	11.5
7	74	50	12.0
8	79	49	14.5
9	86	51	18.5
10	87	56	21.5
11	83	48	16.5
12	83	48	16.5
13	78	45	14.0
14	79	47	14.5
15	80	48	15.0
16	78	46	14.0
17	80	48	15.0
18	89	48	19.5
19	79	46	14.5
20	80	46	15.0
21	89	49	19.5
22	90	54	22.0
23	91	54	22.5
24	92	63	27.5
25	92	57	24.5
26	89	55	22.0
27	93	51	22.0
28	92	49	21.0
29	89	49	19.5
30	92	56	24.0
31	83	51	17.0

AV MAX	AV MIN	GDD
83.1	49.8	539.0

Aug	MAX	MIN	GDD
1	91	59	25.0
2	83	49	16.5
3	93	52	22.5
4	93	54	23.5
5	89	56	22.5
6	92	51	21.5
7	92	50	21.0
8	89	53	21.0
9	85	52	18.5
10	85	42	17.5
11	90	42	20.0
12	91	52	21.5
13	89	54	21.5
14	92	52	22.0
15	97	56	26.5
16	88	44	19.0
17	84	46	17.0
18	81	42	15.5
19	82	43	16.0
20	90	48	20.0
21	89	50	19.5
22	85	50	17.5
23	73	57	15.0
24	73	45	11.5
25	77	43	13.5
26	77	44	13.5
27	75	37	12.5
28	77	37	13.5
29	81	43	15.5
30	78	51	14.5
31	74	46	12.0

AV MAX	AV MIN	GDD
85.0	48.4	567.0

Sept.	MAX	MIN	GDD
1	70	40	10.0
2	76	44	13.0
3	70	45	10.0
4	60	47	5.0
5	65	38	7.5
6	71	37	10.5
7	78	41	14.0
8	84	42	17.0
9	81	42	15.5
10	72	37	11.0
11	65	36	7.5
12	65	32	7.5
13	70	31	10.0
14	71	33	10.5
15	71	44	10.5
16			0.0
17			0.0
18			0.0
19			0.0
20			0.0
21			0.0
22			0.0
23			0.0
24			0.0
25			0.0
26			0.0
27			0.0
28			0.0
29			0.0
30			0.0

AV MAX	AV MIN	GDD
71.3	39.3	159.5

Oct.	MAX	MIN	GDD
1			0.0
2			0.0
3			0.0
4			0.0
5			0.0
6			0.0
7			0.0
8			0.0
9			0.0
10			0.0
11			0.0
12			0.0
13			0.0
14			0.0
15			0.0
16			0.0
17			0.0
18			0.0
19			0.0
20			0.0
21			0.0
22			0.0
23			0.0
24			0.0
25			0.0
26			0.0
27			0.0
28			0.0
29			0.0
30			0.0
31			0.0

AV MAX	AV MIN	GDD
0.0	0.0	0.0

TOTAL GROWING DEGREE DAYS: 1994 1843.0

TITLE: Determine Feasibility of Using Rotational Crops to Reduce Pest Problems in Peppermint

PERSONNEL:
Leon E. Welty, Professor of Agronomy, MSU, Kalispell, MT
Louise Prestbye, Research Technician, MSU, Kalispell, MT
Dr. Don Mathre, Plant Pathologist, MSU, Bozeman, MT
Dr. Bill Grey, Plant Pathologist, MSU, Bozeman, MT

PROCEDURES: Cultures of Verticillium dahliae were isolated from peppermint root samples collected from several fields in the Flathead Valley in February, 1992. Sterile oat kernels were inoculated with spore suspensions from these cultures and incubated until numerous microsclerotia of the fungus were visible on the husks. Greenhouse tests on the pathogenicity of the infested kernels were positive for V. dahliae.

Oat kernels were ground with a coffee grinder and mixed with ground wheat in a 50:50 ratio. On 21 May, 1992, the oat kernel-wheat mixture containing the fungus was seeded at a 2-inch depth at 50 lbs/acre into two fields, one with a fine sandy loam (light) soil and one with a silty clay loam (heavy) soil. Plots were arranged in an RCB design with four replicates for the following treatments:

1. Barley - grain harvested, residue plowed
2. Fallow - hand weeded
3. Vapam fumigant - 50 GPA
4. Sorghum (high HCN), plowed as green manure
5. Marigold, plowed as green manure
6. Winter rapeseed (high glucosinolate), plowed as green manure

On September 5, 1992, the green manure crops were rototilled by treatment so soil and plant debris were not moved from plot to plot.

On May 18, 1993, Black Mitcham meristem foundation roots were hand planted (in one-half of each plot) in four, 17 ft. rows per plot at each site. Planting rate was one 5 gallon bucket of roots per plot. The other half of each plot was strip planted to Humus rapeseed, which was harvested for yield determination on 8/30, returned to the plots and plowed down. Vapam was applied to the barley treatment plots at 100 GPA and to the fallow treatment plots at 200 GPA on 9/23/93.

Meristem Black Mitcham was planted on double green manure plots and fall 1993 Vapam plots (100 and 200 GPA) on 5/24/94. Nitrogen was applied at 100 lbs/a and P_2O_5 at 50 lbs/a on 5/4/94. Sinbar (1.2 lbs/a), Poast (1.5 pt/a + 2 pt/a Dash) and Basagran (2 pt/a + UAN) were applied

5/6/94. On 6/30/94, Tilt was applied at 10 oz/a for rust control. Additional N was applied at 70 lbs/a on 7/13, and another 40 lbs applied to the 1994 planting on 8/26.

Weed invasion was determined by visual estimate and by comparing the fresh weight of all weeds hand-pulled from each plot on 8/8/94. The percentage of each subplot (1993 and 1994 plantings) exhibiting Vert wilt symptoms was visually estimated on 8/11 and again on 9/20/94.

RESULTS:

At the heavy soil site, Vapam in either 1992 or 1993 suppressed weeds, as did the rapeseed and marigold green manure treatments from 1992 (Table 1). The sorghum green manure plots had the most weeds. Very few weeds were present at the light soil site. This data suggests the use of high glucosinolate rapeseed as a green manure crop may benefit weed control in a peppermint rotation scheme.

Vert wilt symptoms appeared in the second-year mint plantings by mid summer. Symptoms appeared later in the new stands. The only significant differences observable at either site were on the 9/20 observation of the 1994 planting (Table 2). The Vapam treated subplots showed lower infestation than the plots which had not been fumigated. In 1993, mint plants in marigold green manure plots showed slightly less disease than plants in other green manure treatments on the light soil. There was some evidence of continued control in the 1994 planting.

Table 1. Weed invasion of peppermint following rotation treatments, observed on 8/8/94.

1992 Treatment	1993 Treatment	Heavy Soil Weeds %	Heavy Soil Weed Wet Wt lbs/a	Light Soil Weeds %
Barley	Vapam–100 GPA	10.8	1335	2.3
Fallow	Vapam–200 GPA	1.8	76	1.8
Vapam–50 GPA	Humus	5.8	377	1.5
Sorghum	Humus	40.7	3369	1.0
Rapeseed	Humus	14.9	1360	0.8
Marigold	Humus	20.0	1471	1.3
	LSD(0.05)	16.4	1602	NS

Table 2. *V. dahliae* infestation on peppermint following rotation treatments.

Heavy Soil

1992 Treatment	1993 Treatment	Symptoms – % of plot[1/] 8/11/94 '93[2/]	8/11/94 '94[3/]	9/20/94 '93[2/]	9/20/94 '94[3/]
Barley	Vapam–100 GPA	10.0	0.0	18.8	6.3
Fallow	Vapam–200 GPA	7.8	0.3	17.5	1.5
Vapam–50 GPA	Humus	7.8	0.3	16.3	8.8
Sorghum	Humus	8.9	0.0	15.1	18.8
Rapeseed	Humus	9.7	0.2	15.7	21.9
Marigold	Humus	9.0	0.0	16.3	13.8
	LSD(0.05)	NS	NS	NS	8.8

Light Soil

1992 Treatment	1993 Treatment	Symptoms – % of plot[1/] 8/11/94 '93[2/]	8/11/94 '94[3/]	9/20/94 '93[2/]	9/20/94 '94[3/]
Barley	Vapam–100	36.3	0.0	73.8	16.3
Fallow	Vapam–200	33.8	0.0	77.5	11.3
Vapam – 50 GPA	Humus	35.0	0.0	78.8	30.0
Sorghum	Humus	29.4	0.4	62.5	50.7
Marigold	Humus	27.5	1.3	62.5	30.0
Rapeseed	Humus	25.0	0.7	59.4	45.0
	LSD(0.05)	NS	NS	NS	18.1

[1/] % Vert wilt based on visual estimates
[2/] Mint planted in 1993
[3/] Mint planted in 1994

RESEARCH PROGRESS REPORT FOR 1994

TITLE: **NITROGEN AND IRRIGATION MANAGEMENT FOR PEPPERMINT**

Scheduling and Rate Effects on Tissue Nitrate, Soil N Behavior, and Oil Yields

PERSONNEL: PI: Dr. Mal Westcott, Professor of Soil Science (Fertility)
Western Ag Research Center, Montana State University

Cooperators: Leon Welty, Professor of Agronomy
Northwestern Ag Research Center, MSU

Dr. Jon Wraith, Assistant Professor of Soil Science (Physics)
Department of Plant and Soil Sciences, MSU

OBJECTIVES: Our objectives are to improve use efficiency for nitrogen fertilizer and irrigation in peppermint production; to develop guidelines for optimum economic input; and to define management standards for minimum impact on environmental quality.

Our approach is to develop a system of precise nitrogen management based on rapid diagnostic procedures for determination of crop nitrogen status, to determine crop water use and model water behavior and solute transport in the soil profile, and delineate the interaction between these factors.

PROCEDURES: A field trial investigating nitrogen fertilization interactions with irrigation scheduling and amounts was conducted on second-year peppermint (Black Mitcham) at the Northwestern Agricultural Research Center, located in Montana's Flathead Valley production area. The experimental design was a randomized complete block (4 replications) with two irrigation schedules as main plots and eleven nitrogen treatments as subplots (8x60 ft). The eleven treatments were:

Control (No added N)

120 lb N/ac standard*
240 lb N/ac standard
360 lb N/ac standard
480 lb N/ac standard
600 lb N/ac standard

120 lb N/ac single**
360 lb N/ac single
600 lb N/ac single

PRFC*** (plant response fertilization based on chlorophyll levels)
PRFS (plant response fertilization based on stem nitrate levels)

*Standard application seeks to mimic the common practice of frequent nitrogen application through irrigation systems. Nitrogen rates were divided into seven equal increments applied weekly commencing June 22 as urea solution by backpack sprayer on plots immediately prior to irrigation.

**Single application was of the total amount as granular urea applied at the beginning of irrigation treatment in June.

***Plant response fertilization (PRF) was managed by applying a rate of 90 lbs N/ac as granular urea at the beginning of the irrigation season and basing further applications on the diagnosis of deficiencies by comparing SPAD chlorophyll readings or stem sap nitrate levels to well fertilized plots.

These subplots were arrayed perpendicular to a line-source sprinkler system which delivered a gradient of decreasing irrigation amounts as a function of distance from the line. The same amount of water was applied to each irrigation schedule main plot each week: 2 inches at a distance of 20 feet from the line-source adjusted for rainfall. One schedule received the total amount in one weekly application and the other schedule received it in two equal weekly applications. The wettest regime adjacent to the line received 2.5 inches weekly, extending to dryland conditions at the outer margins (50 ft) of the plots.

Tensiometers at depths of 6, 24, and 48 inches and neutron probe access tubes were installed at distances of 5, 20, and 35 feet from the line-source in the 360 lb N/ac treatment of each irrigation scheduling main plot in each replication. Tensiometer readings were taken weekly, prior to irrigation. Suction lysimeters were installed to a depth of four feet at distances of 5, 20, and 35 feet from the line-source in the 0, 360, and 600 lb N/ac treatments of each irrigation schedule and each rep. Soil solution extracts were taken weekly.

A new technique was employed for the detection of nitrate leaching. Access tubes were installed at angles to depths of 6, 24, and 48 inches to allow for insertion of ion exchange resin capsules in contact with the soil. Bromide (a tracer for nitrate) as well as nitrogen fertilizer were applied to the soil surface above these access tubes. The resin capsules were assayed weekly for nitrate and bromide content.

Plant stem and soil samples were taken from selected treatments on a weekly basis. Stem sap nitrate concentration was measured with a laboratory model nitrate-specific electrode. Stem nitrate content on a dry matter basis was measured by KCl extracts from ground material. Soil samples are currently being extracted for nitrate concentration analysis. In addition, the chlorophyll content of plant leaves was measured with the SPAD meter, which gives a digital readout of green wavelength light reflectance.

Yield was determined on August 3 by taking parallel swaths at distances 9, 16, 24, 31, and 39 ft from the line-source in each plot with a small-plot forage harvester. Hay fresh weights were recorded and a subsample was taken for moisture and total plant nitrogen determination. Oil content of the hay was determined from all plots in the 24 ft increment and selected plots in the 9 and 39 ft increments. This was done by distillation of dry hay samples in a small-scale distillation facility.

Soil core samples to 4 ft depth were taken after harvest in selected plots at three irrigation levels. The cores were divided into one-ft increments for extraction and analysis of nitrate concentration.

RESULTS:

Yield Response to Nitrogen. Under optimum irrigation, oil yields responded to N fertilization rates up to 240 lbs N/ac, with no further significant yield responses as N rates increased beyond that rate (Fig. 1). The slope of the regression equation in Fig. 1 indicates that within the range of oil yield response, it required the addition of 17 lbs N/ac to increase oil yields by one pound/ac. Single applications of urea were as effective as the standard incremental applications of similar rates.

Stem NO_3, Sap NO_3, and SPAD Analysis of Crop N Status. All three plant testing methods were sensitive to differences in crop N status and readily reflect N fertility management (Figs. 4a-c). There were differences between the methods in the patterns displayed over the course of the season.

Relationship Between Crop N Status and Yield. There was a very good correlation between midseason (July 7) crop N status and final oil yield (Figs. 2 and 3). Yields increased in a linear fashion with increasing sap NO_3-N levels up to 600 ppm and with increasing stem NO_3-N levels up to 5500 ppm and showed no response to higher levels. The outliers in this analysis are the sap NO_3 levels in the PRF treatments (Fig. 2). The particular management of these treatments, where we allowed crop N status to decline and then resumed fertilization, obviously effected the relationship between midseason N status and final yield. This illustrates that these temporary deficiencies can be recovered effectively.

Plant Response Fertilization. Plant Response Fertilization (PRF) is an approach to precise fertilizer management based on progressive plant diagnosis. The idea is to apply a moderate rate of nitrogen fertilizer to a production field and a heavy rate to a designated reference plot located within the production field. The reference plot and the production field are monitored by some diagnostic procedure on a regular basis throughout the growing season. Additional fertilizer is not applied to the production field until a deficiency is detected by comparison to the reference plot. The goal is high yields with less fertilizer. Such a system obviously requires a rapid diagnostic procedure to detect nitrogen status of the crop, preferably one that can be completed on site.

The PRF treatments included the SPAD chlorophyll meter (measures leaf greenness) and sap NO_3 analysis as tools for monitoring crop N status. We initially applied 90 lbs N/ac to these plots and then took SPAD leaf readings or sap NO_3readings on a weekly basis, using the higher N rate treatments as reference. Figure 5 illustrates how we managed the PRF sap NO_3 plots. Compared to other treatments, deficiencies in the PRF plots were not detected until week 4 (Fig. 5). We therefore began applying additional N to the PRF plots in week 5, putting on two applications of 60 lb N/ac each to finish out the season (210 lbs N/ac total). The sap NO_3 readings show the recovery of the plants from this deficiency.

Both PRF treatments (chlorophyll or stem nitrate) resulted in oil yields as high as any N rates of 240 lbs N/ac or greater. The goal of achieving high yields with less fertilizer was attained.

Irrigation Level and Timing. As in past years, there were no significant differences between the once-per-week vs. twice-per-week irrigation schedules in terms of yield or soil-plant N relations. This is due to the fact that peppermint rooting depth is much greater than previously supposed. This is illustrated in Fig. 6, where we see crop extraction of soil water at a depth of four feet under relatively dry conditions (35 ft distance from the line source). This reflects what was found in 1992 on first-year peppermint where water was extracted from the two-foot depth (high precipitation in 1993 prevented these measurements). It is therefore not surprising that a once-per-week irrigation schedule is sufficient to maintain adequate water availability for the crop.

Oil yields declined as irrigation rates declined below two inches/week (Fig. 7). Yields in 1994 were not significantly affected by higher rates of irrigation, but efficiency of use obviously declined.

Leaching. Breakthrough curves for bromide leaching at the 20 and 35 ft increments are shown for the 6, 24, and 48 inch soil depths in Figs. 8 a-c. These curves show the seasonal progression of leached bromide through the soil profile. This added tracer does not appear at the four foot depth until after harvest, which indicates that it stays within the crop rooting zone over the course of the growing season. These results are similar to those found with the resin-capsule measures of NO_3 movement through the profile (not shown): movement of NO_3 from added sources to the bottom of the crop rooting zone occurs primarily after the growing season. These data will be used for comparison of measured vs. modeled (LEACHM) movement of bromide through the soil profile. We'll present those results at the winter meeting.

PUBLICATIONS:

Westcott. M.P., M.L. Knox, and J.M. Wraith. 1994. Kinetics of soil-plant nitrate relations in potato and peppermint: A model for derivative diagnosis. Commun. Soil Sci. Plant Anal. 25:469-478.

Westcott, M.P. 1994. Developments in on-farm plant nitrate testing for high input crops. p. 848-849. *In* M. Borin and M. Sattin (ed.) Proc. 3rd ESA Congress, Abano-Padova, Italy. 18-22 Sept. European Society for Agronomy, BP 52, Colmar Cedex, France.

Westcott, M.P., and J.M. Wraith. 1995. Correlation of leaf chlorophyll readings and stem nitrate concentrations in peppermint. Commun. Soil Sci. Plant Anal. (in review).

Westcott, M.P., and J.M. Wraith. 1994. Suitability of the SPAD meter for nitrogen management in peppermint. Proceedings of the Pacific Division, American Society for the Advancement of Science, June19-24, San Francisco, CA. 13(1):101.

Written progress reports on 1993 results were submitted to the MIRC, the Montana Mint Committee, the Flathead Conservation District, and the Montana Fertilizer Tax Committee.

FUNDING SOURCES FOR 1994:

Montana Mint Committee	$ 1,000
Mint Industry Research Council	8,000
Montana Fertilizer Tax Fund	10,000
Flathead Conservation District	5,000

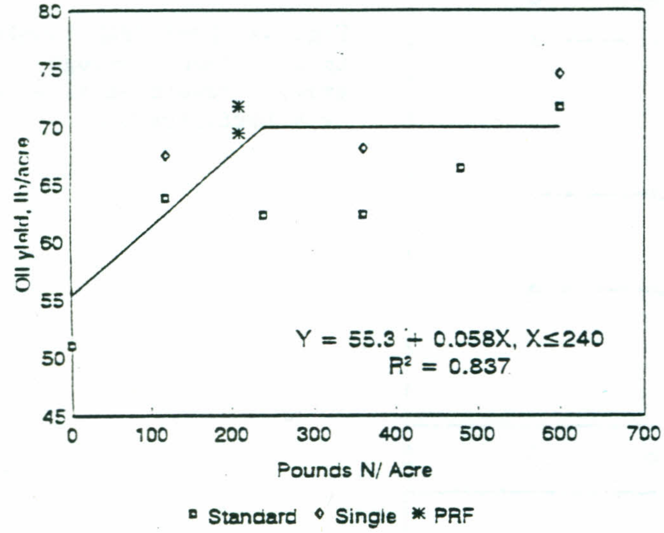

Figure 1. Peppermint oil yield response to N fertilization rates and timings.

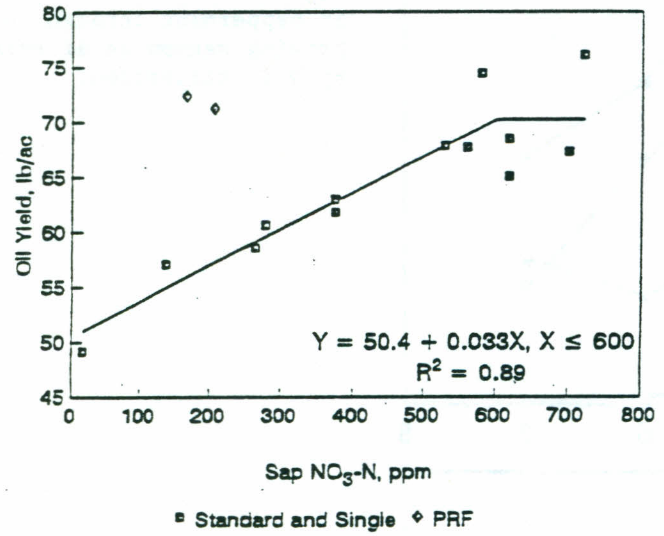

Figure 2. Relationship between sap NO_3-N measured July 7, 1994, and final peppermint oil yields.

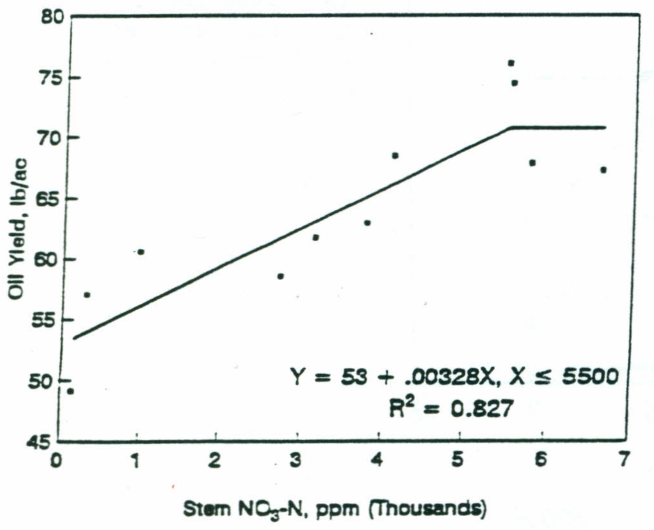

Figure 3. Relationship between stem NO_3-N measured July 7, 1994, and final peppermint oil yields.

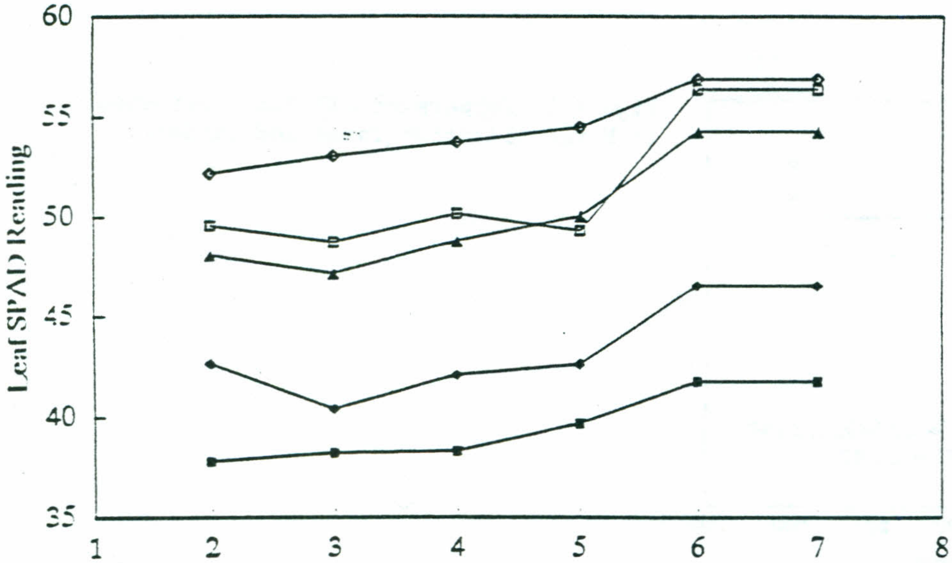

Fig. 4a. Leaf SPAD levels in peppermint through the growing season as affected by N fertilization.

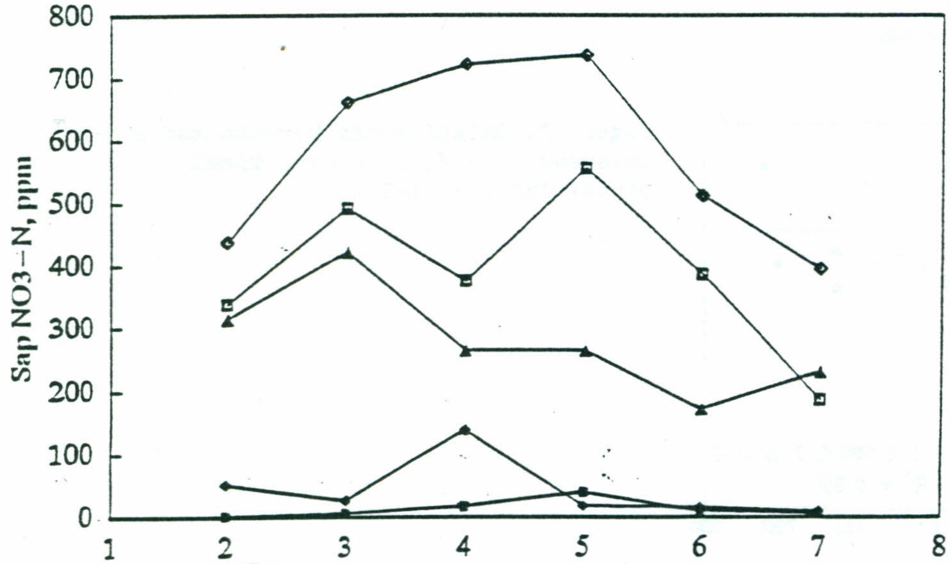

Fig. 4b. Sap nitrate levels in peppermint through the growing season as affected by N fertilization.

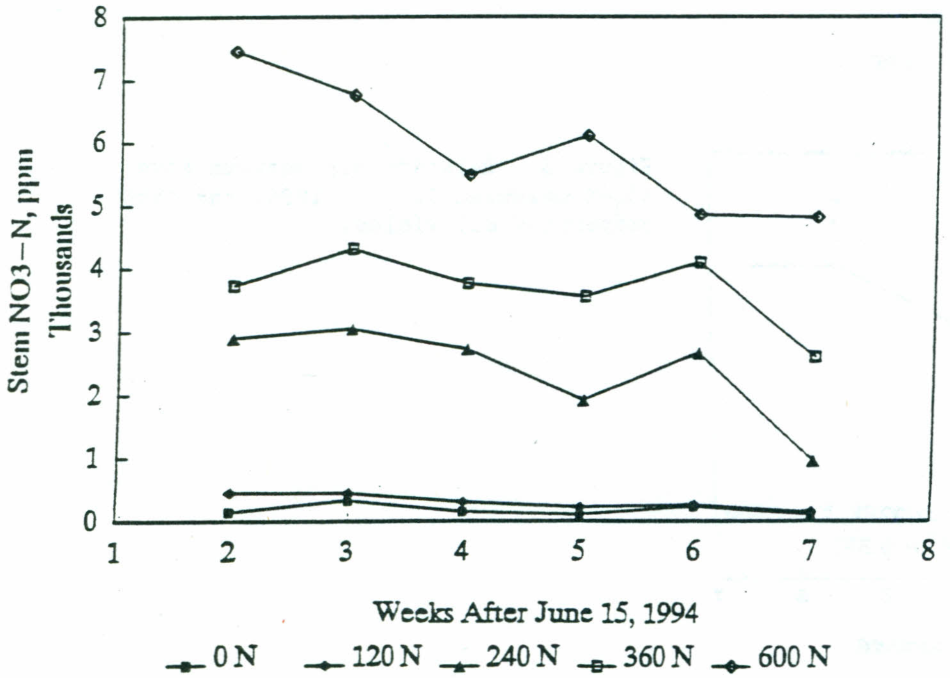

Fig. 4c. Stem nitrate levels in peppermint through the growing season as affected by N fertilization.

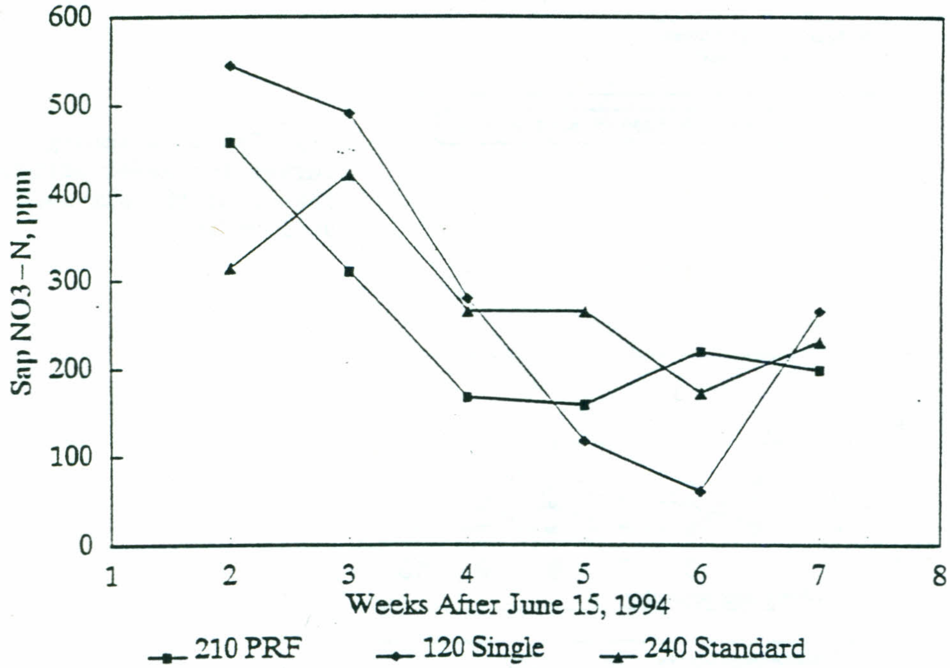

Fig. 5. Comparison of stem nitrate levels in peppermint as affected by timing of N fertilization, including Plant Response Fertilization.

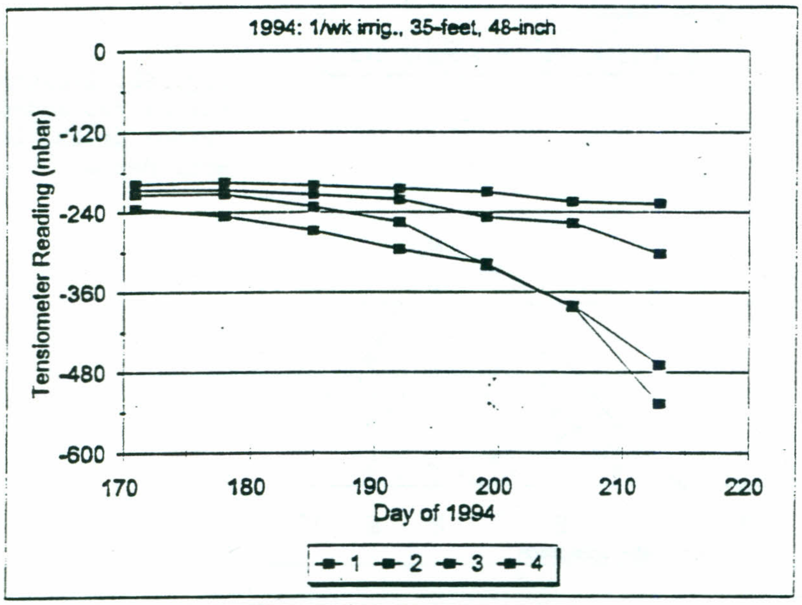

Fig. 6. Soil moisture tension at the 48 inch soil depth in peppermint. Individual lines represent replications.

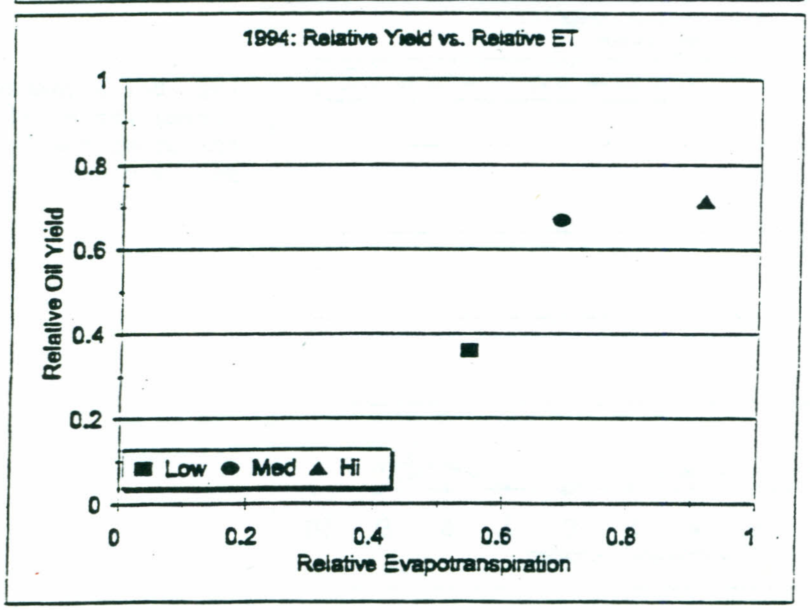

Fig. 7. Relative oil yields in peppermint as affected by relative evapotranspiration rate.

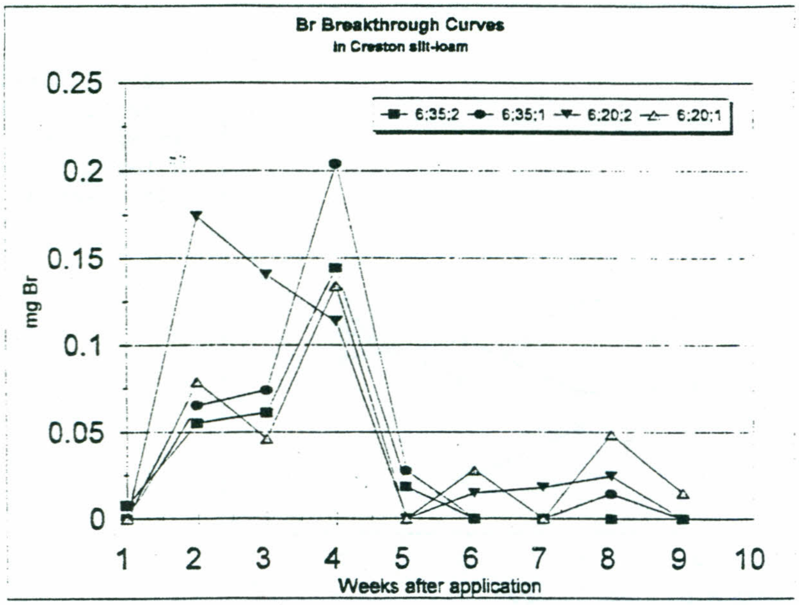

Fig. 8a. Breakthrough curves for added bromide tracer at the six inch soil depth.

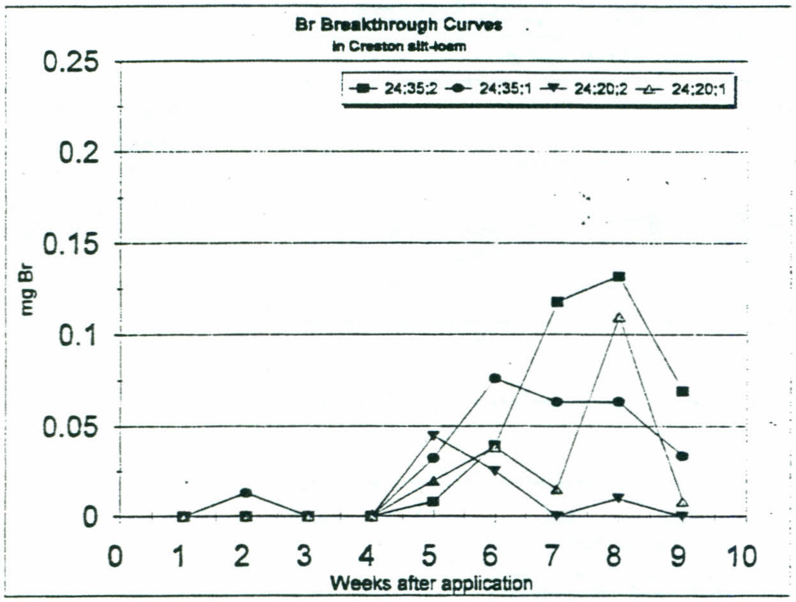

Fig. 8b. Breakthrough curves for added bromide tracer at the 24 inch soil depth.

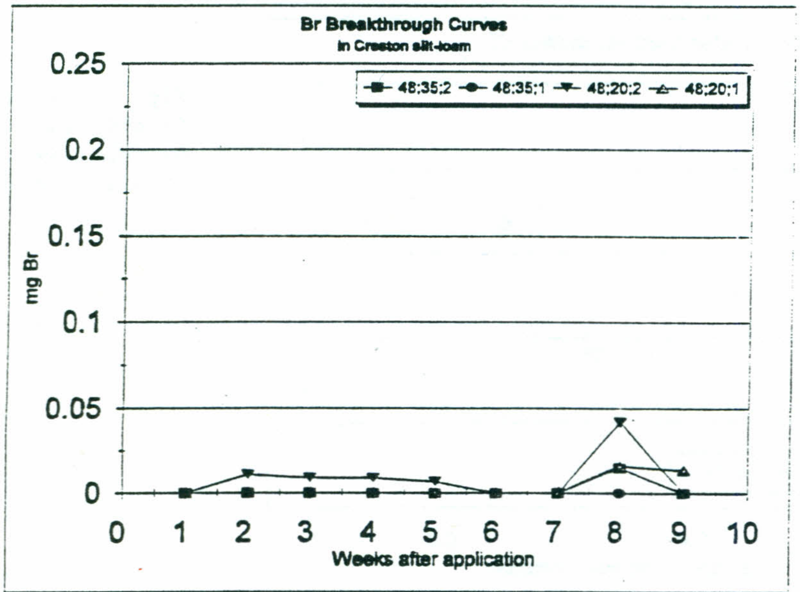

Fig. 8c. Breakthrough curves for added bromide tracer at the 48 inch soil depth.

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PEPPERMINT WILD OAT STUDY - SONSTELLIE FARM 1994

Project Code:94-PWO-SON
Cooperator :DALE SONSTELIE

Location :DALE SONSTELIE FARM
By:Bob Stougaard

Summary Comments: Surfactant type had a pronounced effect on wild oat control, with the response being most apparent at the 3 oz rate. Of the surfactants evaluated, MSO was more effective than NIS, and wild oat control with both surfactants was improved with the addition of UAN.

Wild oat control was most complete when applied at the 4 leaf stage of wild oat. Control with the early applications may have been less complete due to low evening temperatures of 37 F preceding application. This may have stressed plants and reduced herbicide uptake. Reduced control with the last application was probably due to the greater weed biomass present relative to the earlier applications.

Montana State University
PEPPERMINT WILD OAT STUDY - SONSTELLIE FARM 1994

Project Code:94-PWO-SON　　　　Location　:DALE SONSTELIE FARM
Cooperator　:DALE SONSTELIE　　　　By:Bob Stougaard

Trt No	Treatment Name	Form Amt	Rate	Rate Unit	Grow Stg	WILD OAT CONTROL PERCENT 8-9-94	WILD OAT DRY WT ~~PERCENT~~ 8-11-94	MINT DRY WT ~~PERCENT~~ 8-11-94	OIL YIELD LB/A 8-11-94
1	ASSURE II	.88 EC	3	oz pr/A	2 LEAF	0	61.9	38.1	3.5
1	ACTIVATOR 90	1 EC	.125	% v/v	2 LEAF				
2	ASSURE II	.88 EC	3	oz pr/A	2 LEAF	37	44.6	55.4	7.7
2	ACTIVATOR 90	1 EC	.125	% v/v	2 LEAF				
2	28% UAN	1 EC	2	qt pr/A	2 LEAF				
3	ASSURE II	.88 EC	3	oz pr/A	2 LEAF	81	11.4	88.6	10.0
3	MSO	1 EC	1	qt pr/A	2 LEAF				
4	ASSURE II	.88 EC	3	oz pr/A	2 LEAF	87	0.5	99.5	6.7
4	MSO	1 EC	1	qt pr/A	2 LEAF				
4	28% UAN	1 EC	2	qt pr/A	2 LEAF				
5	ASSURE II	.88 EC	7	oz pr/A	2 LEAF	50	24.2	75.8	8.7
5	ACTIVATOR 90	1 EC	.125	% v/v	2 LEAF				
6	ASSURE II	.88 EC	7	oz pr/A	2 LEAF	91	5.6	94.4	10.5
6	ACTIVATOR 90	1 EC	.125	% v/v	2 LEAF				
6	28% UAN	1 EC	2	qt pr/A	2 LEAF				
7	ASSURE II	.88 EC	7	oz pr/A	2 LEAF	93	1.5	98.5	11.4
7	MSO	1 EC	1	qt pr/A	2 LEAF				
8	ASSURE II	.88 EC	7	oz pr/A	2 LEAF	96	1.6	98.4	8.1
8	MSO	1 EC	1	qt pr/A	2 LEAF				
8	28% UAN	1 EC	2	qt pr/A	2 LEAF				
9	ASSURE II	.88 EC	3	oz pr/A	4 LEAF	20	32.8	67.2	4.5
9	ACTIVATOR 90	1 EC	.125	% v/v	4 LEAF				
10	ASSURE II	.88 EC	3	oz pr/A	4 LEAF	89	2.7	97.3	12.0
10	ACTIVATOR 90	1 EC	.125	% v/v	4 LEAF				
10	28% UAN	1 EC	2	qt pr/A	4 LEAF				
11	ASSURE II	.88 EC	3	oz pr/A	4 LEAF	94	3.2	96.8	6.3
11	MSO	1 EC	1	qt pr/A	4 LEAF				
12	ASSURE	.88 EC	3	oz pr/A	4 LEAF	97	0.0	100.0	6.1
12	MSO	1 EC	1	qt pr/A	4 LEAF				
12	28% UAN	1 EC	2	qt pr/A	4 LEAF				
13	ASSURE II	.88 EC	7	oz pr/A	4 LEAF	95	1.5	98.5	8.7
13	ACTIVATOR 90	1 EC	.125	% v/v	4 LEAF				
14	ASSURE II	.88 EC	7	oz pr/A	4 LEAF	98	2.1	97.9	4.3
14	ACTIVATOR 90	1 EC	.125	% v/v	4 LEAF				
14	28% UAN	1 EC	2	qt pr/A	4 LEAF				
15	ASSURE II	.88 EC	7	oz pr/A	4 LEAF	97	1.1	98.9	3.5
15	MSO	1 EC	1	qt pr/A	4 LEAF				
16	ASSURE II	.88 EC	7	oz pr/A	4 LEAF	98	0.0	100.0	6.8
16	MSO	1 EC	1	qt pr/A	4 LEAF				
16	28% UAN	1 EC	2	qt pr/A	4 LEAF				

Continued on next page

PEPPERMINT WILD OAT STUDY - SONSTELLIE FARM 1994

Trt No	Treatment Name	Form Amt	Rate	Rate Unit	Grow Stg	WILD OAT CONTROL PERCENT 8-9-94	WILD OAT DRY WT ~~PERCENT~~ 8-11-94	MINT DRY WT ~~PERCENT~~ 8-11-94	OIL YIELD LB/A 8-11-94
17	ASSURE II	.88 EC	3	oz pr/A	8 LEAF	7	41.7	58.3	1.7
17	ACTIVATOR 90	1 EC	.125	% v/v	8 LEAF				
18	ASSURE II	.88 EC	3	oz pr/A	8 LEAF	42	23.7	76.3	5.5
18	ACTIVATOR 90	1 EC	.125	% v/v	8 LEAF				
18	28% UAN	1 EC	2	qt pr/A	8 LEAF				
19	ASSURE II	.88 EC	3	oz pr/A	8 LEAF	72	31.5	68.5	1.8
19	MSO	1 EC	1	qt pr/A	8 LEAF				
20	ASSURE II	.88 EC	3	oz pr/A	8 LEAF	95	6.0	94.0	8.9
20	MSO	1 EC	1	qt pr/A	8 LEAF				
20	28% UAN	1 EC	2	qt pr/A	8 LEAF				
21	ASSURE II	.88 EC	7	oz pr/A	8 LEAF	85	14.7	85.3	7.6
21	ACTIVATOR 90	1 EC	.125	% v/v	8 LEAF				
22	ASSURE II	.88 EC	7	oz pr/A	8 LEAF	91	12.3	87.7	6.7
22	ACTIVATOR 90	1 EC	.125	% v/v	8 LEAF				
22	28% UAN	1 EC	2	qt pr/A	8 LEAF				
23	ASSURE II	.88 EC	7	oz pr/A	8 LEAF	98	0.8	99.2	10.9
23	MSO	1 EC	1	qt pr/A	8 LEAF				
24	ASSURE II	.88 EC	7	oz pr/A	8 LEAF	98	1.1	98.9	10.6
24	MSO	1 EC	1	qt pr/A	8 LEAF				
24	28% UAN	1 EC	2	qt pr/A	8 LEAF				
25	NONTREATED					0	58.9	41.1	1.3
LSD (.05) =						21	20.9	20.9	5.2
Standard Dev.=						12.6785	12.6716	12.6716	3.16882
CV =						17.52	82.21	14.98	45.54
Block F						1.185	2.382	2.382	10.004
Block Prob(F)						0.3145	0.1039	0.1039	0.0003
Treatment F						21.768	6.929	6.929	2.902
Treatment Prob(F)						0.0001	0.0001	0.0001	0.0012

Montana State University

PEPPERMINT WILD OAT STUDY - SONSTELLIE FARM 1994

Project Code:94-PWO-SON   Location :DALE SONSTELIE FARM
Cooperator :DALE SONSTELIE   By:Bob Stougaard

Site Description

Crop: BABY PEPPERMINT   Variety: BLACK MITCHAM   Planting Date: 5-16-94
Planting Method: ROOTS   Rate, Unit: 1/10A , A   Depth, Unit: 3 , "
Perennial Age, Unit: 0 , YRS   Row Spacing, Unit: 18 , "
Soil Temp., Unit: ,   Soil Moisture: Emergence Date: 6-5-94

Plot Width/Area, Unit: 10 , FT   Plot Length, Unit: 18.3 , FT   Reps: 3
Site Type: SILT CLAYLOAM   Seed Bed Desc.:   Ground Cover: NONE
Tillage Type: PACKED   Study Design: RCB
Field Preparation/Plot Maintenance: WILD OATS SEEDED WITH RESEARCH SEEDER ON 6-3-94

Soil Description

Texture: SILTY CLAY LOAM   % OM: 6.0   % Sand: 40   % Silt: 40   % Clay: 20
pH: 6.5   CEC: Soil Name: SWIMS SCL   Fertility Level:

Moisture Conditions

Moisture On:	Date	Amount Unit	Type		Date	Amount Unit	Type
1.				2.			
3.				4.			
5.				6.			
7.				8.			

Overall Moisture Conditions:

Application Information

	A	B	C	D	E	F
Application Date:	6-20-94	6-27-94	7-3-94			
Time of Day:	11:00	11:00	9:00			
Application Method:	BACKPACK	BACKPACK	BACKPACK			
Application Timing:	2 LEAF	4 LEAF	8 LEAF			
Air Temp., Unit:	65 ,F	67 ,F	68 ,F	,	,	,
% Relative Humidity:	30	59	14			
Wind Velocity, Unit:	1 ,MPH	3 ,MPH	0 ,MPH	,	,	,
Dew Presence (Y/N):	N	N	N			
Water Hardness:	N	N	N			
Soil Temp., Unit:	60 ,F	60 ,F	60 ,F	,	,	,
Soil Moisture:	VERY GOOD	VERY GOOD	VERY GOOD			
% Cloud Cover:	50	25	0			

Weed Species	Weed Stage, Density at Application					
WILD OAT	2 LF,	5 LF,	10LF,6"	,	,	,
PEPPERMINT	.5" ,	1 " ,	4" ,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
A.	BACKPACK	2.5	EVEN FANS	11002XS	13"	20"	10'	20	H20	20
B.	"									
C.	"									
D.										
E.										
F.										

Montana State University

MINT GRASS STUDY

Project Code:94-MNTGRASS

Location: KALISPELL
By: Bob Stougaard

Summary Comments: Herbicide injury was observed with the high rate of Assure II when applied with MSO plus 28% UAN. Similar treatments were used in other studies with no observable mint injury. The injury observed in this study was most likely due to the surfactants redissolving herbicide residues that were in the spray boom and hoses. This reconfirms the importance of cleaning spray equipment when going from crop to crop.

Excellent wild oat control was obtained with all herbicide treatments. There were no differences between herbicides, rates or surfactant types. These results suggest that wild oat is easily controlled and that lower herbicides rates should be evaluated in future studies. However the high level of control achieved might be due to the low populations present in the study. Treatment differences might be more apparent under heavier weed pressure.

Montana State University

MINT GRASS STUDY

Project Code:94-MNTGRASS   Location :KALISPELL
Cooperator :   By:Bob Stougaard

Trt No	Treatment Name	Form Amt	Fm Ds	Rate	Rate Unit	MINT INJURY PERCENT 6-6-94	MINT INJURY PERCENT 6-17-94	WILD OAT CONTROL PERCENT 6-17-94	MINT GRN WT TONS/A 7-26-94
1	ASSURE II	.8	EC	3	oz ai/A	0	0	99	12.0
1	MSO	1	EC	1	qt pr/A				
2	ASSURE II	.8	EC	3	oz ai/A	0	0	99	12.3
2	MSO	1	EC	1	qt pr/A				
2	28 % UAN	1	EC	2	qt pr/A				
3	ASSURE II	.8	EC	7	oz ai/A	0	0	99	12.7
3	MSO	1	EC	1	qt pr/A				
4	ASSURE II	.8	EC	7	oz ai/A	50	40	100	10.3
4	MSO	1	EC	1	qt pr/A				
4	28 % UAN	1	EC	2	qt pr/A				
5	POAST	1.53	EC	1	pt pr/A	3	2	98	13.0
5	MSO	1	EC	1	qt pr/A				
6	POAST	1.53	EC	1	pt pr/A	0	0	99	13.0
6	MSO	1	EC	1	qt pr/A				
6	28 % UAN	1	EC	2	qt pr/A				
7	POAST	1.53	EC	2	pt pr/A	0	0	100	12.9
7	MSO	1	EC	1	qt pr/A				
8	POAST	1.53	EC	2	pt pr/A	0	0	98	12.4
8	MSO	1	EC	1	qt pr/A				
8	28 % UAN	1	EC	2	qt pr/A				
9	SELECT	2	EC	3	oz ai/A	0	0	99	12.6
9	MSO	1	EC	1	qt pr/A				
10	SELECT	2	EC	3	oz ai/A	0	0	99	14.5
10	MSO	1	EC	1	qt pr/A				
10	28 % UAN	1	EC	2	qt pr/A				
11	SELECT	2	EC	6	oz ai/A	0	0	100	12.7
11	MSO	1	EC	1	qt pr/A				
12	SELECT	2	EC	6	oz ai/A	0	0	99	13.2
12	MSO	1	EC	1	qt pr/A				
12	28 % UAN	1	EC	2	qt pr/A				
13	NONTREATED					0	0	0	11.0
LSD (.05) =						3	5	2	2.6
Standard Dev.=						1.60128	3.00482	1.18285	1.56169
CV =						39.03	93.91	1.29	12.49

Montana State University

MINT GRASS STUDY

Project Code:94-MNTGRASS

Location :KALISPELL
By:Bob Stougaard

Site Description

Crop: PEPPERMINT　Variety: Black Mitcham　Planting Date: 4-8-94
Planting Method: Roots　Rate, Unit: 1000 , #/A　Depth, Unit: 3 , "
Perennial Age, Unit: 0 , yr　Row Spacing, Unit: 18 , "
Soil Temp., Unit: ,　Soil Moisture: Good　Emergence Date:

Plot Width/Area, Unit: 10 , FT　Plot Length, Unit: 15 , FT　Reps: 3
Site Type:　Seed Bed Desc.:　Ground Cover: None
Tillage Type:　Study Design: RCB
Field Preparation/Plot Maintenance:

Soil Description

Texture: Fine Sandy Loam　% OM: 2.4　% Sand: 50　% Silt: 40　% Clay: 10
pH: 6.2　CEC:　Soil Name: Kalispell FSL　Fertility Level:

Moisture Conditions

Moisture On:	Date	Amount Unit	Type		Date	Amount Unit	Type
1.				2.			
3.				4.			
5.				6.			
7.				8.			

Overall Moisture Conditions: See irrigation Schedule

Application Information

	A	B	C	D	E	F
Application Date:	5-3-94					
Time of Day:	1:00 pm					
Application Method:	Backpack					
Application Timing:	Post 8-12					
Air Temp., Unit:	78 ,F	,	,	,	,	,
% Relative Humidity:	14					
Wind Velocity, Unit:	1 ,mph	,	,	,	,	,
Dew Presence (Y/N):	N					
Water Hardness:	N					
Soil Temp., Unit:	68 ,F	,	,	,	,	,
Soil Moisture:	Irrigated					
% Cloud Cover:	25					

Weed Species	Weed Stage, Density at Application					
	,	,	,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
A.	BAckpack	2	flatfan	11002XR	14"	20"	10'	20	H2O	20
B.										
C.										
D.										
E.										

Montana State University

1994-95 LIVING MULCH STUDY IN PEPPERMINT

Project Code:95-LMS-R5 Location :KALISPELL, MT
Cooperator :MAL WESTCOTT By:Bob Stougaard

Summary Comments: The purpose of this study was to evaluate eight different crops for potential use as living mulch crops for peppermint production. Crops were seeded at either two weeks prior to mint harvest of directly after mint harvest. The first seeding was broadcast by hand to simulate an aerial application while the second planting used a conventional disk drill.

The post-harvest direct seedings produced the best stands. Aerial seedings did not establish well, possibly due to rodent or insect predation. Of the crops evaluated, winter and spring rye produced the most growth with dry weight biomass in excess of 2 and 1 tons per acre respectively. Winter and spring rape produced the least amount of growth, most likely due to competition from the mint crop.

Montana State University

1994-95 LIVING MULCH STUDY IN PEPPERMINT

Project Code:95-LMS-R5 Location :KALISPELL, MT
Cooperator :WESTCOTT By:Bob Stougaard

Trt No	Treatment Name	SEEDING DATE	MINT HEIGHT INCHES 10-19-94	MULCH HEIGHT INCHES 10-19-94	MULCH GRN CVR PERCENT 10-19-94	MULCH DRY WT LBS/A 10-24-94
9	Winter Wheat	2WK PRE	5.0	6.3	1.3	16
10	Spring Wheat	2WK PRE	4.7	10.0	3.3	89
11	Winter Rye	2WK PRE	5.7	15.7	14.3	195
12	Spring Rye	2WK PRE	4.7	6.3	4.3	146
13	Winter Rape	2WK PRE	4.0	4.3	6.0	19
14	Spring Rape	2WK PRE	4.3	4.7	4.7	30
15	Hairy Vetch	2WK PRE	5.0	5.0	22.7	147
16	Winter Peas	2WK PRE	4.0	3.7	2.7	29
17	Winter Wheat	POST HAR	4.0	5.7	38.3	677
18	Sprint Wheat	POST HAR	4.0	10.3	45.0	541
19	Winter Rye	POST HAR	5.3	16.0	68.3	2335
20	Spring Rye	POST HAR	5.0	6.7	50.0	1241
21	Winter Rape	POST HAR	3.7	2.7	7.0	120
22	Spring Rape	POST HAR	4.0	3.3	11.7	126
23	Hairy Vetch	POST HAR	3.7	3.7	28.3	514
24	Winter Peas	POST HAR	4.0	2.7	18.7	303
25	Straw		3.7	0.0	0.0	0.0
26	Nontreated		3.7	0.0	0.0	0.0
LSD (.05) =			1.8	3.4	9.3	842
Standard Dev.=			1.07659	2.04124	5.56708	504.802
CV =			24.74	34.34	30.68	123.75
Block F			1.981	3.720	2.134	1.292
Block Prob(F)			0.1535	0.0346	0.1340	0.2896
Treatment F			1.031	14.685	39.218	4.360
Treatment Prob(F)			0.4526	0.0001	0.0001	0.0003

Montana State University

1994-95 LIVING MULCH STUDY IN PEPPERMINT

Project Code:95-LMS-R5 Location :KALISPELL, MT
Cooperator :MAL WESTCOTT By:Bob Stougaard

Site Description

Crop: PEPPERMINT Variety: BLACK MMITHCAM Planting Date: 4-8-93
Planting Method: ROOTS Rate, Unit: 1000 , LB/A Depth, Unit: 3 , "
Perennial Age, Unit: 2 , YR Row Spacing, Unit: 18 , "
Soil Temp., Unit: , Soil Moisture: Emergence Date: 5-20-94

Plot Width/Area, Unit: 10 , FT Plot Length, Unit: 15 , FT Reps: 3
Site Type: Seed Bed Desc.: Ground Cover:
Tillage Type: Study Design: RCB
Field Preparation/Plot Maintenance:

Soil Description

Texture: SILT LOAM % OM: 2.8 % Sand: 40 % Silt: 50 % Clay: 10
pH: 6.4 CEC: Soil Name: CRESTON Fertility Level:

Moisture Conditions

Moisture On: Date Amount Unit Type Date Amount Unit Type
1. 2.
3. 4.
5. 6.
7. 8.

Overall Moisture Conditions:

Living Mulch Seeding Information

	2WK PRE	POST HARVEST
Seeding Date:	8-1-94	8-16-94
Seeding Method:	Aerial	Double disc
Seeding Timing:	2 WK PRE	POST HAR
Soil Moisture:	GOOD	GOOD

Seeding Rates:
Cereals 120 lb/A, Austrian Winter Peas 150 lb/A, Rape 12 lb/A
Hairy Vetch 40 lb/A

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
A.										
B.										
C.										
D.										
E.										
F.										

Montana State University

MINT PGR STUDY - PLANT GROWTH REGULATOR

Project Code:94-MINTPGR Location :KALISPELL
By:Bob Stougaard

Summary Comments: The purpose of this study was to determine if plant growth regulators might have a yield enhancing effect on meristem derived peppermint. For both PGR's, the earliest applications produced the most dramatic results. Ethryl had the most obvious effect on mint growth, to the point where the response was almost herbicidal. Initial injury was severe with the earliest applications, but most symptoms diminished by harvest. Early applications of Ethryl resulted in shorter plants, a greater number of leaves retained (base/height ratio), more branching, and a greater number of leaves. However, the initial injury resulted in reduced dry weight and oil yields. Applications of PIX did not result in any morphological differences. However, mint dry weight and oil yields were slightly greater compared to the check.

Montana State University

MINT PGR STUDY - PLANT GROWTH REGULATOR

Project Code:94-MINTPGR Location :KALISPELL
By:Bob Stougaard

Trt No	Treatment Name	Form Rate	Rate Unit	Grow Stg	PEPPERMINT -----INJURY----- % 6/6	% 6/17	% 7/16	Base/HT RATIO CM 11-1-94	Mint BRANCH POINTS 11-1-94	Mint LEAF NUMBER 11-1-94	Mint DRY WT TONS/A 7-26-94	Mint OIL YLD LB/A
1	PIX	2 EC 1.5	oz ai/A	8"	5	5	0	0.46	0.067	81.20	2.9	50.2
2	PIX	2 EC 3	oz ai/A	8"	3	5	0	0.47	0.067	88.10	2.4	40.9
3	ETHRYL	2 EC 1	qt pr/A	8"	50	50	7	0.35	0.600	125.80	1.6	21.9
4	ETHRYL	2 EC 2	qt pr/A	8"	50	50	2	0.42	0.867	61.40	1.5	18.6
5	PIX	2 EC 1.5	oz ai/A	12"	0	5	0	0.39	0.000	118.87	2.4	46.6
6	PIX	2 EC 3	oz ai/A	12"	0	7	2	0.42	0.317	86.93	2.2	39.8
7	ETHRYL	2 EC 1	qt pr/A	12"	0	25	20	0.42	0.200	79.13	1.7	28.4
8	ETHRYL	2 EC 2	qt pr/A	12"	0	22	33	0.36	0.267	119.13	1.8	25.4
9	PIX	2 EC 1.5	oz ai/A	24"	0	5	2	0.45	0.167	87.57	2.4	50.3
10	PIX	2 EC 3	oz ai/A	24"	0	5	3	0.50	0.000	81.33	2.1	43.6
11	ETHRYL	2 EC 1	qt pr/A	24"	0	5	18	0.47	0.200	76.93	2.2	41.0
12	ETHRYL	2 EC 2	qt pr/A	24"	0	5	20	0.52	0.333	85.87	2.2	39.2
13	NONTREATED				0	5	0	0.49	0.000	68.40	2.3	42.0
LSD (.05) =					5	5	5	0.10	0.548	42.92	0.4	11.2
Standard Dev.=					2.941	2.724	3.100	.0573	.3254	25.469	.2088	6.667
CV =					35.30	18.32	37.79	13.03	137.22	28.53	9.78	17.77
Block F					0.519	3.712	1.867	2.067	2.546	2.058	3.125	6.893
Block Prob(F)					0.6019	0.039	0.176	.1486	.0994	.1497	.0622	.0043
Treatment F					119.40	116.6	37.33	2.590	1.838	1.819	9.949	7.458
Treatment Prob(					0.0001	.0001	.0001	.0228	.0987	.1027	.0001	.0001

Montana State University

MINT PGR STUDY - PLANT GROWTH REGULATOR

Project Code:94-MINTPGR   Location :KALISPELL
By:Bob Stougaard

Site Description

Crop: PEPPERMINT   Variety: Black Mitcham   Planting Date: 4-8-94
Planting Method: Roots   Rate, Unit: 1000 , lb/A   Depth, Unit: 3 , "
Perennial Age, Unit: 0 , yr   Row Spacing, Unit: 18 , "
Soil Temp., Unit: ,   Soil Moisture: Emergence Date:

Plot Width/Area, Unit: 10 , FT   Plot Length, Unit: 15 , FT   Reps: 3
Site Type: Seed Bed Desc.:   Ground Cover:
Tillage Type: Study Design: RCB
Field Preparation/Plot Maintenance:

Soil Description

Texture: Fine Sandy Loam   % OM: 2.4   % Sand: 50   % Silt: 40   % Clay: 10
pH: 6.2   CEC: Soil Name: Kalispell FSL   Fertility Level:

Moisture Conditions

Moisture On:	Date	Amount Unit	Type		Date	Amount Unit	Type
1.				2.			
3.				4.			
5.				6.			
7.				8.			

Overall Moisture Conditions:

Application Information

	A	B	C	D	E	F
Application Date:	5-31-94	6-13-94	7-3-94			
Time of Day:	11:00	1:30 pm	1:00 pm			
Application Method:	Backpack	Backpack	Backpack			
Application Timing:	8"	12"	24"			
Air Temp., Unit:	67 ,F	64 ,F	68 ,F	,	,	,
% Relative Humidity:	43	44	18			
Wind Velocity, Unit:	0 ,MPH	2 ,MPH	3 ,MPH	,	,	,
Dew Presence (Y/N):	N	N	N			
Water Hardness:	M	N	N			
Soil Temp., Unit:	58 ,F	64 ,F	65 ,F	,	,	,
Soil Moisture:	Very Good	Very Good	Good			
% Cloud Cover:	99	99	0			

Weed Species	Weed Stage, Density at Application					
Mint	8" ,	12" ,	24" ,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,
	,	,	,	,	,	,

Application Equipment

	Sprayer Type	Speed MPH	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	Carrier	PSI
A.	Backpack	2.5	Flat Fan	11002XR	14"	20"	10'	20	H2O	20
B.	"									
C.	"									
D.										
E.										
F.										