MONTANA
STATE UNIVERSITY
AGRICULTURAL
EXPERIMENT STATION

1995 MONTANA PEPPERMINT RESEARCH REPORT

RESEARCH PROJECTS FOR THE NORTHWESTERN AND WESTERN AGRICULTURAL RESEARCH CENTERS

CULTIVAR, PROPAGATION, AND HARVEST MANAGEMENT STUDIES

Leon Welty and Louise Prestbye

WEED CONTROL STUDIES

Bob Stougaard and Todd Keener

IRRIGATION AND FERTILIZER STUDIES

Mal Westcott and Marty Knox

Plan to attend the Northwestern Ag Research Center Peppermint Tour on July 18, 1996

This publication reports on research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and Federal agencies before they can be recommended.

TABLE OF CONTENTS

Summary of growing degree day (GDD) data for mint at the Northwestern Agricultural Research Center May 1, 1949 through September 15, 1995.

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
1995	219.5	275.0	427.5	383.0	204.0	1509.0
MEAN	236.9	337.1	479.8	469.6	165.4	1688.7

MINT GDD AT NWARC BY DAY IN 1995.

YEAR: 1995 NORTHWESTERN AGRICULTURAL RESEARCH CENTER
MINT

May	MAX	MIN	GDD	June	MAX	MIN	GDD	July	MAX	MIN	GDD
1	56	32	3.0	1	78	43	14.0	1	78	46	14.0
2	63	38	6.5	2	79	47	14.5	2	79	47	14.5
3	53	44	1.5	3	82	54	18.0	3	65	54	9.5
4	55	37	2.5	4	72	55	13.5	4	60	53	6.5
5	64	43	7.0	5	68	51	9.5	5	69	45	9.5
6	59	43	4.5	6	58	38	4.0	6	74	47	12.0
7	61	39	5.5	7	41	33	0.0	7	82	51	16.5
8	61	41	5.5	8	57	34	3.5	8	76	50	13.0
9	61	37	5.5	9	56	45	3.0	9	85	50	17.5
10	70	42	10.0	10	66	43	8.0	10	85	57	21.0
11	64	44	7.0	11	71	47	10.5	11	78	53	15.5
12	55	43	2.5	12	68	41	9.0	12	71	51	11.0
13	47	34	0.0	13	76	49	13.0	13	69	52	10.5
14	60	32	5.0	14	71	46	10.5	14	69	47	9.5
15	66	40	8.0	15	72	44	11.0	15	73	49	11.5
16	68	44	9.0	16	72	45	11.0	16	73	47	11.5
17	71	45	10.5	17	67	49	8.5	17	77	47	13.5
18	65	50	7.5	18	66	49	8.0	18	84	49	17.0
19	64	34	7.0	19	64	48	7.0	19	85	53	19.0
20	64	35	7.0	20	63	41	6.5	20	80	56	18.0
21	69	42	9.5	21	51	45	0.5	21	85	59	22.0
22	62	30	6.0	22	62	49	6.0	22	74	52	13.0
23	67	31	8.5	23	61	51	6.0	23	71	53	12.0
24	68	36	9.0	24	70	48	10.0	24	79	54	16.5
25	67	35	8.5	25	77	48	13.5	25	77	53	15.0
26	57	38	3.5	26	79	48	14.5	26	79	49	14.5
27	60	32	5.0	27	79	45	14.5	27	66	54	10.0
28	68	38	9.0	28	60	37	5.0	28	75	43	12.5
29	76	42	13.0	29	69	37	9.5	29	83	56	19.5
30	80	47	15.0	30	75	44	12.5	30	75	51	13.0
31	82	53	17.5					31	67	47	8.5
	AV MAX	AV MIN	GDD		AV MAX	AV MIN	GDD		AV MAX	AV MIN	GDD
	64.0	39.4	219.5		67.7	45.1	275.0		75.6	50.8	427.5

August			GDD	Sept.			GDD	Oct.			GDD
1	75	44	12.5	1	75	38	12.5	1			0.0
2	82	51	16.5	2	83	43	16.5	2			0.0
3	76	51	13.5	3	85	41	17.5	3			0.0
4	79	48	14.5	4	86	44	18.0	4			0.0
5	84	50	17.0	5	84	53	18.5	5			0.0
6	88	57	22.5	6	70	48	10.0	6			0.0
7	84	56	20.0	7	76	50	13.0	7			0.0
8	64	44	7.0	8	73	52	12.5	8			0.0
9	59	42	4.5	9	71	38	10.5	9			0.0
10	72	41	11.0	10	68	40	9.0	10			0.0
11	83	48	16.5	11	68	45	9.0	11			0.0
12	69	45	9.5	12	79	45	14.5	12			0.0
13	69	47	9.5	13	78	43	14.0	13			0.0
14	59	40	4.5	14	79	42	14.5	14			0.0
15	76	41	13.0	15	78	43	14.0	15			0.0
16	55	46	2.5	16			0.0	16			0.0
17	63	50	6.5	17			0.0	17			0.0
18	59	46	4.5	18			0.0	18			0.0
19	67	38	8.5	19			0.0	19			0.0
20	74	41	12.0	20			0.0	20			0.0
21	83	43	16.5	21			0.0	21			0.0
22	84	46	17.0	22			0.0	22			0.0
23	87	50	18.5	23			0.0	23			0.0
24	84	53	18.5	24			0.0	24			0.0
25	73	37	11.5	25			0.0	25			0.0
26	74	39	12.0	26			0.0	26			0.0
27	76	38	13.0	27			0.0	27			0.0
28	78	40	14.0	28			0.0	28			0.0
29	83	47	16.5	29			0.0	29			0.0
30	69	40	9.5	30			0.0	30			0.0
31	70	38	10.0					31			0.0
	AV MAX	AV MIN	GDD		AV MAX	AV MIN	GDD		AV MAX	AV MIN	GDD
	74.1	45.1	383.0		76.9	44.3	204.0		0.0	0.0	0.0

TOTAL GROWING DEGREE DAYS: 1995 1509.0

AIR/SOIL TEMPERATURE (1995-1996)

°F

	Air	Soil (2")	Soil (4")	Snow Cover (inches)
Oct. 30	18.5	35.2	36.2	0
Nov. 8	31.5	32.8	33.2	6
Nov. 23	34.4	33.5	33.9	0
Dec. 8	-6.4	30.5	32.3	0
Dec. 9	-6.3	28.5	30.6	0
Dec. 11	21.8	30.9	31.3	4
Dec. 13	37.9	32.5	32.4	T
Dec. 25	23.2	31.5	31.9	0
Jan. 5	-8.9	32.4	32.2	6
Jan. 17	7.6	31.0	32.0	0.25
Jan. 18	9.5	28.4	29.6	0.25
Jan. 19	11.2	28.3	29.2	2
Jan. 28	-6.5	31.1	31.3	9.5
Jan. 29	-20.6	30.8	30.9	10
Jan. 30	-26.5	29.9	30.2	9.5
Jan. 31	-21.6	29.6	29.9	9.5
Feb. 3	-14.4	29.2	29.5	9
Feb. 6	36.2	30.6	30.6	9

Note: These temperatures were recorded in a mint field next to the satellite weather station located on the NWARC.

MINT RESEARCH REPORT - 1995

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 (Table 1) were established in Creston silt loam soils at the Northwestern Agricultural Research Center at Kalispell, MT in spring of 1994. The experiment was planted at two sites: one infected with *Verticillium* wilt in fall, 1994, and one kept free of the disease.

Nuclear plants were obtained from three different sources. Black Mitcham, nodal tissue derived, and grown in soil plugs was obtained from Lakes, Ronan, MT. Meristem Black Mitcham and meristem Native and Scotch spearmints were obtained from Starkels, Ronan, MT. All other entries (stem-tip propagated) were provided by MIRC from Don Roberts' breeding program. Plants were placed on one foot centers. Each plot consisted of four rows spaced 20 inches apart, 20 feet in length. Harvest area for hay yield was 96.5 square feet. The peppermint and spearmint experiments were arranged separately in randomized complete block designs with four replicates.

Each nursery was sprinkler irrigated to insure maximum growth. Each experimental site was fertilized with 129 lbs N; 56 lbs P_2O_5, 60 lbs K_2O, and 24 lbs SO_2/acre on Apr. 5; 50 lbs N/acre on June 2; 70 lbs N and 15 lbs SO_2/acre on July 14; and 50 lbs N/acre on Aug. 31, 1995. Sinbar was applied at 1 lb AI/acre on May 2, and Orthene was applied at 1 lb AI/acre on June 29, 1995.

Cultivars were evaluated for agronomic characteristics and disease symptoms. Because very little disease was observed in the Vert wilt nursery, data were pooled allowing 8 replicates per treatment. Twenty stems were pulled from each plot at one site prior to each harvest. Leaves were removed from each stem, and wet and dry weight of leaves and stems, number of leaves, total stem length, and length from base of stem to first leaf node was recorded for each. Dry matter yields of peppermint cultivars were obtained on Aug. 10 and of spearmint on July 24 and Sept. 13, 1995. Twelve to 15 pounds of green hay was air dried and later distilled. Samples were sent to Wm. Leman Co. for quality analyses.

RESULTS AND DISCUSSION:

Spring vigor, as indicated by row cover on 5/19 (Table 1), and fall regrowth after harvest (observed) were greater for Black Mitcham (BM)-nodal and BM-meristem than for other cultivars. Black Mitcham-nodal was actually more vigorous than BM-meristem, which is contrary to past observations. This may indicate that additional factors may be involved in the very vigorous growth of meristem BM other than the meristem process itself.

Hay yields were not necessarily related to spring vigor. Hay yields were greatest for M-83-7, Roberts Mitcham and Murray Mitcham (Table 2). Lower hay yields for BM-nodal and BM-meristem may be attributed to bare stems left in the plot after harvest because of severe lodging. These stems were completely devoid of leaves; therefore, material left in the plot did not affect oil yield.

Peppermint oil yields were greatest for BM-MIRC and lowest for BM meristem (Table 2). Oil yields were not related to hay yields and were inversely related to vigor, indicating that some stress may be needed to produce high oil yields. It is surprising and somewhat alarming that BM-nodal had lower oil yields than BM-MIRC. In May of 1994 the BM-nodal nuclear plants were much more vigorous and healthy looking than the BM-MIRC nuclear plants.

The only leaf/stem parameter with statistically significant ($P <= 0.10$) differences among the peppermints was stem length (Table 3). The stems of the Blacks were longer than the stems of the other cultivars. Comparison of dry matter content in the hay showed that the Blacks had 10% higher moisture content than the other Mitchams (data not shown).

Peppermint rust was evident on all cultivars by mid-July, with the Black Mitchams appearing most heavily infected. By harvest time, all cultivars showed symptoms throughout most of the plot area.

The meristem-derived spearmint covered the rows more completely and had more stolon spread than stem tip spearmint (Table 1). All spearmint cultivars had significant levels of rust by the September harvest.

Native meristem had the highest dry matter production and Scotch stem-tip the least (Table 2). Some stems devoid of leaves were left in the Scotch plots, which may have reduced overall hay yields. Scotch spearmint produced more oil than Native spearmint. **Meristem** derived spearmint produced more oil than stem tip spearmint.

Scotch spearmint had a higher leaf to stem ratio than Native (Table 3). It also had significantly more leaves per stem in the first growth cycle, but not the second. Unlike the peppermints, amount of leaf biomass correlated with oil production. Scotch had slightly higher dry matter content in the first harvest, but Native was higher in the second harvest.

There were significant differences among peppermint cultivars in all major oil quality components except esters. BM-MIRC (stem) and BM-Starkel (meristem) had the highest menthol and menthofuran levels and the lowest menthone. All cultivars were at the mid- to late-bud stage at harvest. (BM-Lake-nodal was between bud and prebloom. Although it appeared slightly more mature, its menthol level was lower and menthone higher.) Scotch spearmint had significantly higher levels of heads, limonene, octanol, and carvone than Native.

Table 1. Agronomic characteristics of mint cultivars at Kalispell, MT in 1995.

CULTIVAR	8/1/95 HEIGHT inches	5/19/95 ROW COVER (1-5) 1/	5/19/95 STOLON SPREAD (1-5) 2/	7/21/95 RUST % 3/	8/1/95 RUST % 3/
Peppermint					
Black Mitcham - MIRC - Roberts	36	2.8	2.3	50	81
Black Mitcham - Lake - *in vitro*	35	4.0	2.7	65	83
Black Mitcham - Starkel - meristem	37	3.5	1.7	52	90
Murray Mitcham	37	2.8	1.8	29	77
Roberts Mitcham	35	3.0	1.5	38	81
M-83-7	38	2.7	1.8	25	81
T-84-5	37	2.0	1.7	35	81
LSD(0.10)	2	0.6	NS	23	NS

	7/13/95 HEIGHT inches	9/13/95 HEIGHT inches	5/19/95 ROW COVER (1-5) 1/	5/19/95 STOLON SPREAD (1-5) 2/	9/5/95 RUST % 3/
Spearmint					
Native - stem - MIRC	33	20	3.3	3.0	65
Native - meristem - Starkel	33	21	4.3	4.1	44
Scotch - stem - MIRC	30	21	3.3	3.1	52
Scotch - meristem - Starkel	30	19	4.0	3.6	52
LSD(0.10)	2	1	0.8	NS	NS

1/ 1=plot area very sparsely covered; 5=plot area totally covered.

2/ 1=no stolon spread; 5=extensive stolon spread.

3/ Visual estimate of percent of plot showing symptoms.

Table 2. Hay yield, oil content, and oil yield for mint cultivars at Kalispell, MT in 1995.

CULTIVAR	HAY YIELD	OIL CONTENT	OIL YIELD
	tons DM/a	*ml/lb*	*lbs/a*
Peppermint			
Black Mitcham - MIRC - Roberts	4.44	3.2	54.0
Black Mitcham - Lake - *in vitro*	4.58	2.6	45.0
Black Mitcham - Starkel - meristem	4.63	2.0	35.5
Murray Mitcham	4.90	2.3	43.2
Roberts Mitcham	4.99	2.5	47.4
M-83-7	5.02	2.6	48.5
T-84-5	4.77	2.4	44.2
LSD(0.10)	0.37	0.3	4.4

	HAY YIELD			OIL CONTENT		OIL YIELD		
	tons DM/a			*ml/lb*		*lbs/a*		
Spearmint	*Harv-1*	*Harv-2*	*Total*	*Harv-1*	*Harv-2*	*Harv-1*	*Harv-2*	*Total*
Native - stem - MIRC	3.11	2.65	5.76	1.7	2.7	35.0	30.0	65.0
Native - meristem - Starkel	3.62	3.16	6.78	1.8	2.4	38.9	33.8	72.7
Scotch - stem - MIRC	2.85	2.29	5.14	3.0	4.1	56.5	40.6	97.1
Scotch - meristem - Starkel	3.22	2.34	5.56	3.1	4.5	67.5	47.0	114.5
LSD(0.10)	0.31	0.29	0.41	0.4	0.5	7.7	4.6	8.5

Nuclear plants established Spring 1994.
Peppermint harvested 8/1/95 (reps 1&2) and 8/10/95 (reps 3&4).
Spearmint harvested 7/12/95 and 9/13/95.

Table 3. Leaf/ stem characteristics of mint cultivars at Kalispell, MT in 1995.

CULTIVAR	LEAF:STEM WET	LEAF:STEM DRY	LEAVES/ STEM	STEM LENGTH	FIRST LEAF 1/
			no.	inches	
Peppermint					
Black Mitcham - MIRC - Roberts	0.56	0.85	47.3	30.1	14.3
Black Mitcham - Lake - *in vitro*	0.50	0.79	47.1	32.9	18.0
Black Mitcham - Starkel - meristem	0.56	0.83	47.0	31.0	16.1
Murray Mitcham	0.57	0.82	29.1	27.4	14.2
Roberts Mitcham	0.57	0.78	33.3	27.9	14.5
M-83-7	0.60	0.84	43.7	28.8	14.3
T-84-5	0.58	0.82	43.0	29.0	13.6
LSD(0.10)	NS	NS	NS	2.8	2.7 (P=0.14)

Sampling date: 7/10/95

	LEAF:STEM WET	LEAF:STEM DRY	LEAVES/ STEM	STEM LENGTH	FIRST LEAF 1/
			no.	inches	
Spearmint					
Native - stem - MIRC	0.49	0.58	37.1	26.3	8.4
Native - meristem - Starkel	0.51	0.60	42.2	28.8	11.4
Scotch - stem - MIRC	0.67	0.70	70.8	27.0	11.4
Scotch - meristem - Starkel	0.59	0.62	45.5	26.1	13.9
LSD(0.10)	0.09	0.06	14.1	2.0 (P=0.12)	1.9

Sampling date: 7/24/95

	LEAF:STEM WET	LEAF:STEM DRY	LEAVES/ STEM	STEM LENGTH	FIRST LEAF 1/
Spearmint			no.	inches	
Native - stem - MIRC	1.00	1.01	15.4	13.4	5.0
Native - meristem - Starkel	0.95	0.99	16.4	17.0	7.6
Scotch - stem - MIRC	1.03	1.05	18.9	17.0	9.2
Scotch - meristem - Starkel	1.15	1.08	17.9	14.3	7.4
LSD(0.10)	0.15 (P=0.16)	0.07 (P=0.14)	NS	2.2	1.8

Sampling date: 9/13/95

1/ # of inches from soil surface to first leaf node.

Table 4. Quality components of mint cultivars at Kalispell, MT in 1995.

CULTIVAR	Total Heads	Total Ketones	Total Menthol	Mentho-furan	Menthone	Menthol	Esters	Pulegone
Peppermint	%	%	%	%	%	%	%	%
Black Mitcham-MIRC-stem	9.5	23.6	45.6	3.4	19.9	39.1	3.4	0.8
Black Mitcham-Lake-nodal	8.4	27.4	44.2	3.0	23.5	37.9	3.3	0.7
Black Mitcham-Starkel-meristem	8.1	24.7	46.3	3.1	21.1	39.7	3.4	0.8
Murray Mitcham-MIRC-stem	9.1	26.7	44.5	2.2	22.9	38.1	3.3	0.6
Roberts Mitcham-MIRC-stem	9.4	26.9	44.9	2.2	23.1	38.5	3.2	0.6
M-83-7 -MIRC-stem	9.3	26.1	44.7	2.8	22.2	38.2	3.4	0.8
T-84-5 -MIRC-stem	8.9	28.5	44.0	2.7	24.6	37.4	3.4	0.8
LSD(0.05)	0.5	1.8	1.5	0.4	1.8	1.2	NS	0.1

Spearmint	Total Heads	b-Pinene	Limonene	Cineole	Octanol	Dihydro-carvone	Carvone
First Harvest - 7/12/95	%	%	%	%	%	%	%
Native-stem-MIRC	18.3	1.1	7.9	1.8	0.9	2.1	53.4
Native-meristem-Starkel	17.9	1.1	7.5	2.0	1.0	2.7	54.8
Scotch-stem-MIRC	19.2	1.0	12.8	1.0	2.3	1.0	68.3
Scotch-meristem-Starkel	19.5	1.1	13.1	0.9	2.2	1.3	68.0
LSD(0.05)	1.2	0.1	0.9	0.2	0.1	0.4	2.2
Second Harvest - 9/13/95							
Native-stem-MIRC	22.0	1.5	9.4	2.0	0.9	3.0	52.4
Native-meristem-Starkel	21.3	1.3	9.0	2.2	0.9	4.1	52.8
Scotch-stem-MIRC	26.2	1.4	17.5	1.4	2.3	2.4	60.0
Scotch-meristem-Starkel	25.3	1.4	18.0	1.0	2.3	2.7	62.2
LSD(0.05)	2.5	NS	1.8	0.2	0.2	0.7	3.0

MINT RESEARCH REPORT - 1995

TITLE: Peppermint Propagation Evaluation

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

OBJECTIVE: Determine effect of propagation method and source on peppermint oil yield and quality.

PROCEDURES: The experiment was established in 1995 on a Creston silt loam soil that was plowed out of alfalfa the previous fall. Nuclear plants of Black Mitcham peppermint were obtained from three sources: Lakes, of Ronan, MT provided nodal tissue derived plants in soil plugs from both 1992 and 1994 cultures, and plants grown with bare roots in growth medium from 1994; Summit Labs, the MIRC propagator, provided plants derived from stem tip cuttings.

On May 23, 1995 the plants were placed on one foot centers in four rows spaced 20 inches apart, 20 feet in length. Harvest area for hay yield was 100 square feet. Propagation lines were arranged in a randomized complete block design with four replicates.

The site was fertilized with 23 lbs N, 52 lbs P_2O_5, and 21 lbs SO_2 per acre on Oct.2, 1994, and with 87 lbs N, 52 lbs P_2O_5, 48 lbs SO_2, and 120 lbs K_2O per acre on June 12, 1995. No pesticides were applied in 1995.The nursery was sprinkler irrigated to insure maximum growth.

Entries were evaluated for agronomic characteristics and disease. Dry matter yields were obtained on Sept.13. Approximately 15 pounds of green hay was air dried and later distilled. Oil samples were sent to Wm. Leman Co. for quality analysis.

RESULTS AND DISCUSSION:

The material from Lakes had the more vigorous growth as of early August, as evidenced by row coverage (Table 1a). The nodal tissue propagated plants from Lakes had more height, row cover, vigor, and stolon spread than the stem tip propagated plants from Summit.

Powdery mildew began to appear in early August and was in most plots by mid-September. The plug-grown plants from Lakes tended to have the most infestation. Peppermint rust had infected large areas of the plots by September.

The 3 nodal lines from Lakes produced more oil than the stem tip line from Summit (Table 2). They also produced more dry matter during this establishment year.

There were significant oil quality differences among propagation lines in total heads, menthol, and menthofuran. Soil plug grown plants derived from the 1992 nodal culture had significantly higher menthol and menthofuran than the stem tip propagated line from Summit.

Table 1a. Agronomic characteristics of Black Mitcham propagation lines at Kalispell, MT on 8/2/95.

PROPAGATION SOURCE	HEIGHT	ROW COVER	VIGOR	STOLON SPREAD
	inches	*(1-5) 3/*	*(1-5) 4/*	*(1-5) 5/*
Lake - plug - 1994 1/	13.0	4.3	3.8	4.5
Lake - plug - 1992 1/	13.8	4.8	4.4	4.8
Lake - bare root - 1994 1/	14.5	4.6	4.4	4.5
Summit - bare root 2/	11.0	3.5	2.3	3.5
LSD(0.10)	1.6	0.6	0.7	NS

1/ in vitro nodal

2/ stem tip

3/ 1=plot area very sparsely covered; 5=plot area totally covered.

4/ 1=poor; 5=highly vigorous.

5/ 1=no stolon spread; 5=extensive stolon spread.

Table 1b. Agronomic characteristics of Black Mitcham propagation lines at Kalispell, MT on 9/11/95.

PROPAGATION SOURCE	HEIGHT	ROW COVER	VIGOR	STOLON SPREAD	RUST
	inches	*(1-5) 3/*	*(1-5) 4/*	*(1-5) 5/*	*% 6/*
Lake - plug - 1994 1/	24.5	5.0	4.0	4.3	70.0
Lake - plug - 1992 1/	23.3	4.3	4.0	4.0	95.0
Lake - bare root - 1994 1/	25.5	4.8	3.8	4.0	77.5
Summit - bare root 2/	22.8	3.8	2.5	3.0	100.0
LSD(0.10)	NS	0.4	0.9	NS	NS

1/ in vitro nodal

2/ stem tip

3/ 1=plot area very sparsely covered; 5=plot area totally covered.

4/ 1=poor; 5=highly vigorous.

5/ 1=no stolon spread; 5=extensive stolon spread.

6/ Visual estimate of percent of plot showing symptoms.

Table 2. Hay yield, oil content, and oil yield for Black Mitcham propagation lines at Kalispell, MT in 1995.

PROPAGATION SOURCE	HAY YIELD	OIL CONTENT	OIL YIELD
	tons DM/a	*ml/lb*	*lbs/a*
Lake - plug - 1994 [1]	2.51	3.6	33.9
Lake - plug - 1992 [1]	2.43	3.4	30.7
Lake - bare root - 1994 [1]	2.47	3.8	33.5
Summit - bare root [2]	1.55	4.4	26.3
LSD(0.10)	0.40	NS	5.0

[1] *in vitro nodal*

[2] *stem tip*

Table 3. Quality components of Black Mitcham propagation lines at Kalispell, MT in 1995.

PROPAGATION SOURCE	Total Heads	Total Ketones	Total Menthol	Menthofuran	Menthone	Menthol	Esters	Pulegone
	%	%	%	%	%	%	%	%
Lake - plug - 1994 [1]	9.2	15.6	60.2	2.2	13.1	46.1	10.2	0.2
Lake - plug - 1992 [1]	7.7	14.9	62.2	2.7	12.5	46.7	11.2	0.2
Lake - bare root - 1994 [1]	9.1	15.6	60.8	2.2	13.2	46.7	10.1	0.2
Summit - bare root [2]	9.0	15.5	60.0	2.4	13.1	45.5	10.4	0.2
LSD(0.05)	0.6	NS	1.6	0.2	NS	1.0	NS	0.0

[1] *in vitro nodal*

[2] *stem tip*

Oil analysis by Wm. Leman Company.

MINT RESEARCH REPORT - 1995

TITLE: Meristem Black Mitcham Peppermint Double Cut Study (1994-1995)

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 were assigned in a randomized complete block design.

In the fall of 1994, the area was fertilized with 17 lbs N, 78 lbs P_2O_5, and 120 lbs K_2O/a. In 1995, a total of 310 lbs N/a was applied. Sinbar was applied at 1.0 lb AI/a on May 2. Orthene, at 1.0 lb AI/a, was sprayed on June 29 for cutworm control.

Stolons were dug from a 15-inch square area in each plot on May 16, 1995, to determine how spring stolon mass was affected by 1994 double cutting. The entire nursery was harvested once on August 3, 1995 at full bud. Ten to 17 pounds of green hay was air dried and later distilled. Samples were sent to A.M. Todd for quality analyses.

RESULTS AND DISCUSSION:

The results of double cutting in 1994 were presented in the 1994 Mint Report. In summary, oil yields ranged from 86 to 99 lbs oil/acre. All double cut treatments produced more oil than a single harvest (49 lbs/a). Harvesting on 7/12 and again on 9/1 produced the most oil of all double cuts tested.

There were significant differences in 1995 spring stolon weight among 1994 cutting treatments (Table 1). The most vigorous stolons, judging by total fresh weight, were found in the plots harvested 6/28 + 9/1. For all first cutting dates, an early second cutting (9/1) resulted in more stolon mass than a late second cutting (9/27). We expected that stolon mass would be greater for the later second harvest date because these plots had an additional 26 days to photosynthesize and replenish root reserves.

Stolon vigor/growth may not be related to carbohydrate root replenishment. Two different systems may be involved. This has some implications for stolon/root production practices. Research is being designed to examine these factors in 1996.

Although there were observable differences in stolon mass, there were no significant differences in hay yield, oil content, or oil yield among the different 1994 double cut treatments or the single cut control (Table 1). Oil yield averaged only 39.9 lbs/a. Oil yields from our experimental still are about 70% of commercial distillation.

Oil quality component analyses showed no significant differences among 1994 double cut treatments or the single cut control (Table 2). Menthol level was 48%, which is acceptable for prime grade peppermint oil.

The important result of this study was that double cutting had no deleterious effect on the subsequent year's oil yield compared to a single cutting. It must be noted that we had about 2 inches of snow cover during the cold weather. Also, we did not have the wind that was experienced in other parts of the Flathead Valley. There was also no obvious relationship between stolon mass in the spring and crop performance in the growing season, which refutes the assumption that "vigorous" looking stolons predict crop performance.

Table 1. Performance of meristem Black Mitcham in 1995 as affected by 1994 double cutting.

1994 HARVESTS		1995 Data [3]			
First Cutting	Second Cutting	STOLON [2] WEIGHT	HAY YIELD	OIL CONTENT	OIL YIELD
		gms	*t/a*	*ml/lb*	*lbs/a*
6/21	9/1	230	3.63	2.9	39.8
6/21	9/27	198	3.67	2.7	36.3
6/28	9/1	253	3.87	3.1	44.8
6/28	9/27	199	3.54	3.5	45.9
7/5	9/1	202	3.59	3.0	41.3
7/5	9/27	158	3.51	3.2	42.6
7/12	9/1	209	3.91	2.8	42.3
7/12	9/27	90	3.27	2.9	35.9
7/19	9/1	163	3.54	3.3	44.4
7/19	9/27	115	3.46	3.4	43.3
8/1[1]/		220	3.49	3.0	38.0
8/1	9/27	79	3.26	3.4	41.9
mean		150	3.37	3.2	39.9
LSD(0.10)		86	NS	NS	NS
CV(s/mean*100)		33.7	10.3	15.3	12.8

[1] Check - cut once at 10% bloom

[2] Dug 5/16/95

[3] All plots cut once at full bud on 8/3/95.

Table 2. 1995 quality components of Black Mitcham peppermint double cut in 1994.

1994 HARVESTS		1995 Data [2]/					
First Cutting	Second Cutting	TOTAL HEADS	TOTAL KETONES	TOTAL MENTHOL	MFURAN	ESTERS	PULEGONE
		%	%	%	%	%	%
6/21	9/1	7.8	27.9	48.7	1.7	4.5	0.2
6/21	9/27	7.8	27.3	48.0	1.6	4.5	0.2
6/28	9/1	8.2	29.0	47.8	1.7	4.2	0.4
6/28	9/27	8.3	28.0	47.4	1.8	4.3	0.3
7/5	9/1	8.0	27.8	47.7	1.8	4.4	0.4
7/5	9/27	8.5	29.1	46.5	1.8	4.2	0.4
7/12	9/1	7.8	30.6	47.0	1.8	4.1	0.4
7/12	9/27	7.8	27.6	47.8	1.8	4.4	0.3
7/19	9/1	7.6	28.3	48.4	1.8	4.5	0.3
7/19	9/27	8.0	26.9	48.5	1.9	4.4	0.4
8/1[1]/		7.8	29.0	47.5	1.7	4.2	0.3
8/1	9/27	8.4	27.6	49.2	1.6	4.3	0.3
mean		8.0	28.2	47.9	1.7	4.3	0.3
LSD(0.10)		NS	NS	NS	NS	NS	NS
CV(s/mean*100)		7.5	8.2	4.0	8.0	7.1	37.2

[1]/ Check - cut once at 10% bloom

[2]/ All plots cut once at full bud on 8/3/95.

MINT RESEARCH REPORT - 1995

TITLE: Effect of second harvest date on hay and oil yield, and oil quality of double cut peppermint.

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

OBJECTIVE: Increase the precision in defining an optimum double cut schedule for Black Mitcham-meristem peppermint.

PROCEDURES: In spring of 1995, plots 10' wide by 15' long were delineated within a fourth year stand of meristem derived Black Mitcham peppermint (root source - Glacier Mint). Four replicates of 5 plots representing 4 second cut harvest dates and a single cut control were assigned in a randomized complete block design.

Harvest area was approximately 70 square feet. The area was irrigated to prevent moisture stress. In fall, 1994 the area was fertilized with 17 lbs N, 78 lbs P_2O_5, and 120 lbs K_2O/a. A total of 360 lbs N/a was applied in 1995. Sinbar was applied at 1.0 lb AI/a on 5/2/95, and Orthene, at 1.0 lb/a, was sprayed on 6/29 for cutworm control.

The first cutting for all 4 double cut treatments was harvested on 7/11/95. This date was chosen because it resulted in the highest total oil yield in the 1994 study. The single cut control was harvested 8/7/95. Second cuttings were made on 9/1, 9/8, 9/15, and 9/22/95, bracketing the second cutting dates from last year's study. 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:

The first cutting, at prebud on 7/11, yielded 2.52 tons/acre of dry matter and 33.8 lbs/acre oil (Table 1). For the second cuttings, both hay and oil yields increased significantly with each weekly delay in harvest from 9/1 to 9/15. On 9/21 a hard freeze caused considerable leaf drop, resulting in a major decrease in both hay and oil yield for the 9/22 harvest. The single harvest control on 8/7 (prebloom) produced 3.41 tons/acre dry matter and 46.3 lbs/a of oil.

The double cut schedule of 7/11 and 9/15 produced the highest amount of total oil per acre - 71.1 lbs/a, 54% more than the single cut control. This schedule allowed the maximum regrowth period between cuttings before freeze damage occurred. Since this area usually experiences its first fall frost in mid-September, postponing the second cutting beyond 9/15 could result in significant yield loss, as evidenced in this study.

Oil analyses of first cutting and the single cut control samples was puzzling, because the earlier cut, less mature plants had higher menthol and ester levels than the more mature control (Table 2). Oil from the second cuttings showed significant decreases in ketones and increases in menthol and esters as harvest was delayed from 9/1 to 9/15. This corresponds with expected changes in maturation of the oil. Quality components did not change following the 9/21 frost.

Double cutting was successful again in 1995, although the average yield was only 74% that of 1994. Growing degree days (GDD) were 18% lower than in 1994, so lower yields would be expected.

Table 1. Hay yield, oil content, and oil yield of Black Mitcham peppermint double cut in 1995.

First Cutting	Hay Yield	Oil Content	Oil Yield
7/11 [1]	t/a	ml/lb	lbs/a
mean	2.52	3.5	33.8
SE(mean)	0.04	0.1	0.8
Control			
8/7 [2]			
mean	3.41	3.6	46.3
SE(mean)	0.17	0.4	3.7

Second Cutting[3]	Hay Yield	Oil Content	Oil Yield	1995 Total Oil
	t/a	ml/lb	lbs/a	lbs/a
9/1	1.27	5.3	25.2	58.2
9/8	1.64	5.0	30.9	66.0
9/15	1.97	4.9	36.5	71.1
9/22 *	1.55	4.5	26.4	59.1
Control[2]				46.3
mean	1.60	4.9	29.8	60.1
LSD(0.10)	0.13	NS	4.6	7.7

[1] Prebud

[2] Cut once at prebloom

[3] Vegetative

** Considerable leaf drop due to hard freeze*

Table 2. Quality components of Black Mitcham peppermint double cut in 1995.

First Cutting	Total Heads	Total Ketones	Total Menthol	Menthofuran	Esters	Pulegone
7/11 [1]						
mean	7.9	22.9	54.3	1.2	5.7	0.9
SE(mean)	0.1	0.2	0.2	0.0	0.1	0.0
Control						
8/7 [2]						
mean	8.7	23.5	52.3	2.6	5.1	0.8
SE(mean)	0.3	0.2	1.2	0.2	0.0	0.0

[1] Prebud

[2] Cut once at prebloom

Second Cutting [1]	Total Heads	Total Ketones	Total Menthol	Menthofuran	Esters	Pulegone
9/1	6.5	28.0	55.2	2.6	5.6	0.5
9/8	7.4	24.5	57.9	2.6	5.8	0.5
9/15	7.0	20.5	62.2	2.4	7.5	0.5
9/22	7.3	20.3	62.6	2.4	7.4	0.4
mean	7.0	23.3	59.4	2.5	6.5	0.4
LSD(0.10)	NS	2.2	1.7	NS	0.6	NS

[1] All vegetative

Montana State University
1995 Dormant Herbicide Applications to Peppermint

Project Code:95-DHA-FISHER
Cooperator :CLYDE FISHER

Location :FISHER FARM, KALISPELL,MT
By:Bob Stougaard

Fall and spring dormant herbicide applications were evaluated in an established stand of peppermint for crop tolerance and control of broadleaf weeds. Devrinol and Command caused moderate peppermint stand reduction in both fall and spring applications. Early season crop injury was observed from other spring applications (Karmex, Sinbar, Stinger and Buctril) but the crop later recovered. The majority of fall treatments provided marginal weed control with the exception of Command and Devrinol which gave good groundsel control. Spring applications were more successful in both weed control and higher peppermint oil yields. Stinger applied in the spring provided the most complete weed control and the highest yields.

Site Description

Crop: PEPPERMINT
Variety: BLACK MITCHAM
Planting Date: 4-4-90
Planting Method: ROOTS
Rate, Unit: ,
Depth, Unit: ,
Perennial Age, Unit: ,
Row Spacing, Unit: ,
Soil Temp., Unit: ,
Soil Moisture:
Emergence Date:
Plot Width/Area, Unit: 10 , FT
Plot Length, Unit: 18 , FT
Reps: 3
Site Type:
Seed Bed Desc.:
Ground Cover:
Tillage Type:
Study Design: RCB
Field Preparation/Plot Maintenance: STUDY WAS CONDUCTED IN AN AREA OF AN ESTABLISHED FIELD

Soil Description

Texture: VERY FINE SL % OM: 3.5 % Sand: 50 % Silt: 40 % Clay: 10
pH: 7.5 CEC: Soil Name: FLATHEAD V F S L Fertility Level:

Moisture Conditions

Overall Moisture Conditions: MOISTURE VERY GOOD THROUGHOUT SEASON. IRRIGATED

Application Information

	A	B	C	D	E	F
Application Date:	10-20-94	10-25-95	3-28-95			
Time of Day:	2:30 PM	2:00	4:00			
Application Method:	BACKPACK	BACKPACK	BACKPACK			
Application Timing:	FALL	FALL	SPRING			
Air Temp., Unit:	52 ,F	45 ,F	52 ,F	,	,	,
% Relative Humidity:	26	40	39			
Wind Velocity, Unit:	2 ,MPH	0 ,MPH	1 ,MPH	,	,	,
Dew Presence (Y/N):	N	N	N			
Water Hardness:	N	N	N			
Soil Temp., Unit:	48 ,F	42 ,F	45 ,F	,	,	,
Soil Moisture:	V GOOD	V.GOOD	GOOD			
% Cloud Cover:	95	99	0			

Weed Species	Weed Stage, Density at Application					
PEPPERMINT	4-5",	SAME,	NO ,	,	,	,
GROUNDSEL	3-10,	SAME,	LIVE,	,	,	,
FLOWERING,SEEDLING	,	,	PLTS,	,	,	,
	,	,	,	,	,	,

Weed Species Stage at Rating	6-13-95	8-1-95	9-5-95			
PEPPERMINT	12-14",	22-24",	36",	,	,	,
GROUNDSEL	5-14",	7-15",	14",	,	,	,
PRICKLY LETTUCE	6-8",	24-36",	36-40",	,	,	,

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.	"									

Montana State University
1995 Dormant Herbicide Applications to Peppermint

Project Code:95-DHA-FISHER   Location :FISHER FARM, KALISPELL,MT
Cooperator :CLYDE FISHER   By:Bob Stougaard

Trt No	Treatment Name	Form Type	Rate lb ai	Appl Time	MINT CRPINJ % 6-13-95	MINT STDRED % 6-13-95	PRKLET CONTROL % 6-13-95	GRNSEL CONTROL % 6-15-95	MINT %BIOMASS INCREASE 8-1-95	BRDLEAF %BIOMASS DECREASE 8-1-95
1	COMMAND	4 EC	.75	FALL	0.0	25.0	0.0	70.0	28.4	44.8
2	DEVRINOL	50 WP	4	FALL	0.0	21.7	23.3	93.3	33.6	60.5
3	KARMEX	80 DF	1.6	FALL	0.0	7.7	0.0	0.0	1.6	6.5
4	SINBAR	80 WP	.8	FALL	0.0	4.3	0.0	16.7	12.3	31.9
5	SINBAR	80 WP	1.6	FALL	0.0	6.7	63.3	30.0	31.5	20.3
6	STINGER	3 EC	.18	FALL	0.0	10.7	46.7	10.0	26.7	8.4
7	BUCTRIL	2 EC	.1875	FALL	0.0	4.3	16.7	40.0	42.5	20.8
8	COMMAND	4 EC	.75	SPRING	5.0	19.3	78.0	100.0	83.3	52.1
9	DEVRINOL	50 WP	4	SPRING	0.0	21.7	46.7	96.7	25.0	39.7
10	KARMEX	80 DF	1.6	SPRING	0.0	11.7	59.3	56.7	73.7	47.2
11	SINBAR	80 WP	.8	SPRING	0.0	9.0	99.7	30.0	79.4	69.6
12	SINBAR	80 WP	1.6	SPRING	0.0	15.0	100.0	80.0	111.4	87.8
13	STINGER	3 EC	.18	SPRING	0.0	10.0	99.7	91.7	118.7	94.4
14	BUCTRIL	2 EC	.1875	SPRING	0.0	8.3	16.7	10.0	43.0	28.6
15	NONTREATED				0.0	6.0	0.0	0.0	0	0

	MINT CRPINJ	MINT STDRED	PRKLET CONTROL	GRNSEL CONTROL	MINT %BIOMASS INCREASE	BRDLEAF %BIOMASS DECREASE
LSD (.05) =	3.7	16.6	41.4	45.6	84.1	51.5
Standard Dev.=	2.23607	9.95219	24.7815	27.2969	50.297	30.8144
CV =	670.82	82.33	57.19	56.48	106.1	75.44
Block F	1.000	0.633	0.588	0.785	11.215	0.661
Block Prob(F)	0.3806	0.5385	0.5620	0.4659	0.0003	0.5243
Treatment F	1.000	1.401	7.248	5.696	1.656	2.577
Treatment Prob(F)	0.4793	0.2167	0.0001	0.0001	0.1244	0.0160

Montana State University

Reduced Herbicide Rates for Wild Oat Control in Peppermint

Project Code:95-WOP-R5 Location :Kalispell, MT
Cooperator: By:Bob Stougaard

Summary Comments:

The surfactants MSO (COC) and Activatror-90 (NIS) were applied alone or with 28% ammonium nitrate (UAN) in combination with Assure II. Results were similar to 1994 observations. MSO enhanced herbicide activity more so than Activator-90 and the addition of 28% UAN aided the activity of both surfactants. The best control was obtained with a combination of MSO plus 28% UAN.

Site Description

Crop: PEPPERMINT Variety: BLACK MITCHAM Planting Date: 4-4-94
Planting Method: ROOTS Rate, Unit: , Depth, Unit: ,
Perennial Age, Unit: , Row Spacing, Unit: ,
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: SILT LOAM % OM: 3.0 % Sand: 40 % Silt: 50 % Clay: 10
pH: 7.0 CEC: Soil Name: CRESTON SL Fertility Level:

Moisture Conditions

Overall Moisture Conditions: GOOD OVERALL MOISTURE CONDITIONS - IRRIGATED

Application Information

	A	B	C	D	E	F
Application Date:	5-18-95	5-30-95				
Time of Day:	9:00 AM	9:00 AM				
Application Method:	BACKPACK	BACKPACK				
Application Timing:	4 LEAF	8 LEAF				
Air Temp., Unit:	61 ,F	64 ,F	,	,	,	,
% Relative Humidity:	69	15				
Wind Velocity, Unit:	2 ,MPH	0 ,MPH	,	,	,	,
Dew Presence (Y/N):	N	N				
Water Hardness:	N	N				
Soil Temp., Unit:	56 ,F	61 ,F	,	,	,	,
Soil Moisture:	V GOOD	V GOOD				
% Cloud Cover:	99	0				

Weed Species	Weed Stage, Density at Application					
WILD OAT	4 LF,3-4"	5-7L,8-9"	,	,	,	,
PEPPERMINT	2-3",	5" ,	,	,	,	,

Weed Stage at Ratings:

	6-28-95
Wild oat	14-20"
Peppermint	12-14"

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	H20	20
B.	"									

Montana State University
Reduced Herbicide Rates for Wild Oat Control in Peppermint

Project Code:95-WOP-R5 Location :Kalispell, MT
Cooperator : By:Bob Stougaard

Trt No	Treatment Name	Form Amt	Fm Ds	Rate	Rate Unit	Grow Stg	WILD OAT CONTROL PERCENT 6-28-95	WILD OAT HAY YLD T/A 8-2-95	MINT HAY YLD T/A 8-2-95	WILD OAT %BIOMASS REDUCTION 8-2-95	MINT %BIOMASS INCREASE 8-2-95	MINT OIL YIELD LB/A 9-7-95
1	ASSURE II	.8	EC	3	oz pr/A	4LF	40	1.88	1.76	50.4	61.2	14.1
1	NIS	1	EC	.125	% v/v	4LF						
2	ASSURE II	.8	EC	3	oz pr/A	4LF	68	1.95	1.38	50.2	23.0	21.5
2	NIS	1	EC	.125	% v/v	4LF						
2	UAN 28%	1	EC	2	qt pr/A	4LF						
3	ASSURE II	.8	EC	3	oz pr/A	4LF	88	0.40	2.42	90.1	124.4	28.6
3	COC	1	EC	1	qt pr/A	4LF						
4	ASSURE II	.8	EC	3	oz pr/A	4LF	94	0.08	2.43	98.2	126.2	37.5
4	COC	1	EC	1	qt pr/A	4LF						
4	UAN 28%	1	EC	2	qt pr/A	4LF						
5	ASSURE II	.8	EC	7	oz pr/A	4LF	84	0.48	2.22	87.9	109.2	30.4
5	NIS	1	EC	.125	% v/v	4LF						
6	ASSURE II	.8	EC	7	oz pr/A	4LF	92	0.09	2.49	97.8	134.4	35.2
6	NIS	1	EC	.125	% v/v	4LF						
6	UAN 28%	1	EC	2	qt pr/A	4LF						
7	ASSURE II	.8	EC	7	oz pr/A	4LF	97	0.03	2.51	99.2	134.1	40.2
7	COC	1	EC	1	qt pr/A	4LF						
8	ASSURE II	.8	EC	7	oz pr/A	4LF	98	0.10	2.71	97.3	156.0	37.4
8	COC	1	EC	1	qt pr/A	4LF						
8	UAN 28%	1	EC	2	qt pr/A	4LF						
9	ASSURE II	.8	EC	3	oz pr/A	8LF	50	0.97	1.97	73.9	86.8	29.9
9	NIS	1	EC	.125	% v/v	8LF						
10	ASSURE II	.8	EC	3	oz pr/A	8LF	84	0.16	2.38	95.6	126.1	37.2
10	NIS	1	EC	.125	% v/v	8LF						
10	UAN 28%	1	EC	2	qt pr/A	8LF						
11	ASSURE II	.8	EC	3	oz pr/A	8LF	68	0.41	2.11	87.6	100.4	33.9
11	COC	1	EC	1	qt pr/A	8LF						
12	ASSURE II	.8	EC	3	oz pr/A	8LF	87	0.18	2.41	95.3	126.8	33.9
12	COC	1	EC	1	qt pr/A	8LF						
12	UAN 28%	1	EC	2	qt pr/A	8LF						
13	ASSURE II	.8	EC	7	oz pr/A	8LF	73	0.37	2.36	91.2	118.2	40.4
13	NIS	1	EC	.125	% v/v	8LF						
14	ASSURE II	.8	EC	7	oz pr/A	8LF	98	0.02	2.37	99.4	123.7	36.0
14	NIS	1	EC	.125	% v/v	8LF						
14	UAN 28%	1	EC	2	qt pr/A	8LF						
15	ASSURE II	.8	EC	7	oz pr/A	8LF	97	0.06	2.62	98.5	145.7	44.8
15	COC	1	EC	1	qt pr/A	8LF						
16	ASSURE II	.8	EC	7	oz pr/A	8LF	98	0.04	2.29	99.0	114.3	30.8
16	COC	1	EC	1	qt pr/A	8LF						
16	UAN 28%	1	EC	2	qt pr/A	8LF						
17	NONTREATED						0	3.81	1.08	0	0	25.9
	LSD (.05) =						21	0.83	0.70	21.3	69.0	15.1
	Standard Dev.=						12.3923	.495844	.422575	12.8028	41.4008	9.05631
	CV =						16.00	76.38	19.16	15.42	38.87	27.61
	Block F						0.540	2.880	6.032	2.316	8.857	1.476
	Block Prob(F)						0.5881	0.0708	0.0060	0.1150	0.0009	0.2438
	Treatment F						13.589	12.539	3.204	12.884	3.099	2.056
	Treatment Prob(F)						0.0001	0.0001	0.0025	0.0001	0.0031	0.0404

Montana State University
1994-95 Living Mulch Study in Peppermint

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

Summary:

This project illustrated which species have the best potential as living mulch crops and also demonstrated the potential weed control benefits and nitrogen reclamation aspects of using this system. At both sites, rye produced the most biomass of all the crops evaluated. Spring rye produces the most fall growth, but overall net biomass accumulation was greater for winter rye. It appears that spring mulch growth has a greater impact than fall growth from the stand point of weed suppression and nitrogen reclamation. Mint yield response to mulching will vary depending upon the severity of the winter and straw seems to serve well in terms of insulating the crop.

Site Description

Crop: PEPPERMINT Variety: BLACK MITCHAM Planting Date: 4-4-93
Planting Method: ROOTS Rate, Unit: 1000 , #/A Depth, Unit: 3 , "
Perennial Age, Unit: 3 , 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: ESTBL. FIELD Seed Bed Desc.: Ground Cover: 30-50%
Tillage Type: Study Design: RCB
Field Preparation/Plot Maintenance: PRODUCER TYPE CULTURAL AND MAINTENANCE PROCEDURES.

Soil Description

Texture: SILT LOAM % OM: 2.8 % Sand: 440 % Silt: 50 % Clay: 10
pH: 6.4 CEC: Soil Name: CRESTON SL Fertility Level:

Moisture Conditions

Overall Moisture Conditions: IRRIGATED WITH .5" WATER EVERY WEEK

Living Mulch Seeding Information

	2 WK PRE	POST HARVEST
Seeding Date:	8-1-94	8-16-94
Seeding Method:	Aerial	Double Disc
Seeding Timing:	2WK Pre	POST Harvest
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

Table 1.

Montana State University
1994-95 Living Mulch Study in Peppermint

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

Treatment Name	Seeding Date	MULCH HEIGHT INCHES 10-19-94	MULCH GRN CVR PERCENT 10-19-94	MULCH DRY WT LBS/A 10-24-94	MULCH DRY WT LBS/A 5-19-95
Winter Wheat	PREHAR	6.3	1.3	16	88
Spring Wheat	PREHAR	10.0	3.3	89	-
Spring Rye	PREHAR	15.7	14.3	195	-
Winter Rye	PREHAR	6.3	4.3	146	1875
Winter Rape	PREHAR	4.3	6.0	19	-
Spring Rape	PREHAR	4.7	4.7	30	-
Hairy Vetch	PREHAR	5.0	22.7	147	757
Winter Peas	PREHAR	3.7	2.7	29	-
Winter Wheat	PSTHAR	5.7	38.3	677	1601
Spring Wheat	PSTHAR	10.3	45.0	541	-
Spring Rye	PSTHAR	16.0	68.3	2335	-
Winter Rye	PSTHAR	6.7	50.0	1241	3761
Winter Rape	PSTHAR	2.7	7.0	120	-
Spring Rape	PSTHAR	3.3	11.7	126	-
Hairy Vetch	PSTHAR	3.7	28.3	514	2050
Winter Peas	PSTHAR	2.7	18.7	303	-
Straw	1 T/A	-	-	-	-
Nontreated		-	-	-	-
LSD (.05) =		3.6	9.8	842	1001
Standard Dev.=		2.14314	5.87993	504.802	550.139
CV =		32.05	28.80	123.75	32.58
Block F		3.796	2.152	1.292	1.076
Block Prob(F)		0.0339	0.1339	0.2896	0.3772
Treatment F		11.636	35.556	4.360	15.660
Treatment Prob(F)		0.0001	0.0001	0.0003	0.0002

Table 2.

Montana State University
1994-95 Living Mulch Study in Peppermint

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

Treatment Name	Seeding Date	WEEDS NUMBER PER ACRE 5-19-95	WEED DRY WT LBS/ACRE 5-19-95	MINT YIELD LBS/A 7-28-95	MULCH EXTRT N LBS/A 10-24-94	MULCH EXTRT N LBS/A 5-19-95
Winter Wheat	PREHAR	116667	121	19831	.4	3.6
Spring Wheat	PREHAR	-	-	17029	2.2	-
Spring Rye	PREHAR	-	-	18261	6.0	-
Winter Rye	PREHAR	78333	481	20906	4.5	76.8
Winter Rape	PREHAR	-	-	19915	.5	-
Spring Rape	PREHAR	-	-	18696	1.0	-
Hairy Vetch	PREHAR	103333	191	19058	5.3	22.2
Winter Peas	PREHAR	-	-	20846	1.0	-
Winter Wheat	PSTHAR	18333	158	15737	18.3	46.9
Spring Wheat	PSTHAR	-	-	19625	15.5	-
Spring Rye	PSTHAR	-	-	21413	50.5	-
Winter Rye	PSTHAR	8333	14	16739	35.8	95.6
Winter Rape	PSTHAR	-	-	22995	3.0	-
Spring Rape	PSTHAR	-	-	19324	3.4	-
Hairy Vetch	PSTHAR	16667	30	19565	18.5	83.0
Winter Peas	PSTHAR	-	-	17271	10.5	-
Straw	1 T/A	106667	268	25387	-	-
Nontreated		173333	282	22669	-	-
LSD (.05) =		84031	260	4016	20.7	41.6
Standard Dev.=		50400.1	156.030	2408.90	12.4344	22.892
CV =		143.62	181.94	12.21	112.70	41.87
Block F		14.590	0.151	13.376	1.182	2.841
Block Prob(F)		.0172	0.8606	0.000	0.3206	0.1055
Treatment F		3.506	2.37	3.008	3.915	7.657
Treatment Prob(F)		0.0009	0.018	0.0031	0.0007	0.0034

Table 3.

Montana State University
1994-95 Living Mulch Study in Peppermint

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

Treatment Name	Seeding Date	SOIL N PPM 0-1'	SOIL N PPM 1-2'	SOIL N PPM 2-3'	SOIL N PPM 3-4'	SOIL N PPM TOTAL
Winter Wheat	PREHAR	5.2	4.3	4.6	86.0	100.1
Spring Wheat	PREHAR	3.9	3.8	9.4	6.9	23.9
Spring Rye	PREHAR	3.9	3.4	20.0	146.3	173.5
Winter Rye	PREHAR	3.3	2.3	3.2	33.5	42.3
Winter Rape	PREHAR	-	-	-	-	-
Spring Rape	PREHAR	-	-	-	-	-
Hairy Vetch	PREHAR	2.4	2.3	2.6	3.5	10.8
Winter Peas	PREHAR	-	-	-	-	-
Winter Wheat	PSTHAR	3.7	3.2	4.5	18.4	29.7
Spring Wheat	PSTHAR	5.6	3.6	6.5	103.0	118.7
Spring Rye	PSTHAR	4.4	2.9	3.0	3.9	14.1
Winter Rye	PSTHAR	2.0	2.3	2.4	3.1	9.8
Winter Rape	PSTHAR	-	-	-	-	-
Spring Rape	PSTHAR	-	-	-	-	-
Hairy Vetch	PSTHAR	3.9	2.5	3.7	3.7	13.8
Winter Peas	PSTHAR	-	-	-	-	-
Straw	1 T/A	9.1	4.1	18.2	127.5	158.8
Nontreated		2.5	2.9	3.4	103.6	112.4
LSD (.05) =		5.329	1.843	17.130	162.407	179.9
Standard Dev.=		3.1466	1.08814	10.1159	95.9051	106.238
CV =		75.85	34.88	149.19	179.99	157.79
Block F		2.805	7.513	3.748	8.961	8.764
Block Prob(F)		0.0822	0.0033	0.0397	0.0014	0.0016
Treatment F		1.069	1.290	1.083	1.005	1.003
Treatment Prob(F)		0.4267	0.2931	0.4171	0.4729	0.4741

Table 4.

Montana State University
Peppermint Living Mulch Study - Corvallis

Project Code:LMS-COR   Location :CORVALLIS, MT
Cooperator :STOUGAARD   By:WESTCOTT

		MULCH HEIGHT INCHES 11-11-94	MULCH NUMBER SQ FT 11-11-94	MULCH DRY WT LBS/A 5-22-95	WEED NUMBER PER ACRE 5-22-95	WEED DRY WT LBS/ACRE 5-22-95	MINT YIELD LBS/A 9-4-95
WINTER WHEAT	PREHAR	3.4	10.8	447	152923	27.4	1041
SPRING WHEAT	PREHAR	7.6	6.3	-	-	-	1520
SPRING RYE	PREHAR	9.4	13.8	-	-	-	1402
WINTER RYE	PREHAR	2.9	7.8	1746	34904	1.4	2597
WINTER RAPE	PREHAR	-	5.3	-	-	-	1123
SPRING RAPE	PREHAR	-	21.1	-	-	-	1483
WINTER WHEAT	PSTHAR	2.6	9.3	615	313962	7.5	1816
SPRING WHEAT	PSTHAR	4.3	8.3	-	-	-	1597
SPRING RYE	PSTHAR	4.6	28.3	-	-	-	1632
WINTER RYE	PSTHAR	2.4	27.0	1252	775000	.3	1765
WINTER RAPE	PSTHAR	-	1.4	-	-	-	1435
SPRING RAPE	PSTHAR	-	3.9	-	-	-	1678
STRAW	1T/A	-		-	-	-	2906
UNTREATED		-		-	-	-	1753
LSD (.05) =		1.23	16.698	728.2	1285433	28.9711	614.4
Standard Dev.=		.821447	11.5641	455.254	803659	18.1129	429.915
CV =		17.72	97.09	44.86	251.78	197.89	25.34
Block F		1.751	0.038	2.938	0.771	2.533	8.073
Block Prob(F)		0.1946	0.9898	0.0916	0.5389	0.1225	0.0003
Treatment F		38.728	2.370	6.900	0.653	1.922	5.492
Treatment Prob(F)		0.0001	0.0274	0.0104	0.6010	0.1966	0.0001

ble 5.

Montana State University
Peppermint Living Mulch Study - Corvallis

oject Code:LMS-COR   Location   :CORVALLIS, MT
operator   :STOUGAARD   By:WESTCOTT

		SOIL N PPM 0-1'	SOIL N PPM 1-2'	SOIL N PPM 2-3'	SOIL N PPM TOTAL	MULCH EXTRT N LBS/A 5-22-95
WINTER WHEAT	PREHAR	9.0	33.4	283.8	326.1	8.0
SPRING WHEAT	PREHAR	-	-	-	-	-
SPRING RYE	PREHAR	-	-	-	-	-
WINTER RYE	PREHAR	10.1	122.0	273.3	336.7	24.6
WINTER RAPE	PREHAR	-	-	-	-	-
SPRING RAPE	PREHAR	-	-	-	-	-
WINTER WHEAT	PSTHAR	7.4	83.9	295.0	313.2	11.2
SPRING WHEAT	PSTHAR	-	-	-	-	-
SPRING RYE	PSTHAR	-	-	-	-	-
WINTER RYE	PSTHAR	7.9	256.3	297.5	412.8	16.8
WINTER RAPE	PSTHAR	-	-	-	-	-
SPRING RAPE	PSTHAR	-	-	-	-	-
STRAW	1T/A	8.0	94.6	265.0	368.5	-
UNTREATED		7.0	67.6	373.3	355.3	-
D (.05)	=	4.715	176.22	128.2	353.1	11.9
andard Dev.	=	3.12928	116.948	81.3561	234.539	7.41858
	=	38.02	106.68	27.30	66.65	48.93
ock F		3.307	1.409	3.428	1.130	3.020
ock Prob(F)		0.0492	0.2789	0.0604	0.3686	0.0865
eatment F		0.536	1.762	0.917	0.093	3.819
eatment Prob(F)		0.7460	0.1815	0.5081	0.9921	0.0514

NITROGEN AND IRRIGATION MANAGEMENT FOR PEPPERMINT

Project leader : Mal Westcott

Objectives:

To develop management guidelines for the most efficient and effective use of nitrogen and irrigation inputs to peppermint production, with the goal of optimum oil yields and minimum environmental impact.

Methods:

We grew stem-tip Black Mitcham peppermint under a line-source irrigation system with the following nitrogen treatments arranged in a randomized, complete block design with four replications: 0, 60, 120, 180, 240, 300, or 360 lbs N/ac season total as weekly applications of urea; 120, 240, or 360 lbs N/ac as a single application of anhydrous ammonia early in the growing season; or PRF management according to crop N monitoring.

Treatments were assessed for effects on soil moisture status, nitrate leaching, crop N status, effective rooting depth, soil nitrate levels, N utilization, and oil yields and quality.

Results:

Maximum oil yields were attained with a total N rate of 180 lbs N/ac as urea applied as a standard fertigation (Fig. 1). The anhydrous source was not as effective as urea fertigation in enhancing oil yields, perhaps due to the timing of anhydrous application or to root damage. Yields with PRF were equivalent to optimum yields (data not shown).

Oil yields across the irrigation gradient did not decline until the irrigation regime dropped below 1.25 inches/week (irrigation + precipitation, Fig. 2). At the optimum rate of fertilization (180 lbs N/ac), oil yields under moderate irrigation (1.25" to 2.0"/week) were slightly higher than with wetter regimes.

No significant effects of N fertilization or irrigation were found on oil quality.

Optimum fertilization maintained soil nitrate-N levels in the top foot at around 5 ppm throughout the growing season (Fig. 3). The anhydrous source was apparently converted to nitrate form over the course of the season; it's possible that it's poor performance relative to urea fertilization was due to deficiencies early in the season, prior to conversion to nitrate.

Crop water use was effective at the two-foot depth, evidenced by soil drying under the driest irrigation regime (Fig. 4). These results are very similar to what we found in first-year meristem mint in 1992, supporting the notion that baby mint develops roots to at least two feet.

Crop nitrogen uptake (Table 1) reached a maximum of 90 lbs N/ac at the optimum fertilization rate of 180 lbs N/ac. At that rate, fertilizer use efficiency was 34%, and dropped off drastically with higher rates of urea fertigation or with any of the anhydrous treatments. The poorer crop use efficiency of high rates or the anhydrous source was evidenced in nitrate leaching (Fig. 5). We detected nitrate leaching beginning in late July continuing through mid-August, with soil solution nitrate concentrations at four feet proportionate to N application rates and irrigation amounts (wettest at 5 ft., driest at 35 ft). Unfortunately, the lowest N rate that we chose to monitor (240 lbs N/ac) turned out to be 60 lbs N/ac over optimum, but the important point is still obvious: nitrate leaching is minimized with optimum N fertilization and judicious irrigation, with no sacrifice of oil yields.

These effects were also apparent in residual soil nitrate levels measured in the fall (Table 2). Under the driest irrigation regime, we see significantly elevated levels of soil nitrate between depths of one to three feet in the soil profile due to high rates of fertilization. As the irrigation regime becomes wetter, these zones of high nitrate descend through the profile and in some cases percolate below four feet, indications of leaching.

The results from 1995 are the clearest evidence that we've gathered so far that mint oil yields are optimized with rates of N fertilization *and* irrigation that should be considered moderate relative to mint production practices. These moderate rates achieve optimum yields while maximizing use efficiency and minimizing nitrate leaching. Higher rates of both inputs are not only poor economic investments, but significantly increase the chances for nitrate leaching.

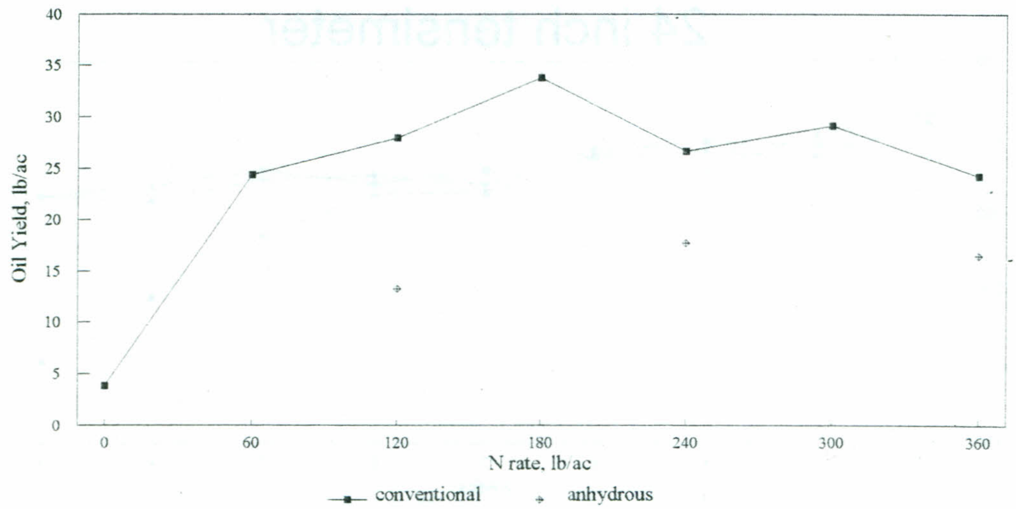

Fig. 1. Mint oil yield response to N rate and source.

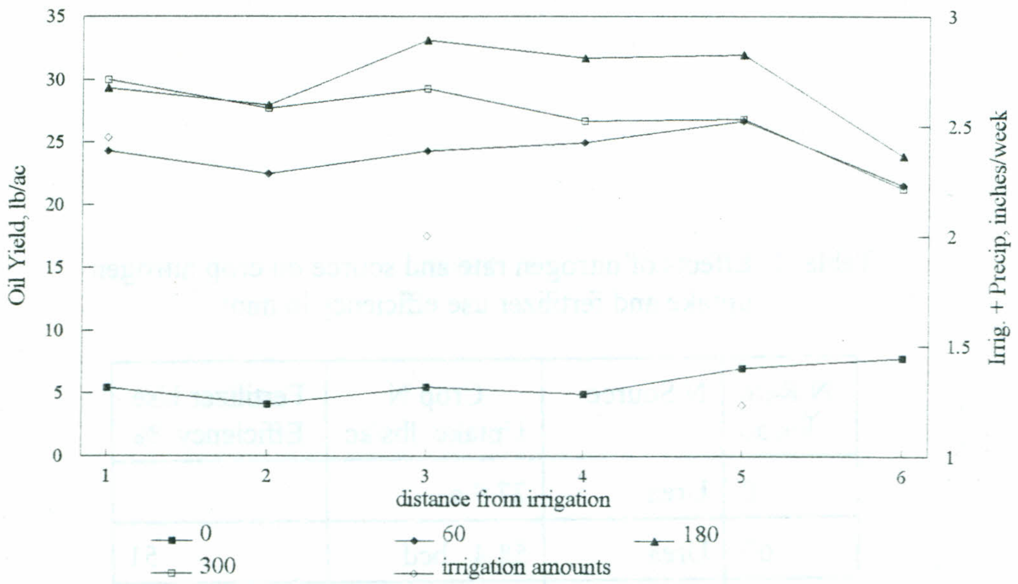

Fig. 2. Oil yields affected by N rates and irrigation regimes.

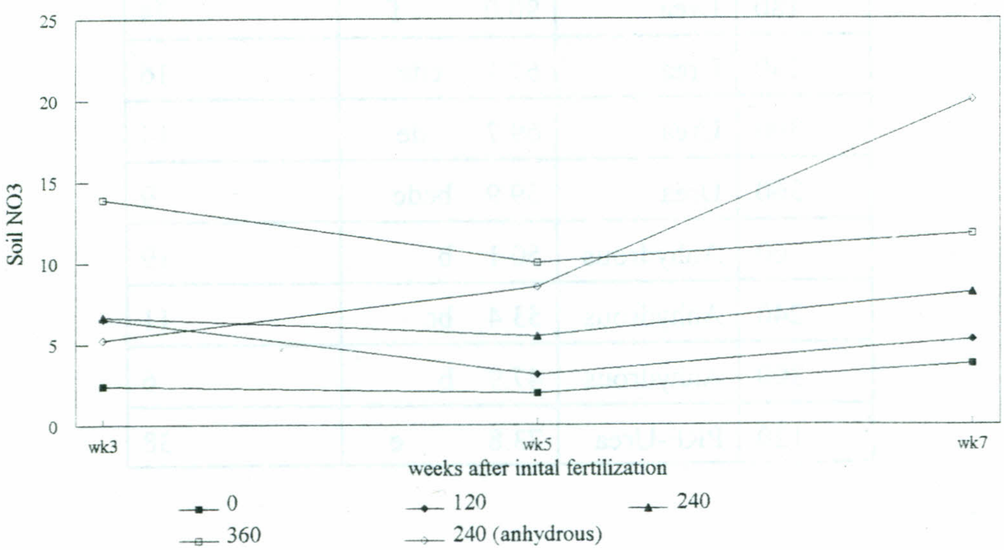

Figure 3. Soil nitrate levels in the top foot as affected by N rate and source.

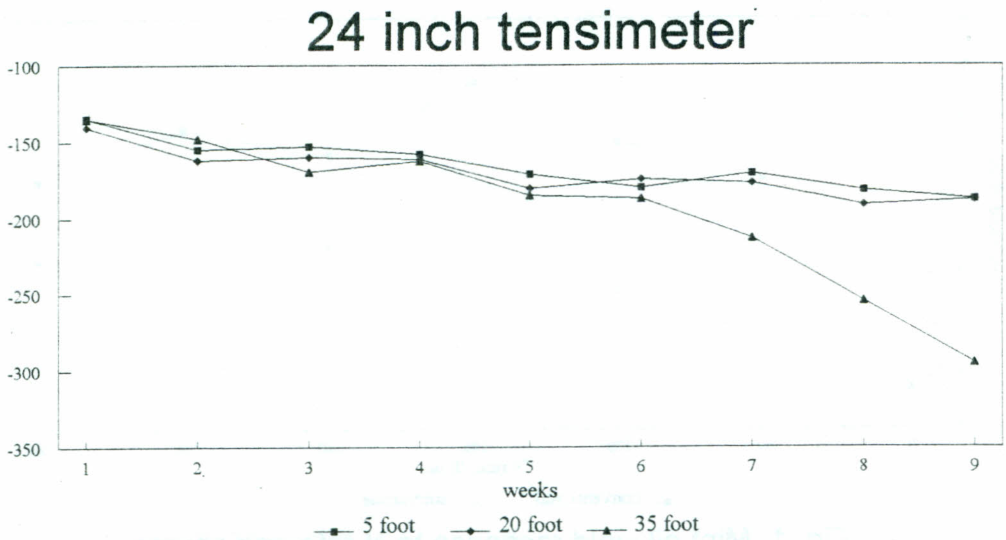

Fig. 4. Soil tensiometer levels at 24 inches as affected by irrigation regime.

Table 1. Effects of nitrogen rate and source on crop nitrogen uptake and fertilizer use efficiency in mint.

N Rate lbs/ac	N Source	Crop N Uptake lbs/ac	Fertilizer Use Efficiency %
0	Urea	27.9 a	
60	Urea	58.4 bcd	51
120	Urea	74.3 e	39
180	Urea	90.0 f	34
240	Urea	67.1 cde	16
300	Urea	69.7 de	14
360	Urea	59.9 bcde	9
60	Anhydrous	50.1 b	19
240	Anhydrous	53.4 bc	11
300	Anhydrous	47.9 b	6
120	PRF-Urea	73.8 e	38

Figure 5. Soil solution nitrate levels at 4 ft. affected by N rate and source.

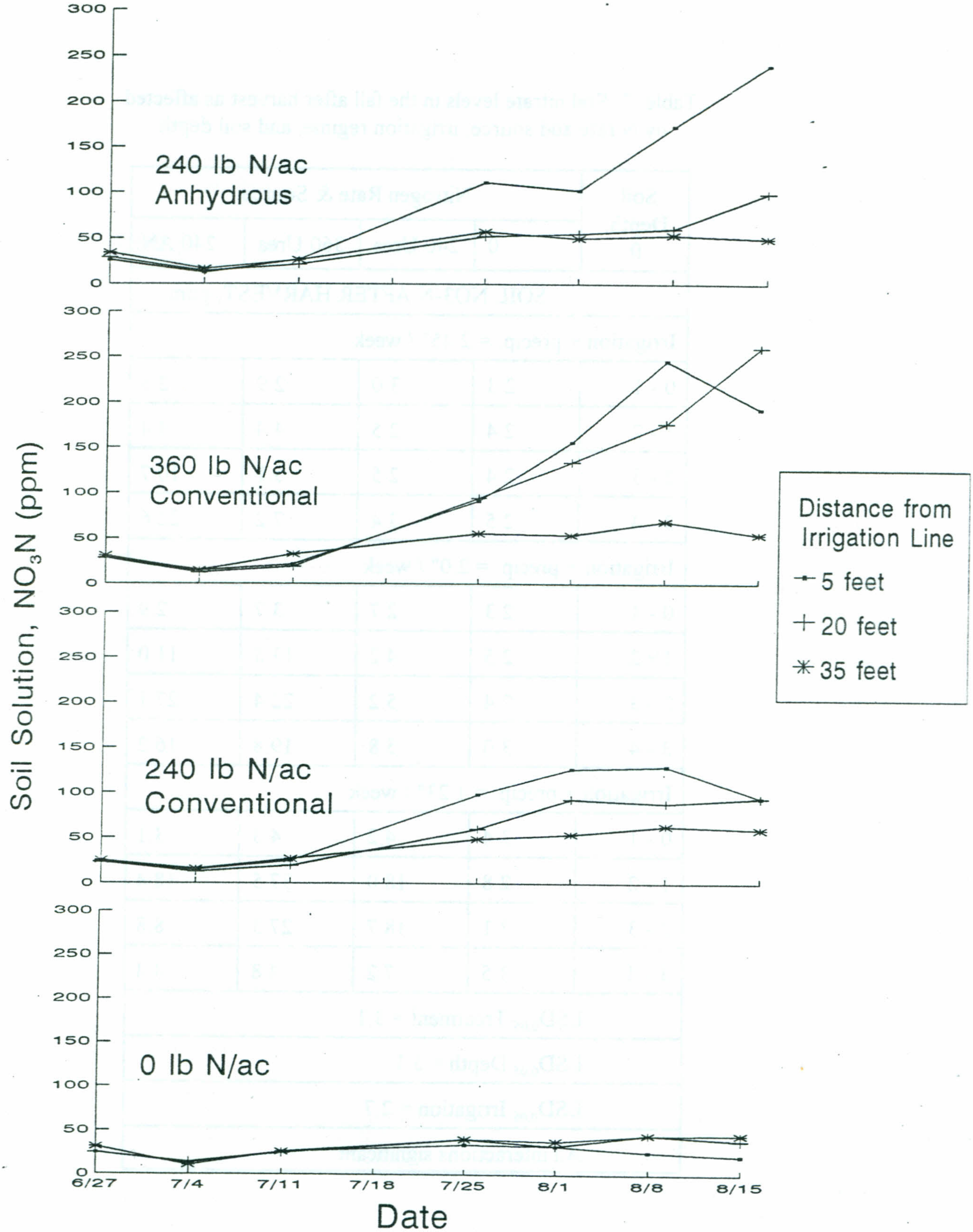

Table 2. Soil nitrate levels in the fall after harvest as affected by N rate and source, irrigation regime, and soil depth.

Soil Depth, ft	Nitrogen Rate & Source			
	0	240 Urea	360 Urea	240 AN
SOIL NO3-N AFTER HARVEST, ppm				
Irrigation + precip. = 2.45" / week				
0 - 1	2.3	3.0	2.9	2.5
1 - 2	2.4	2.5	4.4	4.4
2 - 3	2.4	2.5	5.1	10.7
3 - 4	2.5	3.4	7.2	22.6
Irrigation + precip. = 2.0" / week				
0 - 1	2.3	2.7	3.7	2.9
1 - 2	2.5	4.2	13.8	11.0
2 - 3	2.4	5.2	22.4	27.1
3 - 4	3.0	5.8	19.8	16.2
Irrigation + precip. = 1.23" / week				
0 - 1	3.4	4.2	4.3	3.1
1 - 2	2.8	18.0	37.5	18.4
2 - 3	3.1	18.7	27.3	8.8
3 - 4	3.5	7.2	4.8	4.4
$LSD_{0.05}$ Treatment = 3.1				
$LSD_{0.05}$ Depth = 3.1				
$LSD_{0.05}$ Irrigation = 2.7				
All interactions significant				

PHOSPHORUS AND POTASSIUM FERTILIZATION FOR PEPPERMINT

Project leader: Mal Westcott

Objectives:

To define phosphorus and potassium fertilization effects on mint oil yields.

Methods:

Phosphorus rates of 0, 25, 50, 100, or 200 lbs P_2O_5/ac were applied to established meristem mint in combination with potassium rates of 0 or 200 lbs K_2O/ac in a factorial design with 4 replications at the Northwestern Ag Research Center. Plots were assayed for oil yields and quality and crop tissue levels of P and K. Rates of 0 to 500 lbs P_2O_5/ac were applied to established mint at the Western Ag Research Center in a replicated trial. Plots were assayed for oil yields.

Results:

No significant effects of P were found on oil yield or quality at either site (Table 1, WAC data not shown). The only detectable effect was an elevation in plant tissue P from 0.27 to 0.36% due to fertilization. There was a significant negative effect of high K on oil yield at the Kalispell site, which we did not expect and which we have a hard time explaining in terms of toxicity. The important point is that, even at the Kalispell site where soil test would indicate a response (Olsen P = 4.3 ppm in top foot), we do not see evidence of need for high P or K fertilization on peppermint.

Table 1. Phosphorus and potassium fertilization effects on mint oil yields and plant tissue nutrient composition.

P_2O_5 lbs/ac	Oil Yield	Plant P (%)
0	73	0.27
25	72	0.28
50	70	0.31
100	65	0.32
200	76	0.36
$LSD_{.05}$	NS	0.02
K_2O rate lbs/ac	Oil Yield	Plant K (%)
0	74	2.2
200	68	2.9
$LSD_{.05}$	5	0.2