MONTANA STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

MONTANA MINT 2000 RESEARCH REPORT

RESEARCH PROJECTS FOR THE
NORTHWESTERN AGRICULTURAL RESEARCH CENTER
4750 MT 35 Kalispell, Montana 59901

WEB PAGE:
http://www.montana.edu/wwwnwarc/northw.htm

NWARC STAFF

Leon E. Welty, Superintendent & Professor of Agronomy
Dr. Bob Stougaard, Associate Professor of Weed Science
Dr. Qingwu Xue, Post-doctoral Research Scientist
Douglas L. Holen, Jr., Research Associate (Oct. 1999 – Mar. 2000)
Scott A. Halley, Research Associate (after Aug. 2000)
Louise M. Strang, Ag Research Specialist
Gary R. Haaven, Ag Research Specialist
Paul P. Koch, Ag Research Technician
Barbara F. Honeycutt, Administrative Support

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 at the Northwestern Agricultural Research Center

May 1, 1949 through October 30, 2000

GDD = Temp Max + Temp Min : 2-50

Max Temp > 86F substituted with 86; Min Temp < 50F substituted with 50

Average growing degree days by month and year

YEAR	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	TOTAL
1949	314.0	356.5	467.0	499.5	322.0	57.5	2016.5
1950	208.0	308.0	459.5	465.0	314.0	97.5	1852.0
1951	223.0	251.5	488.5	411.5	212.5	33.0	1620.0
1952	243.5	309.0	458.5	472.5	358.0	199.0	2040.5
1953	194.5	252.5	503.5	455.5	336.0	172.0	1914.0
1954	270.5	255.0	473.5	387.0	248.0	61.5	1695.5
1955	165.0	364.5	439.5	502.5	263.0	103.5	1838.0
1956	282.0	351.5	491.0	437.5	316.5	98.0	1976.5
1957	312.5	350.5	509.5	466.0	366.0	60.0	2064.5
1958	427.5	398.0	504.5	553.0	295.0	136.0	2314.0
1959	187.0	370.0	499.5	417.5	211.0	68.0	1753.0
1960	202.5	380.5	563.0	383.0	334.0	132.5	1995.5
1961	248.0	479.5	537.5	548.5	190.0	99.5	2103.0
1962	201.0	367.5	454.0	438.0	326.0	86.5	1873.0
1963	265.0	335.0	468.0	508.5	378.0	150.0	2104.5
1964	219.5	324.5	484.5	357.0	208.0	88.0	1681.5
1965	222.0	328.5	488.5	453.5	126.0	173.0	1791.5
1966	306.5	291.0	495.0	445.5	375.0	97.0	2010.0
1967	255.0	354.5	538.0	545.0	444.0	101.5	2238.0
1968	207.5	348.0	497.0	407.0	243.0	57.5	1760.0
1969	293.5	338.5	460.5	503.5	306.5	38.0	1940.5
1970	281.5	391.0	472.5	474.5	196.5	72.5	1888.5
1971	259.0	263.0	434.0	553.5	217.0	100.0	1826.5
1972	228.5	348.5	425.0	505.5	226.0	87.0	1820.5
1973	259.5	320.5	515.0	497.0	266.5	106.5	1965.0
1974	152.5	390.5	476.0	432.5	314.0	179.0	1944.5
1975	180.0	283.5	563.0	362.5	290.5	77.5	1757.0
1976	251.0	247.0	463.0	400.0	347.5	119.5	1828.0
1977	184.0	419.0	431.5	428.0	224.5	93.0	1780.0
1978	131.0	348.0	442.0	375.0	243.5	145.0	1684.5
1979	225.5	368.5	484.5	510.5	362.0	163.0	2114.0
1980	268.0	290.0	438.5	361.0	254.0	151.0	1762.5
1981	209.0	210.5	445.5	517.0	312.5	73.0	1767.5
1982	195.0	369.5	402.5	473.0	282.0	66.5	1788.5
1983	259.5	315.5	358.5	510.5	229.0	98.5	1771.5
1984	162.0	294.5	511.0	511.0	214.0	108.5	1801.0
1985	294.5	347.0	562.0	394.5	162.0	67.0	1827.0
1986	247.5	456.5	363.0	529.0	152.0	86.0	1834.0
1987	287.5	404.0	434.5	388.5	352.5	154.0	2021.0
1988	218.5	397.0	449.0	503.0	276.5	197.5	2041.5
1989	178.5	350.5	516.0	388.5	276.5	80.0	1790.0
1990	165.5	296.0	485.0	459.0	417.5	75.0	1898.0
1991	175.0	243.0	464.0	499.5	312.5	170.5	1864.5
1992	277.0	410.5	375.0	441.5	223.0	140.0	1867.0
1993	301.5	273.5	260.0	383.0	249.5	114.0	1581.5
1994	261.5	315.0	512.5	529.5	361.0	82.0	2061.5
1995	219.5	275.0	427.5	381.5	303.5	39.0	1646.0
1996	91.5	322.0	498.0	435.5	214.5	108.5	1670.0
1997	229.0	295.5	423.0	465.5	280.5	69.5	1763.0
1998	267.5	235.5	567.5	517.0	375.5	85.5	2048.5
1999	163.5	256.5	411.5	499.5	270.0	91.0	1692.0
2000	193.0	286.5	464.5	487.5	241.5	95.0	1768.0
MEAN	232.0	329.6	468.4	459.1	281.2	103.9	1874.1

Mean growing degree days for all years = 1874.1

NORTHWESTERN AGRICULTURAL RESEARCH CENTER

GROWING DEGREE DAYS MAY THROUGH OCTOBER 2000

May	MAX	MIN	GDD
1	66	34	8.0
2	73	42	11.5
3	56	37	3.0
4	58	41	4.0
5	54	33	2.0
6	58	35	4.0
7	54	25	2.0
8	57	26	3.5
9	60	35	5.0
10	53	39	1.5
11	50	31	0.0
12	49	36	0.0
13	53	28	1.5
14	62	28	6.0
15	61	33	5.5
16	73	35	11.5
17	71	49	10.5
18	67	40	8.5
19	64	41	7.0
20	56	44	3.0
21	67	48	8.5
22	72	51	11.5
23	72	53	12.5
24	72	35	11.0
25	69	43	9.5
26	69	44	9.5
27	62	47	6.0
28	64	47	7.0
29	61	33	5.5
30	64	35	7.0
	AV MAX	AV MIN	GDD
	62.2	37.0	186.0

June	MAX	MIN	GDD
1	64	32	7.0
2	62	38	6.0
3	73	46	11.5
4	71	39	10.5
5	74	39	12.0
6	74	39	12.0
7	73	41	11.5
8	78	49	14.0
9	77	52	14.5
10	58	39	4.0
11	61	41	5.5
12	54	44	2.0
13	57	47	3.5
14	66	49	8.0
15	63	47	6.5
16	59	38	4.5
17	65	44	7.5
18	70	47	10.0
19	70	44	10.0
20	59	40	4.5
21	71	45	10.5
22	77	51	14.0
23	0	0	0.0
24	0	0	0.0
25	0	0	0.0
26	0	0	0.0
27	0	0	0.0
28	0	0	0.0
29	0	0	0.0
30	0	0	0.0
	AV MAX	AV MIN	GDD
	49.2	30.7	189.5

July	MAX	MIN	GDD
1	85	49	17.5
2	78	48	14.0
3	74	46	12.0
4	62	44	6.0
5	57	35	3.5
6	70	35	10.0
7	62	44	6.0
8	72	44	11.0
9	74	48	12.0
10	73	42	11.5
11	76	44	13.0
12	81	45	15.5
13	86	50	18.0
14	91	50	18.0
15	85	56	20.5
16	77	42	13.5
17	81	45	15.5
18	81	49	15.5
19	80	51	15.5
20	82	51	16.5
21	85	48	17.5
22	86	51	18.5
23	96	59	22.5
24	78	48	14.0
25	80	45	15.0
26	84	48	17.0
27	89	54	20.0
28	85	49	17.5
29	87	51	18.5
30	94	50	18.0
	AV MAX	AV MIN	GDD
	77.1	45.8	443.5

Aug	MAX	MIN	GDD
1	91	55	20.5
2	91	53	19.5
3	85	50	17.5
4	91	59	22.5
5	87	50	18.0
6	85	53	19.0
7	86	53	19.5
8	86	50	18.0
9	89	50	18.0
10	94	53	19.5
11	94	53	19.5
12	79	38	14.5
13	83	44	16.5
14	81	43	15.5
15	79	39	14.5
16	81	42	15.5
17	81	40	15.5
18	83	44	16.5
19	81	44	15.5
20	72	38	11.0
21	71	38	10.5
22	73	38	11.5
23	80	41	15.0
24	87	41	18.0
25	80	45	15.0
26	83	45	16.5
27	77	44	13.5
28	68	35	9.0
29	69	36	9.5
30	74	41	12.0
31	71	42	10.5
	AV MAX	AV MIN	GDD
	81.7	45.1	487.5

Sept	MAX	MIN	GDD
1	73	42	11.5
2	64	50	7.0
3	64	44	7.0
4	64	39	7.0
5	67	43	8.5
6	58	46	4.0
7	58	46	4.0
8	68	48	9.0
9	66	41	8.0
10	66	43	8.0
11	52	40	1.0
12	63	37	6.5
13	75	38	12.5
14	76	44	13.0
15	79	44	14.5
16	78	46	14.0
17	78	48	14.0
18	78	57	17.5
19	72	42	11.0
20	65	33	7.5
21	65	34	7.5
22	43	32	0.0
23	45	18	0.0
24	50	22	0.0
25	59	24	4.5
26	64	25	7.0
27	67	27	8.5
28	71	29	10.5
29	71	31	10.5
30	65	39	7.5
	AV MAX	AV MIN	GDD
	65.5	38.4	241.5

Oct.	MAX	MIN	GDD
1	59	47	4.5
2	65	41	7.5
3	55	37	2.5
4	54	26	2.0
5	51	26	0.5
6	46	19	0.0
7	55	20	2.5
8	56	21	3.0
9	60	22	5.0
10	69	26	9.5
11	69	35	9.5
12	55	33	2.5
13	54	33	2.0
14	49	43	0.0
15	52	35	1.0
16	55	33	2.5
17	60	37	5.0
18	68	36	9.0
19	58	35	4.0
20	57	35	3.5
21	63	36	6.5
22	47	26	0.0
23	47	24	0.0
24	51	23	0.5
25	50	24	0.0
26	53	25	1.5
27	58	26	4.0
28	58	26	4.0
29	56	29	3.0
30	44	29	0.0
31	43	30	0.0
	AV MAX	AV MIN	GDD
	55.4	30.3	95.5

TOTAL GROWING DEGREE DAYS: 2000 1671.5

TITLE: **EFFECT OF FREEZING TEMPERATURES ON THE SURVIVAL OF MINT CULTIVARS/SELECTION LINES.**

PERSONNEL: Leon E. Welty, Professor of Agronomy, MSU, Kalispell, MT
Louise Strang, Research Specialist, MSU, Kalispell, MT

OBJECTIVE: Identify *Mentha* cultivars/selection lines with superior stolon tolerance to subfreezing temperatures, and evaluate them for oil yield and quality.

DURATION: 1997-2000

PROCEDURES: Nuclear plants from 27 mint lines were planted in 2-row plots between 5/21/97 and 6/3/98 in a randomized block design with 2 replicates (Table 1). In 1998 and 1999 stolons were removed from each plot in the fall and subjected to freezing temperatures from 5° F to 20° F. Because of the small number of replicates, these results could be viewed as only a suggestion of which mint lines may have special cold temperature tolerance. Based on the fall 1999 stolon freezer tests, 'Black Mitcham', 'Todd's Mitcham', 'Native', 'N-83-5', and 'Scotch' might be considered. In 1999 the 'Arctic' mint (believed to be a naturally occurring mutant of Scotch) did demonstrate more cold tolerance than many other entries.

Stands were rated for occupancy on May 9, 2000. Heights, maturity stages, pest damage and lodging were noted July 25. All surviving plots were harvested July 27, 2000. The mint was dried, steam distilled and oil yields calculated. Major oil components were analyzed by A.M. Todd Company.

RESULTS AND DISCUSSION: The *longifolia-polyadenia* entry did not survive the winter of 1998-99. There was considerable variation in winter stand survival and vigor as observed on 5/9/00 (Table 2). The two *surviving M. longifolia* entries again had the most robust stands, followed by the *M. piperita* entries. The *M.cardiaca* spearmint lines had the weakest early stands.

All plots were harvested 7/27/00 (Table 2). Plant heights ranged from 21 inches (stem-cut 'Scotch 770') to 46 inches (the Dutch *longifolia*). 'Murray Mitcham' was the least mature, having barely started to bud, and the *cardiaca, longifolia,* and *suaveolens* lines were the most mature, having reached full bloom. The two *longifolia*s, the N-83-5 and the meristem Native produced the most dry matter, and the *cardiaca* lines produced the least. Stem-cut Scotch 770 produced the highest concentration of oil per unit dry matter, significantly more than any other entry, including the meristem propagated Scotch 770. The *longifolia* and *suaveolens* lines and the *spicata* spearmints had the lowest oil content. Of the peppermint entries, the Black Mitcham stem-cut and meristem propagated lines from Summit, the 'MIRC-92' line, Todd's Mitcham, 'Robert's Mitcham', 'M-83-7', the 3 McClelland lines, and the 'UK-2' line produced the most oil. Of the spearmints, Native-meristem and nodal-propagated, and 'Scotch 213' were the top producers. The Arctic entry produced as much oil as the Black Mitcham entries. Over the three years that this trial has been conducted, the highest total oil yields have come from the Black Mitcham stem-cutting and nodal propagated entries, the Scotch 213 and the Arctic entries (Figures 1&2).

Oil quality is summarized in Table 3. Murray, Todd's, and Robert's Mitcham and M-83-7 had lower menthofuran and pulegone concentrations than the Black Mitcham lines. The Native spearmint lines tended to have higher dihydrocarvone, myrcene, cineole, and sabinene hydrate levels than the Scotch lines. The Scotch type mints had higher limonene, octanol, and carvone levels than the Native. The Arctic mint had lower carvone, myrcene, cineole, and octanol, similar limonene and sabinene hydrate, and much higher dihydrocarvone levels than the other Scotch lines, supporting the theory that it may be a naturally occurring mutant of *M. cardiaca*.

Table 1. Entries in the *Mentha* cold tolerance study at NWARC.

Species	**Cultivar**	**Propagation Method**	**Source**	**Propagator**
piperita	Black Mitcham	meristem	MIRC	Summit
piperita	Black Mitcham	meristem	MIRC	Starkel
piperita	Black Mitcham	nodal	MIRC-92	Lake
piperita	Black Mitcham	nodal	McClelland	Lake
piperita	Black Mitcham	nodal	English 1	Lake(Margetts-Roberts)
piperita	Black Mitcham	nodal	English 2	Lake
piperita	Black Mitcham	nodal	McClelland	Lake(Mc96-7)
piperita	Black Mitcham	nodal	McClelland	Lake(Mc96-19)
piperita	Black Mitcham	stem cut	MIRC	Summit
piperita	Black Mitcham	meristem	McClelland	Starkel/Clarke
piperita	M-83-7	stemcut	MIRC	Summit
piperita	Murray Mitcham	stem cut	MIRC	Summit
piperita	Roberts Mitcham	stem cut	MIRC	Summit
piperita	Todd's Mitcham	stem cut	MIRC	Summit
cardiaca	Scotch	stemcut	MIRC	Summit
cardiaca	Scotch 213	stem cut	MIRC	Summit
cardiaca	Scotch 227	stem cut	MIRC	Summit
cardiaca	Scotch 770	meristem	MIRC	Starkel
cardiaca	Scotch 770	stem cut	MIRC	Summit
cardiaca	Arctic	nodal	I.P.Callison	Lake
spicata	N-83-5	stemcut	MIRC	Summit
spicata	Native	meristem	MIRC	Starkel
spicata	Native	stem cut	MIRC	Summit
longifolia	*hymaliensis*	stem cut	Davis	Grey
longifolia	*polyadenia*	stem cut	Davis	Lake (S.Africa)
longifolia		nodal	NCGR	Lake (Netherlands)
suaveolens	rotundifolia	nodal	NCGR	Lake (Minnesota)

Table 2. Height, growth stages, and yield components of entries in the cold tolerance trial at Kalispell in 2000.

Cultivar	Method	Source	Prop.	Cover[1] %plot	Height inches	Stage *	Hay Yield t/a	Oil Content %dm	Oil Yield lbs/a	Total Oil 1998-2000 lbs/a
Black M.	stem	MIRC	Summit	83	32	fb	3.13	1.3	78.6	176.4
Black M.	meris.	MIRC	Summit	85	31	fb	2.84	1.4	79.1	172.3
Black M.	meris.	MIRC	Starkel	88	33	mb	2.75	1.1	60.1	141.0
Black M.	nodal	MIRC92	Lake	90	35	fb	3.13	1.3	80.3	188.3
Murray M.	stem	MIRC	Summit	88	32	pb	3.02	1.0	60.5	163.1
Todd's M.	stem	MIRC	Summit	78	30	mb	2.96	1.2	68.1	130.0
Roberts M	stem	MIRC	Summit	85	31	pb	3.03	1.1	65.8	173.4
M-83-7	stem	MIRC	Summit	88	30	mb	3.07	1.1	65.4	158.4
Black M.	nodal	Mc96-7	Lake	85	33	mb	2.64	1.3	66.6	174.7
Black M.	nodal	UK-1	Lake	88	30	eb	2.75	0.7	40.0	132.8
Black M.	nodal	UK-2	Lake	88	29	mb	2.59	1.3	67.1	171.0
Native	stem	MIRC	Summit	78	38	eblm	4.08	0.7	49.9	114.1
N-83-5	stem	MIRC	Summit	80	37	eblm	5.68	0.4	48.1	99.8
Native	meris.	MIRC	Starkel	88	35	eblm	5.63	0.5	58.1	151.3
Scotch	stem	MIRC	Summit	35	26	fblm	1.63	1.7	54.5	143.2
Scotch 213	stem	MIRC	Summit	65	26	fblm	2.09	1.3	62.2	216.3
Scotch 227	stem	MIRC	Summit	33	28	fblm	1.85	1.1	39.2	120.0
Scotch 770	stem	MIRC	Summit	38	21	fblm	1.23	2.1	51.2	155.3
Scotch 770	meris.	MIRC	Starkel	78	27	fblm	1.96	1.2	47.3	170.5
longifolia-hymal.	stem	Davis	Grey	95	39	fblm	5.76	0.3	34.7	65.0
longifolia	nodal	NCGR	Lake	95	46	fblm	6.27	0.2	26.0	61.4
suaveolens	nodal	NCGR	Lake	78	27	fblm	3.00	0.2	9.9	21.6
Black M.	nodal	Mc96-9	Lake	83	30	mb	2.70	1.4	73.2	195.0
Native	nodal			73	38	mblm	4.44	0.7	62.3	83.9
Black M.	nodal	Mc96-19	Lake	88	35	mb	2.86	1.3	72.8	149.6
Arctic	nodal	Callison	Lake	75	27	fb	3.14	1.1	68.1	198.4
		mean		78	32		3.24	1.0	57.3	143.3
		LSD(0.10)		12	4		0.92	0.3	15.4	41.9
		CV(s/mean) %		9.4	7.8		16.6	16.8	15.8	17.1

[1] Evaluated 5/9/00.

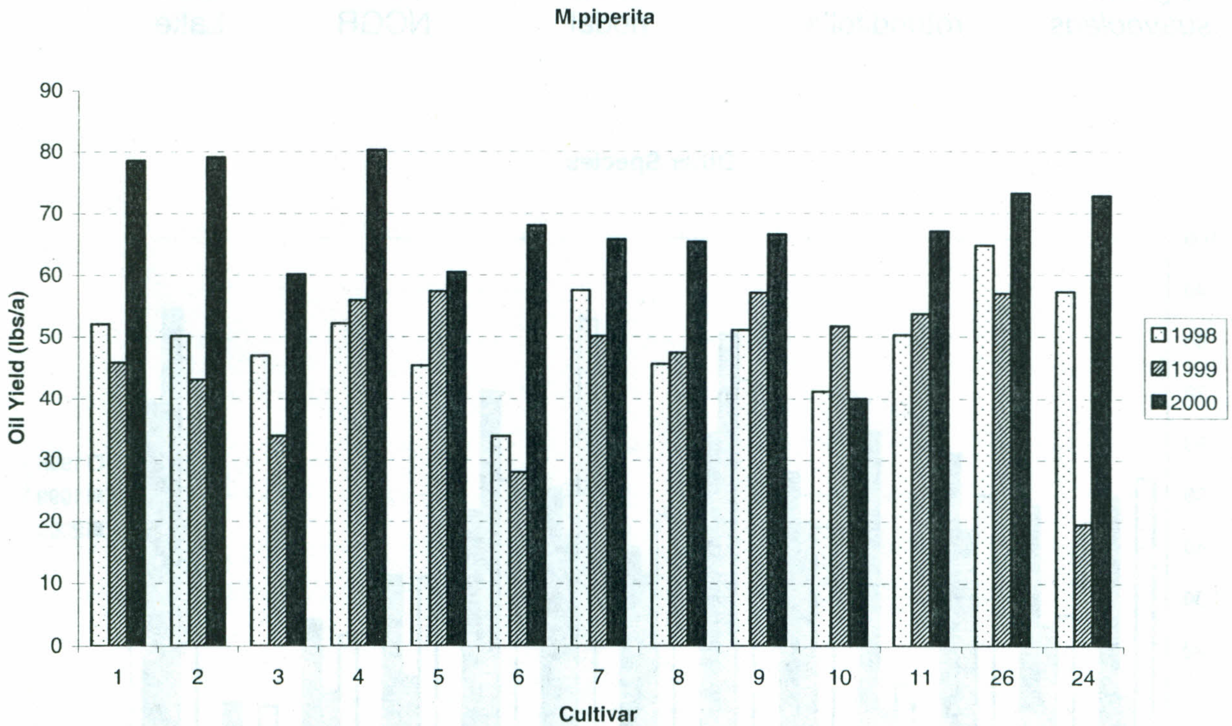
** pb=prebud; eb=early bud; mb=mid bud; fb=full bud; eblm=early bloom; mblm=med bloom; fblm=full bloom*

Table 3. Quality components of mint oil from the *Mentha* Cold Tolerance Study (GC%).

Peppermint Species	Cultivar	Method	Source	Menthol	Neo-menthol	Menthone	D-iso-menthone	Mentho-furan	Esters	Pulegone
piperita	Black Mitcham	stem-cut	MIRC	34.8	3.2	27.2	3.1	1.8	4.9	0.45
piperita	Black Mitcham	meristem	MIRC	23.2	2.0	19.2	2.2	1.6	4.0	0.71
piperita	Black Mitcham	meristem	Starkel	36.9	3.1	26.7	3.0	1.3	4.8	0.21
piperita	Black Mitcham	nodal	MIRC-92	32.5	3.0	25.5	2.9	1.8	4.9	0.43
piperita	Murray Mitcham	stem-cut	MIRC	34.1	3.3	30.2	3.3	1.0	5.2	0.16
piperita	Todd's Mitcham	stem-cut	MIRC	31.1	3.2	30.8	3.3	1.2	4.9	0.24
piperita	Roberts Mitcham	stem-cut	MIRC	32.4	3.0	30.3	3.3	1.0	4.6	0.14
piperita	M-83-7	stem-cut	MIRC	33.4	3.5	29.2	3.4	1.0	5.3	0.21
piperita	Black Mitcham	nodal	Mc96-9	34.1	2.9	26.6	3.0	1.8	4.9	0.35
piperita	Black Mitcham	nodal	UK-1	33.2	3.2	26.6	2.9	1.2	5.0	0.17
piperita	Black Mitcham	nodal	UK-2	33.1	3.0	28.4	3.2	1.5	4.8	0.21
piperita	Black Mitcham	meristem	Mc96-7	36.2	3.4	24.7	2.9	1.9	4.8	0.43
piperita	Black Mitcham	nodal	Mc96-19	33.9	2.9	26.0	2.8	1.6	4.8	0.33
			mean	33.0	3.1	27.0	3.0	1.4	4.8	0.31
			LSD(0.10)	NS	NS	NS	NS	0.6	NS	0.12
			CV(s/mean)%	11.2	15.1	12.0	13.5	22.4	11.1	22.5
Spearmint Species	Cultivar	Method	Source	Dihydro-carvone	Myrcene	Limonene	Cineole	Octanol	Sabinene Hydrate	Carvone
spicata	Native	stem-cut	MIRC	2.10	2.99	13.5	2.09	0.94	2.68	54.6
spicata	N-83-5	stem-cut	MIRC	1.55	3.86	12.1	2.09	0.90	3.34	55.4
spicata	Native	meristem	MIRC	2.05	4.07	13.6	2.29	0.88	2.89	54.4
spicata	Native	stem-cut	Clarke	1.35	3.97	14.0	2.20	0.92	3.95	54.7
cardiaca	Scotch	stem-cut	MIRC	1.05	0.69	19.1	1.35	1.88	0.48	61.5
cardiaca	Scotch 213	stem-cut	MIRC	1.75	0.65	16.0	1.28	2.23	0.37	63.9
cardiaca	Scotch 227	stem-cut	MIRC	1.85	0.98	19.6	1.21	2.12	0.30	59.8
cardiaca	Scotch 770	stem-cut	MIRC	1.60	1.11	20.4	1.24	1.83	0.35	58.5
cardiaca	Scotch 770	meristem	MIRC	1.70	1.82	15.6	1.51	1.46	1.13	59.5
cardiaca	Arctic	nodal	Callison	5.59	0.60	19.2	0.99	0.72	0.42	45.2
			mean	1.67	2.23	16.0	1.69	1.46	1.72	58.0
			LSD(0.10)	0.25	0.93	3.1	0.39	0.41	0.85	4.8
			CV(s/mean)%	8.2	22.4	10.4	12.5	15.3	26.7	4.5
Other Species										
longifolia	hymaliensis	stem-cut	Davis	0.26	0.91	6.2	2.25	0.71	0.92	11.8
longifolia		nodal	NCGR	0.16	0.55	3.5	1.37	0.30	0.65	25.3
suaveolens	rotundifolia	nodal	NCGR	0.24	0.65	7.1	0.52	0.30	0.34	8.3
			mean	1.56	0.68	9.0	1.28	0.51	0.58	22.6
			LSD(0.10)	0.54	NS	6.8	0.86	NS	NS	9.2

Figure 1. Oil yields of peppermint entries in the Mint Cold Tolerance Trial from 1998-2000.

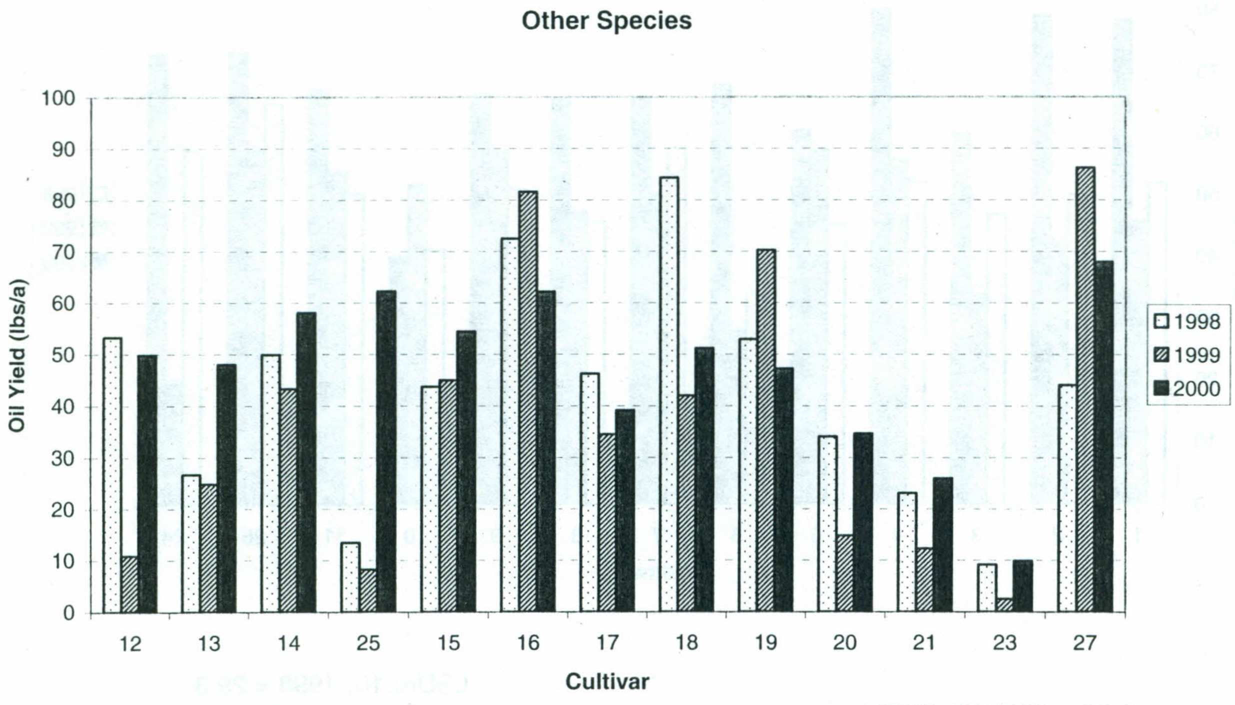
	Species	Cultivar	Method	Source	Propagator
1	*piperita*	Black Mitcham	stem-cut	MIRC	Summit
2	*piperita*	Black Mitcham	meristem	MIRC	Summit
3	*piperita*	Black Mitcham	meristem	MIRC	Starkel
4	*piperita*	Black Mitcham	nodal	MIRC-92	Lake
5	*piperita*	Murray Mitcham	stem-cut	MIRC	Summit
6	*piperita*	Todd's Mitcham	stem-cut	MIRC	Summit
7	*piperita*	Roberts Mitcham	stem-cut	MIRC	Summit
8	*piperita*	M-83-7	stem-cut	MIRC	Summit
9	*piperita*	Black Mitcham	nodal	McClelland	Lake
10	*piperita*	Black Mitcham	nodal	English 1	Lake
11	*piperita*	Black Mitcham	nodal	English 2	Lake
26	*piperita*	Black Mitcham	nodal	Mc96-9	Lake
24	*piperita*	Black Mitcham	nodal	McClelland	Clarke



LSD(0.10) 1998 = 29.3
1999 = 20.8
2000 = 15.8

Figure 2. Oil yields of other mint entries in the Mint Cold Tolerance Trial from 1998-2000.

	Species	Cultivar	Method	Source	Propagator
12	*spicata*	Native spearmint	stem-cut	MIRC	Summit
13	*spicata*	N-83-5	stem-cut	MIRC	Summit
14	*spicata*	Native spearmint	meristem	MIRC	Starkel
25	*spicata*	Native spearmint	nodal		Lake
15	*cardiaca*	Scotch	stem-cut	MIRC	Summit
16	*cardiaca*	Scotch 213	stem-cut	MIRC	Summit
17	*cardiaca*	Scotch 227	stem-cut	MIRC	Summit
18	*cardiaca*	Scotch 770	stem-cut	MIRC	Summit
19	*cardiaca*	Scotch 770	meristem	MIRC	Starkel
27	*cardiaca*	Alaska/Arctic	nodal	I.P.Callison	Lake
20	*longifolia*	hymaliensis	stem-cut	Davis	Grey
21	*longifolia*		nodal	NCGR	Lake
23	*suaveolens*	rotundifolia	nodal	NCGR	Lake



LSD(0.10) 1998 = 29.3
1999 = 20.8
2000 = 15.8

TITLE: **1998 MINT CULTIVAR TRIAL**

PERSONNEL: Leon E. Welty, Professor of Agronomy, MSU, Kalispell, MT
Louise Strang, Research Specialist, MSU, Kalispell, MT

OBJECTIVE: Determine peppermint and spearmint germplasm response to an Intermountain environment in terms of pest tolerance, oil yield and oil quality.

DURATION: 1998-2001

PROCEDURES: The following cultivars/selection lines were planted May 18 and 19, 1998:

1) Black Mitcham peppermint, stem-cut propagated by MIRC
2) B-90-9 peppermint, stem-cut propagated by MIRC
3) Murray Mitcham peppermint, stem-cut propagated by MIRC
4) M-83-14 peppermint, stem-cut propagated by MIRC
5) 92(B-37 x M0110) peppermint, stem-cut propagated by MIRC
6) Lewis McKellip selection, nodal propagated by MIRC
7) UK-1 peppermint, nodal propagated by Lake
8) UK-2 peppermint, nodal propagated by Lake
9) McClelland selection, meristem propagated by Starkel
10) Plant Tech-94 selection, stem-cut propagated by Grey
11) Native spearmint, stem-cut propagated by MIRC
12) N-83-22 spearmint, stem-cut propagated by MIRC
13) Scotch spearmint, stem-cut propagated by MIRC
14) Scotch 770 spearmint, stem-cut propagated by MIRC
15) S-90-9 spearmint, stem-cut propagated by MIRC

Experimental design was two side-by-side randomized complete blocks (peppermint and spearmint) with four replicates. Each plot consisted of four, 20-ft long rows spaced 22 inches apart with 3 ft between plots. Plant spacing was one foot within each row. Appropriate management practices (irrigation, fertility, and weed and pest control) were employed to insure maximum mint oil production. On 10 April, 2000 *Verticillium* wilt was seeded in a 50/50 mixture of oats and ground wheat in the middle ten feet of each plot. Stand vigor was rated May 17 and August 8. Spearmint plots were harvested July 9 at the early to mid bud stage, and September 14, 2000 at the early to mid bloom stage. Peppermint entries were harvested August 8, 2000 at the early bloom stage. There were some indications of downy mildew in the second spearmint harvest. Plant height and growth stage was determined immediately before harvest. Yields were determined by swathing a 99 ft^2 area of each plot, drying a 500-g subsample to determine dry matter content, and drying a 20-lb. sample for distillation. Oil was collected by steam distillation with a research still at the NWARC. Oil samples were analyzed for quality by gas chromatography at RCB International.

RESULTS AND DISCUSSION: Spring stand evaluation indicated the UK-1 and UK-2 selection peppermints and Native and N-83-22 spearmints had the best stand retention, while the 92(B-37xM0110) cross, Scotch and Scotch 770 had the poorest stands (Table 1).

No rust symptoms were observed in 2000, but some spearmint plots showed mild symptoms of powdery mildew at the second harvest. The Scotch-derived cultivars seemed more susceptible than the Native lines. No *Verticillium* wilt was observed.

In this second post-establishment year of the study, there was variation in yield parameters among peppermint cultivars and selection groups (Table 2, Figure 1). No peppermint entry produced significantly more dry matter than Black Mitcham, and 92(B-37xM0110) produced significantly less. B-90-9 had a higher amount of oil as percent of dry matter than the other entries. B-90-9, Black Mitcham, and the Plant Tech-94 selection produced the most oil, and 92(B-37xM0110) produced significantly less oil than any other entry. No new introduction or selection line surpassed the Black Mitcham from the MIRC mother block in oil production.

Of the spearmint entries, the parent Native produced the most dry matter. The Scotch lines produced less hay than the Native lines (Table 3). Scotch 770 had the highest concentration of oil on a dry matter basis, and Native and N-83-22 had the lowest. Scotch and Scotch 770 produced the most oil over the two harvests, and N-83-22 produced the least (Figure 2). Scotch 770 produced 115 lbs./acre of spearmint oil, 20% more than Native and 65% more than N-83-22. None of the new peppermint or spearmint cultivars or selections showed significant improvement in oil yield over the parental lines (Table 4).

Quality data for peppermint entries are summarized in Table 5. B-90-9 was similar to Black Mitcham in menthone, menthol, pulegone, ketones, and alcohol levels, but similar to Murray Mitcham in menthyl acetate level. M-83-14 was similar to Murray Mitcham in menthone, menthol, ketones, and alcohols. The hybrid 92(B-37xM0110) was similar to Murray Mitcham in menthone, menthyl acetate, pulegone, menthofuran, and ketones, but similar to Black Mitcham in menthol and total alcohols. Spearmint quality data is summarized in Table 6. The Native lines had higher levels of cineole than the Scotch lines, and Scotch lines had higher levels of limonene, octanol, and carvone.

Table 1. Stand evaluation of peppermint and spearmint entries at Kalispell, MT on May 17, 2000.

Selection/Cultivar	Source	5/17/00 Cover (0-5)[1/]	8/8/00 Vigor (0-5)[2]
PEPPERMINT			
Black Mitcham	stem-cut/MIRC	4.0	4.3
B-90-9	stem-cut/MIRC	4.0	4.8
Murray Mitcham	stem-cut/MIRC	4.0	4.0
M-83-14	stem-cut/MIRC	4.0	5.0
92 (B-37 x M0110)	stem-cut/MIRC	2.0	3.8
Lewis McKellip	nodal/MIRC	4.0	5.0
UK-1	nodal/Lake	5.0	5.0
UK-2	nodal/Lake	4.5	5.0
McClelland	meristem/Starkel	4.5	5.0
Plant Tech 94	stem-cut/Grey	4.5	5.0
	LSD(0.10)	1.0	0.5
SPEARMINT			
Native	stem-cut/MIRC	4.0	5.0
N-83-22	stem-cut/MIRC	3.5	4.0
Scotch	stem-cut/MIRC	2.0	3.0
Scotch 770	stem-cut/MIRC	2.0	2.0
S-90-9	stem-cut/MIRC	2.5	2.5
	LSD(0.10)	1.5	1.0

Planted 5/19/98

1/0=plot empty, 5=plot totally occupied
2/ 0=dead, 5=strong, vigorous plants

Table 2. Heights, total dry matter, oil concentration, and oil yield of peppermint entries in the 1998 Mint Cultivar Trial at Kalispell, MT in 2000.

Selection/Cultivar	Source	Height	Hay Yield	Oil Content	Oil Yield
		inches	*t/a*	*%dm*	*lbs/a*
B-90-9	stem-cut/MIRC	36	3.00	1.6	92.1
Black Mitcham	stem-cut/MIRC	37	3.01	1.4	84.7
Plant Tech-94	stem-cut/Grey	39	3.15	1.3	82.8
Lewis McKellip	nodal/MIRC	38	3.19	1.3	79.2
UK-2	nodal/Lake	35	2.72	1.4	72.6
UK-1	nodal/Lake	36	2.92	1.3	72.3
Murray Mitcham	stem-cut/MIRC	36	3.17	1.1	71.8
McClelland	meris.-Starkel	38	2.68	1.2	65.0
M-83-14	stem-cut/MIRC	38	3.10	1.0	62.9
92 (B-37 x M0110)	stem-cut/MIRC	21	0.57	1.3	15.2
	LSD(0.10)	4	0.41	0.2	10.6
	CV(s/mean) %	10.1	12.3	14.4	12.6

Planted 5/19/98
Harvested 8/8/00

Table 3. Height, total dry matter, oil concentration and oil yield of spearmint entries in the 1998 Mint Cultivar Trial established at Kalispell, MT in 1998.

First Harvest 7/5/00

Selection/Cultivar	Source	Height	Hay Yield	Oil Content	Oil Yield
		inches	*t/a*	*%dm*	*lbs/a*
Scotch 770	stem-cut/MIRC	21	1.71	1.6	54.0
S-90-9	stem-cut/MIRC	22	2.04	1.3	48.8
Native	stem-cut/MIRC	30	2.56	0.9	46.9
Scotch	stem-cut/MIRC	23	1.89	1.2	46.8
N-83-22	stem-cut/MIRC	28	2.08	1.1	45.0
	LSD(0.10)	2	0.25	0.2	NS
	CV(s/mean x100)	5.8	9.7	14.7	16.4

Second Harvest 9/14/00

Selection/Cultivar	Source	Hay Yield	Oil Content	Oil Yield
		t/a	*%dm*	*lbs/a*
Scotch 770	stem-cut/MIRC	1.69	1.8	61.0
Scotch	stem-cut/MIRC	1.68	1.7	57.5
Native	stem-cut/MIRC	2.29	1.1	48.8
S-90-9	stem-cut/MIRC	1.64	1.4	43.4
N-83-22	stem-cut/MIRC	2.00	0.6	24.7
LSD(0.10)		0.22	0.2	7.6
CV(s/mean x100)		9.5	10.6	12.9

Planted 5/19/98

Table 4. Total dry matter and oil yields for peppermint and spearmint entries in the 1998 Mint Cultivar Trial at Kalispell, MT from 1998 to 2000.

Peppermint Selection/Cultivar	1998 Hay *t/a*	1998 Oil *lbs/a*	1999 Hay *t/a*	1999 Oil *lbs/a*	2000 Hay *t/a*	2000 Oil *lbs/a*	Total Hay *t/a*	Total Oil *lbs/a*
Black Mitcham	2.09	59.7	3.54	87.1	3.01	84.7	8.64	231.5
B-90-9	1.98	61.2	3.45	91.9	3.00	92.1	8.42	245.1
Murray Mitcham	1.87	47.2	2.87	61.7	3.17	71.8	7.91	180.7
M-83-14	2.05	55.4	3.37	66.6	3.10	62.9	8.52	184.8
92 (B-37 x M0110)	1.67	37.3	1.61	36.8	0.57	15.2	3.85	89.2
Lewis McKellip	2.15	55.1	3.89	89.2	3.19	79.2	9.23	223.5
UK-1	1.83	50.3	3.21	70.6	2.92	72.3	7.96	193.2
UK-2	1.60	46.9	3.09	66.9	2.72	72.6	7.40	186.4
McClelland	1.98	52.4	3.66	70.4	2.68	65.0	8.32	187.8
Plant Tech 94	1.73	49.5	3.49	87.7	3.15	82.8	8.37	220.0
mean	1.89	51.5	3.22	72.9	2.75	69.8	7.86	194.2
LSD(0.10)	0.23	8.0	0.54	15.0	0.41	10.6	0.88	24.3
CV(s/mean x 100)	10.3	12.8	14.0	17.1	12.3	12.6	9.3	10.4
Spearmint								
Native	1.84	34.6	5.34	77.0	4.85	95.6	12.04	208.1
N-83-22	1.57	17.7	4.54	38.8	4.08	69.7	10.18	124.3
Scotch	1.76	44.5	4.14	110.6	3.58	104.2	9.67	265.9
Scotch 770	1.39	38.0	3.58	116.6	3.41	115.0	8.36	268.8
S-90-9	1.41	26.3	3.33	74.4	3.59	92.2	8.33	193.6
mean	1.59	32.2	4.19	83.5	3.90	95.3	9.72	212.1
LSD(0.10)	0.27	7.4	0.34	14.1	0.46	16.3	1.00	25.1
CV(s/mean x 100)	12.5	13.7	12.2	13.3	9.4	13.6	8.1	9.3

Table 5. Oil quality constituents of peppermint entries in the 1998 Mint Cultivar Trial at Kalispell, MT in 2000.

Selection/Cultivar	Menthone	Menthyl acetate	Menthol	Pulegone	Mentho-furan	Total ketones	Total alcohols
				GC Area %			
Black Mitcham	20.1	4.40	37.6	1.62	4.40	25.5	41.4
B-90-9	20.0	3.75	37.7	1.76	5.31	25.4	41.7
Murray Mitcham	25.9	3.76	35.9	0.72	2.11	30.8	39.6
M-83-14	25.4	3.26	36.1	1.44	3.04	31.1	40.3
92 (B-37 x M0110)	25.9	3.93	36.9	0.75	2.15	30.6	41.3
Lewis McKellip	20.9	3.95	36.9	1.35	5.15	23.8	47.6
UK-1	24.4	3.82	35.2	0.88	3.68	27.6	45.8
UK-2	23.6	3.96	35.7	0.90	3.53	26.9	46.6
McClelland	20.3	4.02	37.3	1.24	4.63	23.5	48.2
Plant Tech 94	20.8	3.88	37.2	1.35	5.18	24.0	47.9
mean	22.7	3.87	36.6	1.20	3.92	26.9	44.0
LSD(0.10)	1.4	0.31	1.2	0.19	0.59	1.5	1.4
CV(s/mean)%	5.2	6.6	2.8	13.3	12.5	4.6	2.7

Table 6. Oil quality constituents of spearmint entries in the 1998 Mint Cultivar Trial at Kalispell, MT in 2000.

First Harvest - Selection/Cultivar	A-Pinene	B-Pinene	Limonene	Cineole	3-Octanol	Dihydro-carvone	Carvone
				GC Area %			
Native	0.97	0.82	11.9	1.53	1.08	1.89	55.5
N-83-22	0.89	0.74	12.8	1.47	0.99	1.07	52.7
Scotch	1.01	0.93	21.0	1.08	2.17	0.87	59.5
Scotch 770	0.90	0.85	18.4	0.91	2.16	1.18	63.8
S-90-9	0.85	0.83	16.1	1.15	1.66	1.53	61.7
mean	0.92	0.83	16.0	1.23	1.61	1.31	58.6
LSD(0.10)	NS	0.10	1.7	0.17	0.17	0.21	4.1
CV(s/mean)%	12.8	9.2	8.2	11.2	8.2	12.9	5.5
Second Harvest							
Native	1.03	0.86	10.8	2.36	0.92	2.43	57.8
N-83-22	1.12	0.90	13.8	2.42	0.80	1.45	52.2
Scotch	0.92	0.88	19.8	1.76	2.15	1.54	61.5
Scotch 770	0.94	0.89	19.5	1.57	2.25	1.65	62.7
S-90-9	0.95	0.94	18.8	1.74	1.55	3.93	58.1
mean	0.99	0.90	16.5	1.97	1.53	2.20	58.5
LSD(0.10)	0.14	NS	2.1	0.21	0.09	0.58	2.6
CV(s/mean)%	11.0	8.3	9.9	8.3	4.9	20.8	3.6

Figure 1. Oil yields of peppermint lines in the Mint Cultivar Trial established in 1998.

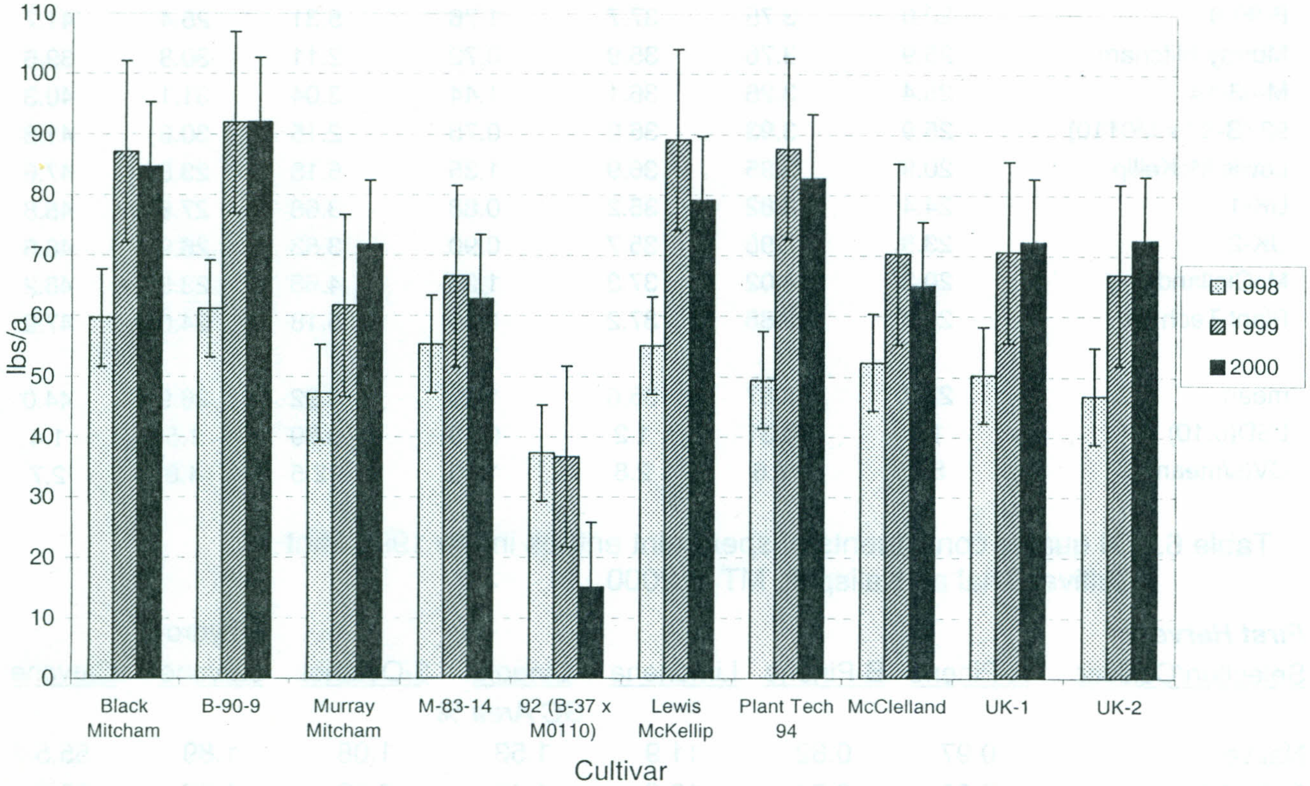
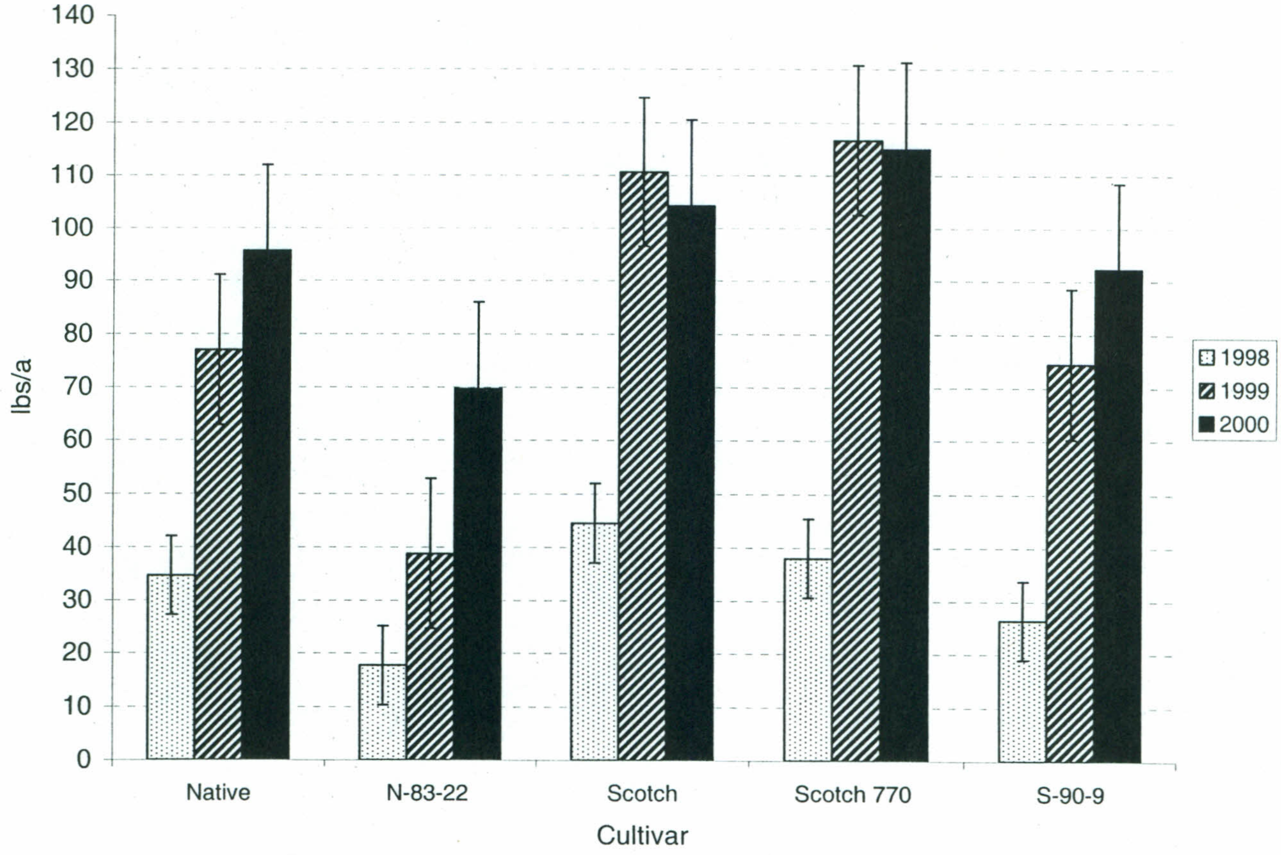


Figure 2. Oil yields of spearmint lines in the Mint Cultivar Trial established in 1998.



TITLE: **EVALUATION OF MIRC PEPPERMINT GERMPLASM - 1999**

PERSONNEL: Leon E. Welty, Professor of Agronomy, MSU, Kalispell, MT
Louise Strang, Research Specialist, MSU, Kalispell, MT

OBJECTIVE: Determine peppermint response to an Intermountain environment in terms of pest tolerance, oil yield, and oil quality.

DURATION: 1999-2001

PROCEDURES: The following cultivars/selection lines were stem-cut propagated at Summit Labs from randomly selected plants within the mother block of each line. They were transplanted to the field at NWARC on May 18, 1999:

1) Black Mitcham
2) Murray Mitcham
3) 84-M0107-7
4) 87-M0109-1
5) M-90-11

Experimental design was a randomized complete block with four replicates. Each plot consisted of four, 20-ft long rows spaced 22 inches apart with 3 ft between plots. Plant spacing was one foot within each row. Appropriate management practices (irrigation, fertility, and weed and pest control) were employed to insure maximum mint oil production. On 10 April 2000, *Verticillium* wilt was seeded in a 50/50 mixture of oats and ground wheat in the middle ten feet of each plot. Stand occupancy was rated May 17, 2000. Plots were harvested 7 August 2000, when all cultivars were at the pre-bloom to early bloom stage. Plant height and growth stage was determined the day of harvest. Yields were determined by swathing a 99 ft^2 area of each plot, drying a 500-g subsample to determine dry matter content, and drying a 20- lb. sample for distillation. Oil was collected by steam distillation with a research still at the NWARC. Oil samples were analyzed for quality by gas chromatography at RCB International, Ltd.

Data were analyzed using MSUSTAT, Version 5.22 (R.E. Lund, Montana State University), Procedure ANOVA for a randomized block with 4 replicates. Means of treatments were separated by the method of Least Significant Differences (Student's t) at the P=0.90 confidence level.

RESULTS AND DISCUSSION: All entries survived the winter in excellent condition. Spring stand evaluation indicated 84-M0107-7 had the most vigorous early season stand establishment, while 87M0109-1 had the least vigorous early stand (Table 1). There were no signs of disease at any time during the growing season.

In this first post-establishment year of the study, there were significant differences in oil yield and oil content among cultivars and selection groups (Table 2). Black Mitcham had the highest ratio of oil to dry matter and 87-M0109-1 had the lowest. Black Mitcham had significantly higher oil yield than any other entry in 2000 and total oil production from 1999-2000. Murray Mitcham was the second most productive entry in

2000. Murray Mitcham's lack of vigor at establishment was followed by more vigorous growth the second season (Figure 1). We have not yet been able to evaluate the entries in the presence of disease pressure.

Analysis of the chemical constituents of the oil is summarized in Table 3. Black Mitcham and Murray Mitcham contained higher menthol levels than the experimental lines. Black Mitcham had a much higher menthofuran level than the other entries.

Table 1. Stand establishment evaluation of peppermint entries in the 1999 Peppermint Germplasm Trial at Kalispell, MT on May 17 and Aug.4, 2000.

Selection/Cultivar	*5/17* Cover *% of plot*	*8/4* Vigor *(0-5)*[1]	*8/4* Stolon Spread *(0-5)*[2]
Black Mitcham	89	4.5	4.5
84-M0107-7	95	5.0	5.0
M-90-11	84	5.0	4.0
87-M0109-1	81	5.0	4.0
Murray Mitcham	84	5.0	4.0
LSD (0.10)	3	0.3	0.3
CV(s/mean) %	2.8	5.3	6.0

Planted 5/18/99

[1/] 0=dead; 5=very healthy, vigorous growth
[2/] 0=no visible spread from crowns; 5=extensive spreading

Table 2. Plant height, dry matter yield, and oil yield of peppermint entries in the 1999 MIRC Peppermint Trial at Kalispell, MT on 7 August, 2000 and total yields for the duration of the trial.

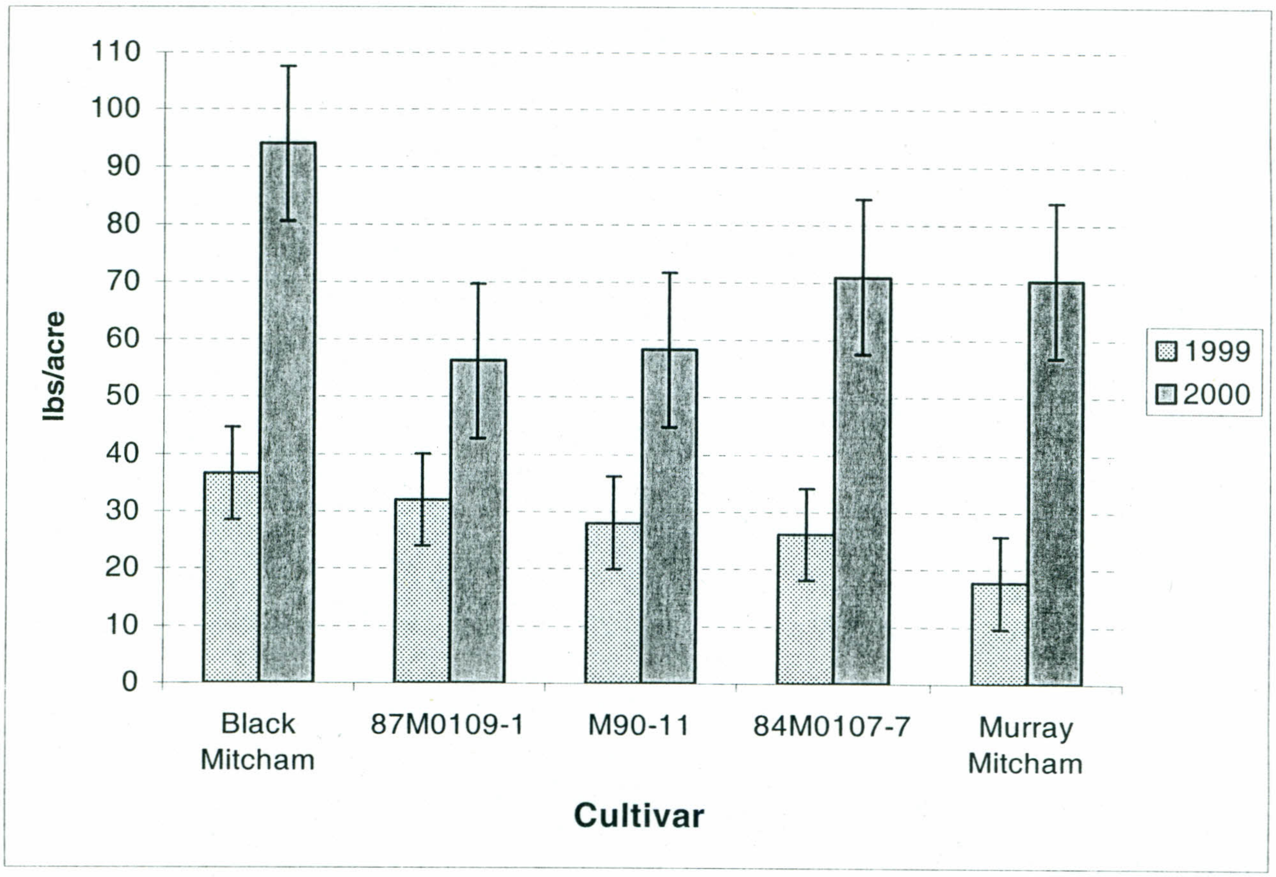
Selection/Cultivar	Height *inches*	Hay Yield *T/a*	Oil Content *%Dm*	Oil Yield *Lbs/a*	1999-2000 Hay Yield *T/a*	1999-2000 Oil Yield *Lbs/a*
Black Mitcham	38	3.60	1.3	94.0	4.88	130.6
87-M0109-1	43	4.22	1.7	56.3	5.45	82.4
M-90-11	41	4.06	1.7	58.3	5.37	86.3
84-M0107-7	45	4.34	0.8	71.0	6.10	103.0
Murray Mitcham	37	3.46	1.0	70.4	4.15	88.1
LSD (0.10)	3	NS	0.2	13.5	0.81	17.2
CV(s/mean x100)	5.9	13.5	10.4	15.3	12.4	13.9

Planted 5/18/99
Harvested 8/7/00

Table 3. Levels of oil quality components (GC % area) of entries in the 1999 Peppermint Germplasm Trial harvested at Kalispell, MT on 7 August 2000.

Line/Cultivar			*GC % area*				
	Menthone	Mentho-furan	D Iso-menthone	Menthyl acetate	Neo-menthol	Menthol	Pulegone
Black Mitcham	20.7	4.8	3.0	3.7	3.3	37.1	1.6
84M0107-7	33.6	1.3	13.2	2.1	2.3	25.2	0.7
M90-11	20.2	2.7	11.3	3.3	1.8	28.3	2.4
87M0109-1	28.2	0.9	14.3	3.1	3.5	24.3	1.2
Murray Mitcham	25.0	2.2	3.9	3.4	3.2	36.0	0.8
Mean	25.5	2.4	9.1	3.1	2.8	30.2	1.3
LSD (0.10)	1.8	0.4	1.4	0.4	0.4	2.1	0.3
CV(s/mean) %	5.7	12.2	12.3	9.7	10.6	5.4	17.3

Figure 1. Oil yields of entries in the MIRC Peppermint Cultivar Trial, established in 1999 at Kalispell, MT.



Connect Mint Study

The study, conducted on spearmint, *Mentha spicata* (L.), was located at the NWARC station field R-4. The soil consisted of a Creston Silt Loam with a pH of 7.5 and organic matter of 3.5 percent. Plots were 10 X 15 ft with three replicates in a randomized complete block design.

The herbicides were applied to 6-inch spearmint on May 22 at 9:00 a.m. with a CO_2 backpack sprayer in 20 gallons water per acre. Teejet XR11002 nozzles spaced 20 inches apart were used for applications. The application day had zero to five mph wind, a 62° F air temperature, 58° F soil temperature, good soil moisture, and a relative humidity of 49 percent.

Crop injury was minor this year. There did appear to be a rate response, with injury increasing as use rate increased. However, there was no difference in injury between the two formulations. As last year, Basagran appeared to reduce the degree of injury associated with bromoxynil treatments. However, it is difficult to assess this trend. The 0.25 ai rate was used in the tank-mix. The same rate applied alone failed to demonstrate significant injury. None of the treatments evaluated resulted in significant yield reductions.

Connect Mint Study

HERBICIDE	APPLIC. RATE	CROP INJURY		FRESH WEIGHT	DRY WEIGHT
		6-6	6-19	7-7	
		%		TONS/ACRE	TONS/ACRE
BUCTRIL	0.25 LB A/A	1.7	0.0	15.37	4.05
BUCTRIL	0.50 LB A/A	8.3	0.0	17.55	4.62
BUCTRIL	0.25 LB A/A	0.0	0.0	19.38	5.10
BASAGRAN	1 QT/A				
UAN	2 QT/A				
TADS	0.25 LB A/A	1.7	0.0	18.46	4.86
TADS	0.50 LB A/A	5.0	0.0	18.65	4.91
TADS	0.25 LB A/A	0.0	0.0	18.14	4.78
COC	1 % V/V				
TADS	0.50 LB A/A	8.3	0.0	18.14	4.78
COC	1 % V/V				
TADS	0.25 LB A/A	0.0	0.0	17.02	4.48
COC	1 % V/V				
BASAGRAN	1 QT/A				
UAN	2 QT/A				
CHECK			0.0	18.96	4.99
LSD (P=.05)		4,7	0.0	3.0	0.8
Standard Deviation		2.7	0.0	1.7	0.5
CV		99	0.0	10	10
Replicate F		0.452	0.0	10.354	10.360
Replicate Prob (F)		0.6448	1.0	0.0015	0.0015
Treatment F		5.179	0.0	1.471	1.472
Treatment Prob (F)		0.0031	1.0	0.2472	0.2468

Dry weight calculated as 26.34 % of harvest sample (shrink calculation mean of four samples)

Prowl Spearmint Study

The study, conducted on spearmint, *Mentha spicata* (L.), was located at the NWARC station field R-4. The soil consisted of a Creston Silt Loam with a pH of 7.5 and organic matter of 3.5 percent. Plots were 10 X 15 ft with three replications in a randomized complete block design.

The study area was over-seeded on October 4, 1999 with redroot pigweed, *Amaranthus retroflexus* (L.), and green foxtail, *Setaria viridis* (L.) Beauv. Dormant fall applications were applied on October 26, 1999 at 2:00 p.m. with a wind speed of three MPH, an air temperature of 54° F, 48° F soil temperature, good soil moisture, and a relative humidity of 70 percent. Dormant spring applications were applied on March 24, 2000 at 1:00 p.m. The dormant spring application day had a wind of three mph, 48° F air temperature, 52° F soil temperature, good soil moisture, 45 percent cloud cover and a relative humidity of 52 percent. Treatments were applied with a CO_2 backpack sprayer in 20 gallons of water per acre. Teejet XR11002 nozzles, spaced 20 inches apart, were used for all applications.

Although weeds were seeded into the area, weed pressure was minor, preventing an assessment of treatment efficacy. Crop injury was not observed with any of the treatments. There were no significant differences in either fresh or dry mint hay yields. These results indicate that Prowl can safely be used prior to the labeled pre-harvest interval.

Prowl Spearmint Study

HERBICIDE	APPLICATION RATE	APPLICATION TIMING	FRESH WEIGHT 7-7 TONS/ACRE	DRY WEIGHT TONS/ACRE
PROWL	0.825 LB AI/A	FALL	14.45	4.66
PROWL	1.5 LB AI/A	FALL	14.68	4.74
PROWL	2 LB AI/A	FALL	14.89	4.80
SINBAR	1.25 LB PR/A	FALL	16.11	5.20
PROWL	0.825 LB AI/A	SPRING	14.22	4.59
PROWL	1.5 LB AI/A	SPRING	14.12	4.56
PROWL	2 LB AI/A SPRING	SPRING	15.14	4.88
SINBAR	1.25 LB PR/A	SPRING	15.23	4.92
CHECK	NA		15.94	5.14
LSD (P=.05)			3.1	0.8
Standard Deviation			1.8	0.5
CV			10	10
Replicate F			2.475	2.475
Replicate Prob (F)			0.1157	0.1158
Treatment F			0.688	0.688
Treatment Prob (F)			0.6971	0.6971

Spartan Mint Tolerance Study

The study, conducted on spearmint, *Mentha spicata* (L.), was located at the NWARC station field R-4. The soil consisted of a Creston Silt Loam with a pH of 7.5 and organic matter of 3.5%. Plots were 10 X 15 ft with 3 replicates in a randomized complete block design.

The herbicides were applied to dormant spearmint on March 24 at 1:00 p.m. with a CO_2 backpack sprayer in 20 gallons water per acre. Teejet XR11002 nozzles spaced 20 inches apart and an operating pressure 30 psi were used for applications. The application day had a 3 mph wind, 48° F air temperature, 52° F soil temperature, good soil moisture, 45 % cloud cover and a relative humidity of 52 %.

There were no visible injury symptoms present. Although it was not significant, mint fresh and dry weights tended to decline as the rate of Spartan increased. However, it appears that either the 0.141 or 0.094 rate would provide an acceptable level of crop tolerance. Spearmint is generally more susceptible to herbicide injury as compared to peppermint. Therefore trials on peppermint are advised.

HERBICIDE	APPLIC. RATE	FRESH WEIGHT 7-7 TONS/ACRE	DRY WEIGHT TONS/ACRE
SPARTAN	0.094 LB A/A	16.28	4.29
SPARTAN	0.141 LB A/A	15.22	4.01
SPARTAN	0.188 LB A/A	14.53	3.83
CHECK	NA	17.90	4.71
LSD (P=.05)		3.1	0.8
Standard Deviation		1.5	0.4
CV		9	9
Replicate F		0.156	0.156
Replicate Prob(F)		0.8592	0.8591
Treatment F		2.805	2.805
Treatment Prob(F)		0.1306	0.1306

Dry weight calculated as 26.34 % of harvest sample (shrink calculation mean of four samples)

Starane Mint Tolerance Study

The study, conducted on spearmint, *Mentha spicata* (L.), was located at the NWARC station field R-4. The soil consisted of a Creston Silt Loam with a pH of 7.5 and organic matter of 3.5 percent. Plots were 10 X 15 ft with three replicates in a randomized complete block design.

The initial herbicide applications were applied to 2-inch spearmint on May 3 at 7:30 a.m. The first application day had no wind, 45° F air temperature, 48° F soil temperature, good soil moisture, 100 percent cloud cover, and a relative humidity of 66 percent. A mist began at 8:30 a.m. for a 15 minute period. The second growth stage, four inches, received herbicides on May 14 at 9:00 a.m. The second application day had no wind, 58° F air temperature, 49° F soil temperature, good soil moisture, 30 percent cloud cover, and a relative humidity of 66 percent. The last growth stage application, six inches, received herbicides on May 22 at 9:00 a.m. The final application day had 0 to 5 mph wind, 62° F air temperature, 58° F soil temperature, good soil moisture, 10 percent cloud cover, and a relative humidity of 49 percent. All herbicide was applied with a CO_2 backpack sprayer in 20 gallons water per acre. Teejet XR11002 nozzles spaced 20 inches apart and an operating pressure of 30 psi were used for all herbicide applications.

Crop injury increased with rate and did not appear to be affected by crop growth stage. Severe symptoms included a gray-blue cast to the foliage, cupping of the upper-most leaves, and stunted growth. Most injury symptoms were transitory with the exception of stunting, which was readily observable up to harvest. Mint fresh and dry weight, as well as oil yields, decreased as rates increased. However, only three treatments produced oil yields significantly less than the nontreated check. These included the 0.375 rate at the 4 and 6-leaf stage and the 0.250 rate when applied at the 4-leaf stage.

Although some injury does occur, yield reductions were noted in only a few treatments. The gains achieved in weed control may offset this injury. Spearmint is generally more susceptible to herbicide injury as compared to peppermint. Therefore trials in peppermint should be investigated as well.

Starane Mint Tolerance Study

HERBICIDE	APPLIC. RATE	GROWTH STAGE	CROP INJURY			FRESH WEIGHT	DRY WEIGHT	OIL
			5-14	6-6	6-19	7-7		
	LBS A/A	INCHES		%		TONS/ACRE	TONS/ACRE	LBS/ACRE
STARANE	0.060	2	20.0	3.3	0.0	15.56	4.10	38.58
STARANE	0.125	2	26.7	10.0	6.7	14.67	3.86	42.51
STARANE	0.250	2	31.7	11.7	8.3	13.93	3.67	33.31
STARANE	0.375	2	36.7	16.7	10.0	13.32	3.51	32.35
STARANE	0.060	4	0.0	0.0	0.0	13.79	3.63	32.71
STARANE	0.125	4	0.7	5.0	1.7	16.48	4.34	37.75
STARANE	0.250	4	0.0	21.7	13.3	13.90	3.66	30.44
STARANE	0.375	4	0.0	41.7	28.3	11.96	3.15	26.94
STARANE	0.060	6	0.0	3.3	0.0	16.40	4.32	41.07
STARANE	0.125	6	0.0	10.0	6.7	15.39	4.05	38.07
STARANE	0.250	6	0.0	23.3	16.7	15.27	4.02	39.09
STARANE	0.375	6	0.7	23.3	28.3	12.81	3.37	30.27
CHECK			0.7	0.0	0.0	16.56	4.36	37.23
LSD (P=.05)			4.2	10.0	9.4	2.4	0.6	6.3
Standard Deviation			2.5	5.9	5.6	1.5	0.4	3.7
CV			28	45	61	10	10	11
Replicate F			4.555	2.030	6.869	9.984	9.846	5.371
Replicate Prob (F)			0.0210	0.1532	0.0044	0.0008	0.0008	0.0118
Treatment F			95.776	12.360	9.683	3.085	3.085	4.767
Treatment Prob (F)			0.0001	0.0001	0.0001	0.0091	0.0091	0.0006

Dry weight calculated as 26.34 % of harvest sample (shrink calculation mean of four samples)

TITLE: **1997 SPEARMINT CULTIVAR/PROPAGATION TRIAL**

PERSONNEL: Leon E. Welty, Professor of Agronomy, MSU, Kalispell, MT
Louise Strang, Research Specialist, MSU, Kalispell, MT

OBJECTIVE: Evaluate new spearmint cultivars / propagation methods for vigor, hay and oil production.

DURATION: 1997-2000

PROCEDURES: Nuclear plants of Native, N-83-5, and Scotch 770 spearmint were provided by the following propagators:

Summit – stem-cut
Starkel – meristem
Lake – nodal

The meristem and nodal tissue propagated material was planted 5/20/97, and the stem-cut material was planted 5/29/97. The entries were planted in a randomized complete block design in 20-ft long plots consisting of 4 rows of 20 plants with 20-inch row spacing.

Stands were rated for occupancy on 5/17/00. All plots were harvested 7/5/00 at the early to mid bud stage and on 9/14/00 at the late bud to mid bloom stage. Harvest method and hay and oil yield calculations were the same as the other mint trials. A.M. Todd Company conducted oil quality analyses.

RESULTS AND DISCUSSION: Scotch 770 had the least vigorous early season growth. N-83-5 and Native produced more vigorous spring stands (Table 1). Propagation method had no significant effect on spring vigor.

At each cutting, Scotch 770 had 48% to 64% higher oil content than Native and its derivative N-83-5 (Table 2). The nodal and meristem propagated Native and Scotch 770 had higher concentrations of oil than the stem-cut propagated. Native and N-83-5 produced significantly more dry matter than Scotch 770. In the second cutting, meristem Scotch 770 produced more oil than the other entries. Scotch 770 produced less oil than Native and N-83-5 in the first harvest and 41% and 26% more oil in the second harvest. There were no differences among propagation sources in the first harvest, but meristem and nodal Native and meristem Scotch 770 produced more oil than the stem cut types of these cultivars at the second harvest. Perhaps Scotch 770's slow establishment prevented it from reaching its production potential until later in the season.

Rust symptoms did not appear this year. Powdery mildew was just showing up by the second cutting. As in the first harvest, Scotch 770 produced the least hay (Table 3). Scotch 770 had 64% higher oil content than the other cultivars and also had the highest oil yield of the three cultivars. The interaction between cultivar and propagation type was significant. There was no effect of propagation source on oil yield of N-83-5. Stem cut Native produced less oil than meristem and nodal Native. Meristem Scotch 770 produced more oil than the non-meristem Scotch.

Total oil yields for 2000 (Table 4) are displayed graphically in Figure 1. The nodal derived plants did not differ significantly in oil yield regardless of cultivar. Scotch 770 meristem produced more oil than the Native lines. Native stem cut produced significantly less oil than stem cutting derived N-83-5 or Scotch 770. Total oil yields from 1997-2000 show significant differences among cultivars and propagation sources (Table 5, Figure 2). Scotch 770 was most productive, followed by N-83-5. Native was the least productive.

Differences in major quality components in first cutting oil are summarized in Table 6a. The spearmint had reached the early budding stage. Scotch 770 had higher carvone and limonene levels than Native or N-83-5. Second harvest oil quality is summarized in Table 6b. The plants were slightly more mature than at first harvest, reflected by higher carvone and lower limonene levels.

Table 1. Occupancy (% of plot covered) of spearmint cultivar/propagation sources on 5/17/00.

	Propagation Source			
Cultivar	Stem cut	Meristem	Nodal	means
Native	86.3	91.3	87.5	88.3
N-83-5	82.5	88.8	86.3	85.8
Scotch 770	43.8	37.5	38.8	40.0
Means	70.8	72.5	70.8	

LSD(0.10) Cultivar: 8.2
Propagation: NS
Interaction: NS

Table 2. Hay yield, oil content, and oil yield of entries at first harvest – 7/5/00.

HAY YIELD (tons/acre)[1/]

	Propagation Source			
Cultivar	Stem cut	Meristem	Nodal	means
Native	2.34	2.46	2.39	2.40
N-83-5	2.38	2.52	2.41	2.44
Scotch 770	1.41	1.45	1.16	1.34
means	2.04	2.14	1.99	

LSD(0.10) Cultivar: 0.15
Propagation: NS
Interaction: NS

OIL CONTENT (%dm)

	Propagation Source			
Cultivar	Stem cut	Meristem	Nodal	means
Native	0.86	0.87	0.97	0.90
N-83-5	0.93	0.87	0.90	0.90
Scotch 770	1.25	1.29	1.46	1.33
means	1.01	1.01	1.11	

LSD(0.10) Cultivar: 0.14
Propagation: NS
Interaction: NS

OIL YIELD (lbs/acre)[1/]

	Propagation Source			
Cultivar	Stem cut	Meristem	Nodal	means
Native	41.2	43.3	51.1	45.2
N-83-5	45.3	42.8	42.9	43.7
Scotch 770	34.7	36.0	32.4	34.3
means	40.4	40.7	42.1	

LSD(0.10) Cultivar: 6.2
Propagation: NS
Interaction: NS

[1/] All spearmints were in the early to mid bud stage on 7/5/00.

Table 3. Hay yield, oil content, and oil yield of cultivars at second harvest – 9/14/00.

HAY YIELD (tons/acre) [1/]

	Propagation Source			
	Stem cut	Meristem	Nodal	means
Native	2.45	2.44	2.40	2.43
N-83-5	2.49	2.64	2.39	2.50
Scotch 770	2.08	2.02	1.75	1.95
Means	2.34	2.37	2.18	

LSD(0.10) Cultivar: 0.18
Propagation: NS
Interaction: NS

OIL CONTENT (%dm)

	Propagation Source			
	Stem cut	Meristem	Nodal	Means
Native	0.91	1.11	1.13	1.05
N-83-5	1.16	1.04	1.21	1.14
Scotch 770	1.54	1.92	1.95	1.80
Means	1.20	1.36	1.43	

LSD(0.10) Cultivar: 0.10
Propagation: 0.10
Interaction: 0.17

OIL YIELD (lbs/acre) [1/]

	Propagation Source			
	Stem cut	Meristem	Nodal	Means
Native	41.5	51.1	53.6	48.7
N-83-5	55.3	52.4	56.8	54.8
Scotch 770	62.6	76.5	67.2	68.8
Means	53.1	60.0	59.2	

LSD(0.10) Cultivar: 4.4
Propagation: 4.4
Interaction: 7.7

[1/] All spearmints were in the early to late bud stage on 9/14/00.

Table 4. Total hay and oil yields from the Spearmint Cultivar/Propagation Trial at Kalispell in 2000.

TOTAL HAY YIELD 2000(t/a)

	Propagation Source			
	Stem cut	Meristem	Nodal	Means
Native	4.79	4.90	4.79	4.83
N-83-5	4.87	5.16	4.79	4.94
Scotch 770	3.49	3.48	2.90	3.29
Means	4.38	4.51	4.16	

LSD(0.10) Cultivar: 0.28
Propagation: NS
Interaction: NS

TOTAL OIL YIELD 2000 (lbs/acre)

	Propagation Source			
	Stem cut	Meristem	Nodal	Means
Native	82.6	94.3	104.7	93.9
N-83-5	100.6	95.2	99.7	98.5
Scotch 770	97.3	108.6	99.5	101.8
Means	93.5	99.4	101.3	

LSD(0.10) Cultivar: NS
Propagation: NS
Interaction: 12.1

Table 5. **Total oil yields 1997-2000 (lbs/acre).**

	Propagation Source			
	Stem cut	Meristem	Nodal	Means
Native	289.2	302.3	333.0	308.2
N-83-5	322.6	319.8	344.3	328.9
Scotch 770	366.3	372.8	410.9	383.3
Means	326.0	331.6	362.7	

LSD(0.10) Cultivar: 16.2
Propagation: 16.2
Interaction: NS

Table 6a. Quality components of 3 spearmint cultivars and 3 propagation types for the first harvest, 2000.

Cultivar	A:Pinene	B:Pinene	Limonene	Cineole	Dihydro-Carvone	Carvone
Stem tip Native	1.0	1.5	12.3	2.1	1.6	55.9
Stem tip N-83-5	1.1	1.5	11.3	2.2	1.1	55.2
Stem tip Scotch 770	1.1	1.6	21.4	1.4	0.7	58.9
Meristem Native	1.1	1.6	12.8	2.3	1.4	53.2
Meristem N-83-5	1.1	1.6	12.5	2.2	1.1	54.0
Meristem Scotch 770	1.1	1.6	18.7	1.2	1.0	61.8
Nodal Native	1.1	1.5	11.8	1.8	1.3	55.0
Nodal N-83-5	1.2	1.6	12.2	2.3	1.3	52.6
Nodal Scotch 770	1.0	1.5	19.8	1.1	1.0	62.0
Mean	1.1	1.6	14.7	1.8	1.2	56.5
LSD (0.10)	NS	NS	1.1	0.2	0.2	2.9
CV(s/mean) x100	7.8	6.7	6.1	8.4	16.0	4.3

Table 6b. Quality components of 3 spearmint cultivars and 3 propagation types for the second harvest, 2000.

Cultivar	A:Pinene	B:Pinene	Limonene	Cineole	Dihydro-carvone	Carvone
Stem tip Native	1.1	1.6	10.1	2.7	2.7	57.07
Stem tip N-83-5	1.0	1.5	9.3	2.8	1.6	58.95
Stem tip Scotch 770	0.9	1.4	16.8	1.8	1.4	64.05
Meristem Native	1.2	1.6	10.4	2.7	2.2	57.06
Meristem N-83-5	1.1	1.5	9.0	2.7	1.4	58.56
Meristem Scotch 770	1.0	1.5	16.8	1.6	1.8	63.98
Nodal Native	1.0	1.4	10.2	2.2	1.5	60.09
Nodal N-83-5	1.1	1.6	10.0	2.8	1.7	58.34
Nodal Scotch 770	1.0	1.4	17.8	1.6	1.7	63.44
Mean	1.0	1.5	12.3	2.3	1.8	60.2
LSD (0.10)	0.1	NS	1.3	0.2	0.3	2.2
CV(s/mean) x100	9.3	8.0	8.7	8.8	14.2	3.0

Analysis by A.M.Todd Co.

Figure 1. Total oil yields for entries in the Spearmint Cultivar/Propagation Trial at Kalispell in 2000.

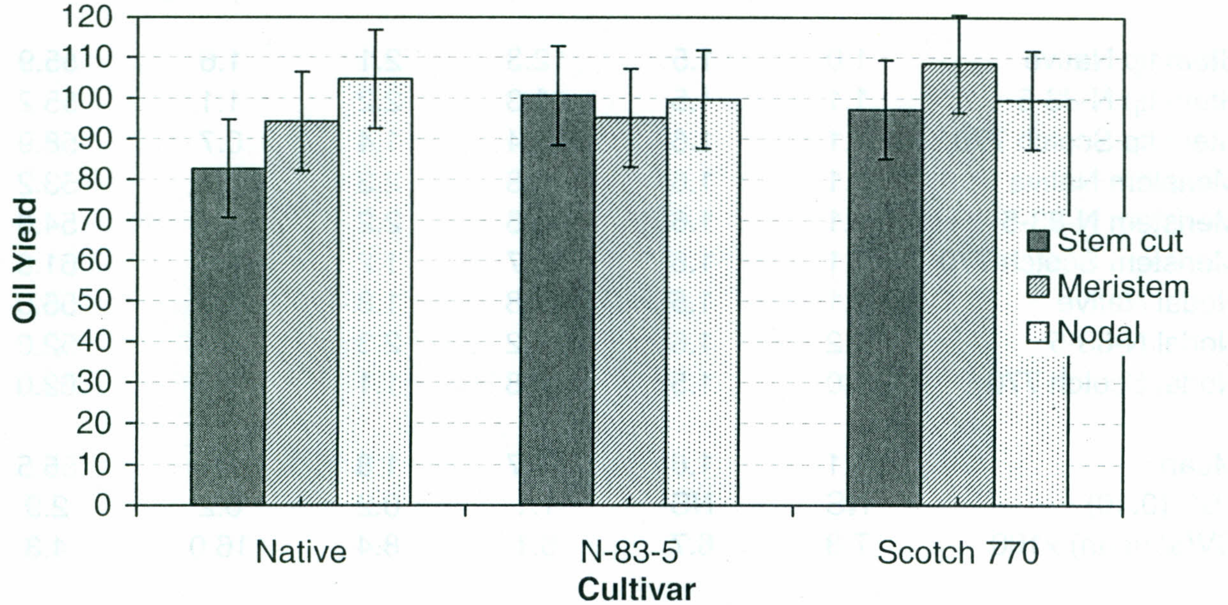


Figure 2. Total oil yields for entries in the Spearmint Cultivar/Propagation Trial at Kalispell from 1997 to 2000.