CONTINUED EVALUATION OF PEPPERMINT VARIETIES AND ADVANCED SELECTIONS IN CENTRAL OREGON'

Fred Crowe, Charissa Yang & Neysa Farris

Abstract

In 1996, the spring stand on all peppermint varieties was excellent. In 1995, the trial area was irrigated more or less as per the needs of Black Mitcham, and other varieties became water stressed and stopped growth prior to harvest. In 1996, the trial area was irrigated more than in 1995, and little or no water stress was observed. In 1996 as in 1995, Black Mitcham grew very little and remained off-color during the extended, cool spring, whereas all other varieties grew very vigorously earlier in the season. By mid- to late June, Black Mitcham began to grow vigorously, and by mid-July it was fully lodged. Other varieties eventually lodged in most plots, but later and less completely than Black Mitcham. The soil in Black Mitcham plots remained much wetter between irrigations than soil beneath other varieties. Whether Black Mitcham used water more efficiently than other varieties, or whether its early lodging prevented evaporation from the soil was not determined. Differences in soil water status is discussed with respect to growth, nitrogen usage, wilt development, and lodging — and with respect to our ability to maintain each variety as per its optimum management and within cost-effective experimental designs. In 1995 and 1996, Black Mitcham frequently performed differently than other varieties, but it could be argued that such differences resulted from different soil moisture status through the growing season, which clearly is related to soil water management input.

Infested plots were not tilled in the fall of 1995 or the spring of 1996 due to excessive precipitation, thus inoculum of V. dahliae did not increase much in 1996 over what was present in 1995. Twice as many seasonal wilt symptoms (or more) occurred on Black Mitcham than other varieties, but this was not enough to result directly in yield losses. Once again, Black Mitcham recorded the highest powdery mildew ratings. 14 percent compared to all varieties, which averaged 0.4 percent on June 14.

Oil and dry hay yields averaged 89 lb/ac and 8,537 lb/ac, respectively, across all varieties, with no statistically significant differences among varieties, with or without the presence of the wilt fungus. As in 1995, Black Mitcham yielded the least dry hay in 1996, but, in contrast to 1995, Black Mitcham was not the highest oil yielding variety in 1996. Oil character for all varieties was not representative of the Madras area, and some significant compositional differences were measured between varieties. These are discussed at greater length below.

Introduction

A well designed field trial was established in central Oregon in 1994, to compare yield, oil character, verticillium wilt tolerance and other noteworthy responses among Mint Industry Research Council sanctioned peppermint varieties and advanced MIRC selections. Comparable field trials (including spearmint) were established in other mint production regions of the United States. Previously, no comparative efforts were conducted for varietal comparisons that could be subjected to statistical analyses.

In central Oregon and in some other locations, varieties were tested both with and without a uniform background of added inoculum of the verticillium wilt fungus, *Verticillium dahliae*. Cultural practices were applied uniformly across the trial, and were considered appropriate for commercial peppermint production in central Oregon. Results from 1995 appear in an earlier report.

Methods

In two adjacent trial areas (main plots), rooted cuttings for six peppermint varieties (sub-plots) received from Plant Technologies Inc. were established during the summer of 1994 in 8.5 ft x 20 ft plots, replicated and randomized within four blocks within each area. Mint growth

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thereafter was maintained within a 10 ft x 20 ft sub-plot area. All individual sub-plots in one of the areas were overseeded with microsclerotia (MS) of *Verticillium dahliae* in the fall of 1994, sufficient to provide 2 MS/g soil in the top 10 cm of each sub-plot. Both areas were rototilled in the fall of 1994, which also re-distributed rhizomes and provided for more uniform plant stand in the spring of 1995. With respect to irrigation, fertility, weed, and pest control, etc., the overall trial was uniformly maintained as per routine mint culture in central Oregon, but great care was taken to avoid cross-contaminating *V. dahliae* into the non-infested trial area. Data on plant growth and performance, oil yield and character, and disease incidence were taken since establishment. Detail of data collection methods is included in the footnotes of accompanying tables.

Results and Discussion

Plots were to be tilled in the fall of 1995 or the spring of 1996 to intensify verticillium wilt and place added disease pressure on all varieties [See companion report "Peppermint performance and wilt incidence, as influenced by selected cultural practices and inoculum density of verticillium wile]. However, consistently wet conditions from fall through spring precluded this operation. Following the mild winter of 1996-96, all varieties had perfect spring stands (data not shown). As in 1995, all other varieties grew very vigorously in the cool, wet spring, whereas Black Mitcham remained without much growth and was visibly stressed during this period. As the spring warmed, Black Mitcham grew vigorously and was highly lodged by the first to second week of July (Table 1). Other varieties grew well through the summer, but lodging was highly erratic for these varieties.

Because we had observed some moisture stress in 1995, the trial area was irrigated more in 1996. Nevertheless, it was determined that percent lodging was correlated with mean soil moisture (r^2=0.68). This suggested variability in soil moisture due to irrigation layout and/or soil texture around the trial area. More noteworthy, soil in Black Mitcham sub-plots was consistently wetter than soil in sub-plots of other varieties ($p<0.08$). We are uncertain at this time whether Black Mitcham might utilize soil moisture more efficiently, or if its early lodging characteristic slowed the amount of evaporation from the soil surface. In 1995, we irrigated somewhat less, and all varieties except Black Mitcham became water stressed prior to harvest. In future years we are left with the difficulty in irrigating Black Mitcham vs. other varieties as per their physiological needs.

Differences in soil moisture among varieties might have several experimentally-undesirable ramifications: Excessive soil moisture early in the season when Black Mitcham is not using water much might possibly increase root infection by *V. dahliae*, whereas excessive moisture later in the season might inhibit wilt symptom development on Black Mitcham compared to other varieties (Geaudreault, Powelson, Cappaert, Christensen and Crowe, 1994). Excessive soil moisture might lead to different patterns of root behavior, nitrogen leaching, and other edaphic characters for Black Mitcham vs. other varieties, which in turn might result in different growth patterns. Excessive soil moisture might directly contribute to early lodging on Black Mitcham. If humidity within the plant canopy encourages powdery mildew activity, excessive soil moisture combined with early lodging might partially account for higher powdery mildew incidence in Black Mitcham compared to other varieties. Unfortunately, as long as the field trials are sprinkler irrigated, it would be cost prohibitive to irrigate varieties on different schedules, or to apply different amounts on the same schedule.

In response to the above observations and concerns, we evaluated data in two ways. First, including Black Mitcham in the analysis, and second, excluding Black Mitcham. In no case did the statistical relationships change among other varieties when Black Mitcham was excluded from the analysis.

Only selected and limited growth data from a few dates are shown in Table 1. By mid-June, Black Mitcham was branching more than other varieties, and its stem length was shorter ($p<0.05$). Lodging proceeded early as in the previous year for Black Mitcham, and later for other varieties. Other varieties lodged more fully in 1996 than in 1995, presumably due to less water stress in 1996. Overall, lodging was not correlated with either stem height or stem weight ($r^2<0.20$).

Powdery mildew was not considered a problem that threatened plant growth or yield in the 1996 plots, but this disease was greater on Black Mitcham than other varieties, which experienced nearly no powdery mildew as a group (Table 1). Although the mean of Black Mitcham seems greater in Table 1, this was not determined to be statistically significant ($p<0.05$).

In the heat of July, verticillium wilt symptoms became abundant. As shown in Table 1, Black Mitcham accumulated significantly more wilt loci (60 per plot) than all other varieties, but these differences were not statistically significant ($p<0.05$). By harvest, Murray had accumulated a mean of 22 wilt loci per infested plot, whereas Todds and Roberts had accumulated a mean of 39.3 and 36.7, respectively, and M-83-7 and T84-5 were intermediate. During July, a somewhat unusual rapid scorch symptom was present only in infested plots, and *V. dahliae* was cultured from most stems. Wilt was not considered to have affected yields in 1996.

Plots were harvested on August 19, 1996. Oil was distilled at the OSU-Corvallis stills. Dry hay yields and oil yields are listed in Table 1. No statistically significant differences were seen among varieties in either infested or non-infested areas of the trial with respect to yields ($p<0.05$). In 1996 as in 1995, Black Mitcham yielded the least dry hay per acre.

Oil composition and character from varieties in the trial are listed in Table 2. The following discussion was abstracted from communications with Norm Rowe, Wm. Leman Co., who performed the analysis of the trial samples. In general, oil from all varieties in the trial was considered out of character for typical "Madras quality." Specifically, in the variety trial for 1996, menthofuran, menthone, esters, and pulegone averaged 8.57, 17.15, 5.63, and 2.27 percent, respectively, whereas the 1996 Madras area averages were near 1.9, 20.7, 4.5 and 1.1 percent, respectively, for these four components. Typical long-term Madras area composition would be near 2.5, 16.6, 4.5 and 1.1 percent, respectively, for these components. These compositions suggest that mint in the trial area was overmature. The excessively high menthofuran is particularly noteworthy. In contrast, the varieties averaged only 36.1 percent menthol, which is considered immature in comparison to "typical Madras oil" that would average near 41.5 percent menthol. The discrepancies in this analysis are not easily explained. In general, mint was harvested with more flower development in 1996 than in 1995, when the trial oil was considered quite immature, but in both years harvest timing was considered to be appropriate after consultation with several local oil buyer representatives. Discrepancies might be due to the nature of distillation from the research stills compared to distillation from commercial stills (Mitchell & Crowe, 1996), to delayed harvest in 1996 associated partly with delayed plant development following a very cool spring, and/or to other plant responses resulting from unspecified weather and trial management in 1996.

As indicated by N. Rowe, common problems with research stills are lower total heads (from mint oil vapor escaping the condenser), associated with excessive steam rate, inadequately sized condenser, or inadequate condenser water flow rate. However, the total heads listed among the variety trial entries was typical for Madras oil. Improper mini-still operation may be reflected in missing high boiling components, but these too were relatively normal. N. Rowe also recommended certain changes in oil handling following distillation and during shipment for analysis.

The variety trial oil compositional data can be compared with oil character for the peppermint oil recovered commercially from the non-test areas of the COARC farm (last row in Table 2), which was commercially harvested and distilled 2 days after the variety trial harvest. This oil was a composite of about 1 part Black Mitcham, 2 parts Murray and parts of the variety trial mixture of varieties, and was also analyzed by Wm. Leman Co. The mint in these areas was located very near to the variety trial (or was part of it). This mint had been managed identically and it was in comparable stages of growth and development except for the 2-day delay. This oil showed a more typical Madras-type composition of menthofuran, esters, and menthol than entrees in the variety trial. But like the variety trial entrees, it was also high in menthone and even higher in pulegone in comparison to typical Madras composition. The most noticeable distinguishable difference between the variety trial and the commercial harvest was for menthofuran: 1.6 percent for the commercial lot (which was perhaps 1/3 oil from the variety trial) vs. 8.57 percent for the variety trial average.

Odor rating was similar for all varieties. Oil compositional analysis indicated that Black Mitcham was substantially different from other varieties -- in Table 2 note differences among total ketones, menthol, and pulegone total ketones, menthol and pulegone components. All varieties seemed to vary with respect to total ketones. Varieties seemed to cluster into two groups with respect to menthofuran, Murray and Roberts were lower than Black Mitcham, Todds, M83-7, and T84-5.

In general, the field trial was managed better in 1996 than in 1995, which was partially reflected in improved yields. Without wilt as a yield-reducing factor, all varieties yielded comparably. As discussed above, we are concerned about the non-uniform soil water differences between Black Mitcham and other varieties, and we believe that Black grows differently and/or uses water differently than other varieties. This may have implications for experimental design and management when trying to compare variety performance.

In addition to seeming varietal variation with respect to irrigation and fertility management as discussed above, it seems apparent that some varieties may require different harvest dates. This may be more true with respect to oil character than yield, but might affect both measurements (White et al. 1987). Detailed data demonstrating this was not collected in 1996. Nevertheless, maturity differences suggest implications for both yield and oil character. For example, in 1996 Black Mitcham seemed to be slightly more advanced in flower development than other varieties, and was more advanced in this respect in 1995. There was probably less difference in leaf maturity (i.e. the proportion of older and younger leaves) in 1996 than in 1995. With higher irrigation in 1996 the other varieties continued to grow and produce new leaves until harvest (in contrast to 1995, in which all other varieties were water stressed and did not produce new growth near harvest), but earlier lodging on Black Mitcham vs. other varieties in 1996 still resulted in some leaf age differences — and there may have been differences among the other varieties.

With the current trial design, it is difficult (but perhaps not impossible) to harvest experimentally on different days with respect to irrigation cut-back so that test plot equipment and commercial equipment can get into each variety as needed. Harvesting on different days influences the timing of other management factors such as post-harvest flaming, irrigation resumption, etc.

We believe field trials to be of very high value in distinguishing among varieties with respect to important characteristics, but feel that further discussion is needed to review feasible, optimum, and cost-effective experimental design and management, including all pre- and post-harvest management of plots, plants, and oil.

References:

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Table 1. Means for Disease, Yield, and Seasonal Growth Ratings for Peppermint Variety Trial, Madras, Oregon, 1996[1]

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Variety	Powdery Mildew[2] (All Plots)	Branched Stems3 (All Plots)	Main Stem Height (All Plots)	Lodging4 (All Plots)	Lodging (All Plots)	Wilt Loci[5] (Non-Infested Plots)	Wilt Loci (Infested Plots)	Dry Hay Yield° (All Plots)	Oil yield[6] (All Plots)
	6/14/96	6/17/96	7/1/96	7/8/96	8/15/96	8/19/96	8/19/96	8/19/96	8/19/96
	%	%	cm		OV[a]	per 200 sq. ft	per 200 sq. ft	lbs/Ac	lb/Ac
Murray	0.3 a[7]	11 a	62 be	68.3 a	89 a	0 a	22.0 a	7,725 a	81 a
Todds	0.3a	11 a	62 bc	68.8 a	86 a	0 a	39.3 a	7,965 a	89 a
Black Mitcham	14.0 b	35 b	54 a	98.3 a	100 a	0 a	60.4 a	6,823 a	87 a
Roberts	0.3 a	17 a	58 ab	72.3 a	94 a	0 a	36.7 a	7,366 a	83 a
M83-7	0.8 a	23 ab	60 ab	59.8 a	82 a	0 a	26.5 a	7,560 a	90 a
T84-5	0.5a	12a	67 c	79.5 a	90 a	0 a	30.0 a	8,537 a	89 a

1. Trial was as two split blocks: a single non-infested area adjacent to another single area infested with 2.0 microsclerotia/g soil of *V. dahliae.* Within infested and non-infested blocks, six varieties were included in a randomized complete block experimental design with four replications. Varieties can be compared within or across infested and non-infested areas, but infested and non-infested comparisons are statistically valid only via variety vs. *+I-V. dahliae* interaction terms.
2. Rating for each plot was determined by averaging the area covered by mildew on the third and fourth leaves from 20 stems per plot.
3. Rating for each plot was determined by averaging the height of 20 stems per plot.
4. Proportion of plot area in which plants were lodged, expressed as a percentage.
5. Wilt ratings were cumulative for each date. Wilt loci are considered a measure of the number of independent systemic infections which developed by the dates shown. Separate infections occurring close to each other (i.e. within 20 cm) could not be distinguished. so actual systemic infection prior to harvest may be underestimated, especially as frequency increases. Not all pre-harvest systemic infection may manifest as wilt symptoms prior to harvest, and systemic infection may continue on fall re-growth after harvest. Wilt infection can lead to enhanced winter damage and possibly to enhanced damage from other stress factors. Winter damage in 1995-96 did not occur, as measured by uniform 100% plant stand ratings (data not shown) for all varieties in both infested and non-infested plot in the spring of 1996 ($p<0.05$).
6. Harvest was on 8/19/96. Dry hay weights were determined from air dried samples of fresh hay harvested. Sub-samples of fresh hay from each plot (approximately 10 lbs.) was allowed to air dry in burlap sacks, prior to distillation at the OSU-Corvallis research stills in late August.
7. Means followed by the same letter are not significantly different, $p<0.05$.

Table 2. Means for Oil Character Ratings for Peppermint Variety Trial, Madras, Oregon, 1996.[1]
Using the Fisher LSD Procedure

	Odor Rating[2] (All Plots)	Total Heads[3] (All Plots)	Total Ketones[3] (All Plots)	Total Menthol[3] (All Plots)	Menthofuran[3] (All Plots)	Menthone3 (All Plots)	Menthol3 (All Plots)	Esters3 (All Plots)	Pulegone3 All Plots)
Variety	Grade Level								
Murray	1.3 a[4]	11.4 a	23.3 b	45.0 a	7.64 ab	17.7 bc	35.3 ab	5.9 a	2.31 be
Todds	1.3 a	11.7 a	22.5 b	45.3 a	8.53 ab	17.2 be	35.7 ab	5.8 a	2.39 bc
Black Mitcham	1.3 a	11.5 a	19.0 a	46.8 a	9.01 b	14.4 a	38.0 c	5.3 a	1.84 a
Roberts	1.0 a	11.8 a	23.1 b	45.7 a	7.34 a	17.9 be	36.7 be	5.2 a	2.10 ab
M83-7	1.1 a	11.3 a	21.7 b	45.4 a	8.91 b	16.1 ab	35.8 ab	5.9 a	2.59 c
T84-5	1.4 a	11.4 a	24.1 b	44.5 a	8.98 b	18.7 be	34.9 a	5.7 a	2.36 be
commercial[5]	ND6	12.8	23.9	47.9	1.6	17.3	39.9	4.2	2.7

1. Trial was as two split blocks: a single non-infested area adjacent to another single area infested with 2.0 microsclerotia/g soil of *V. dahliae.* Within infested and non-infested blocks, six varieties were included in a randomized complete block experimental design with four replications. Varieties can be compared within or across infested and non-infested areas, but infested and non-infested comparisons are statistically valid only via variety vs. *+1-V. dahliae* interaction terms.
2. As per organoleptic analysis, Wm. Leman Co.: 1 = acceptable, 2 = acceptable with modification, 3 = unacceptable.
3. As per chromatographic analysis, Wm. Leman Co.
4. Means followed by the same letter are not significantly different, $p<0.05$. Because Black Mitcham plots were consistently wetter during the season, all data was re-analyzed excluding Black Mitcham, but no new statistical relationships arose among remaining varieties.
5. Oil composition for the commercial harvest and distillation for the parts of three trials on the COARC Madras field which were not included in small test plot harvests. This included 0.1 acre Black Mitcham, 0.2 acre Murray, and 0.15 acre of the above mixed varieties (1/6th each). This composition is included for general comparisons only, and is not included in the statistical analysis.
6. ND = not determined.