Sources of Resistance to *Puccinia menthae* in Mint

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ABSTRACT

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All commercial mint (*Mentha* sp.) cultivars are susceptible to one or more races of rust (*Puccinia menthae*). Mint strains resistant or immune to rust were identified from a 4-yr study of a diverse collection containing 703 accessions. Resistance or susceptibility of the host did not change during the study and mint strains identified as immune in 1976 remained so through 1979. Strains of *Mentha arvensis, M. citrata, M. aquatica*, and *M. rotundifolia* had the highest degree of resistance and possess other characteristics important to a mint breeding program.

Rust on mint (*Mentha* sp.) caused by *Puccinia menthae* Pers. causes severe crop losses. The disease is more severe in some geographic areas than others, but it has reduced yield in all mint-growing areas (1,6). The fungus is autoecious, full cycle and occurs on many species and genera of the Labiatae (1,2,10).

The biotypes that infect peppermint (*M. piperita* L.) are not pathogenic on cv. Native spearmint (*M. spicata* L.), and rust that infects Native spearmint does not infect peppermint. Scotch spearmint (*M. cardiaca* (S. F. Gray) Baker) is susceptible to both the peppermint and spearmint biotypes (1,3). Previous research has shown the existence of physiologic races of the fungus. The number of races varies from six (9), nine (2), or at least 15 (1) and appears to be related to the number and genetic diversity of the host clones.

In the Midwest, spearmint rust occurs in Michigan, Wisconsin, and Indiana where both peppermint and spearmint are grown. Spearmint and peppermint are grown in the Yakima Valley of Washington, but rust is important only on spearmint because high summer temperatures are lethal to the peppermint rust strain (4). Only peppermint is grown commercially in the Willamette Valley of Oregon, and rust causes severe damage every year unless control measures are taken. Excellent control is achieved by flaming the initial spring growth sometime between 10 April and 15 May (5). Flaming eliminates teliospores on soil and plant debris along with rust-infected leaves and susceptible plant tissue, thus breaking the life cycle of the fungus at a critical time when aeciospores must infect leaves or perish.

Fall or early spring plowing that buries the teliospores controls rust but causes rapid spread of mint wilt caused by *Verticillium dahliae* Kleb. (5,8). Thus, because of the potential crop damage inherent with the rust disease, Willamette Valley mint growers flame fields in early spring. The cost of flaming has increased with rising petroleum costs and more than 1 million gallons of propane are consumed each spring.

A USDA-SEA-AR-supported mint breeding program to improve peppermint and spearmint was started in 1978 in cooperation with Oregon State University. The purpose of this study was to evaluate the mint collection for rust resistance and to identify germ plasm for use in the breeding program.

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MATERIALS AND METHODS

More than 700 entries in a mint germ plasm collection maintained by USDA-SEA-AR and Oregon State University at Corvallis were exposed to natural inoculum and evaluated for rust resistance from 1976 through 1979. Each entry was maintained in a 1-m^2 plot with a 1.5-m fallow area on each side.

The collection was established at a new site every 3 yr by planting vegetative cuttings from old plots. The 1976-1977 data were collected from plots established in 1975 and the 1978-1979 data from plots established in 1978. Several strains succumbed to other diseases or lacked the ability to adapt to the area (Tables 1 and 2). The plots were replanted for continued rust evaluation and preservation.

Spring rains supplied moisture until mid-June when sprinkler irrigation was begun and continued at 7- to 10-day intervals through the growing season. The plots were fertilized with 220 kg/ha of a granular 13-13-13 formulation in May and with 140 kg/ha of granular ammonium nitrate in July.

Observations for rust were made in the first weeks of July and September. The rating system used was: 1 = no visible symptoms, 2 = less than 20 pustules per 1-m^2 plot, 3 = up to 20% of the leaves infected, 4 = 21–50% of leaves infected, and 5 = 50–100% of leaves infected. When plants appeared to be immune or highly resistant (rating 1 or 2), the entire plot was surveyed for symptoms. Ratings 1 and 2 were considered immune or highly resistant, respectively, whereas 3, 4, and 5 were considered susceptible.

RESULTS AND DISCUSSION

Rust developed to epidemic proportions on the more susceptible strains of the mint germ plasm collection each year of the study (Tables 1 and 2). The disease defoliated susceptible strains in 1978, and the plots were flamed in 1979 because the spring growth was heavily infected. This delayed disease development as indicated by July 1979 ratings compared with July ratings of previous years (Table 1); but by September, rust was severe. Flaming did not control rust in the genetically diverse collection probably because late emerging strains provided susceptible tissue for aeciospore infection.

None of the commercial cultivars was immune, as indicated by the mean September ratings. These same ratings indicate Murray Mitcham and Todd's Mitcham peppermint to be resistant, but each cultivar was rated as high as 3 at least once. Strains 10, 13, 14, and 15 of *M. piperita* consistently had ratings of 2 or less. *M. spicata* 'Native' and *M. cardiaca* 'Scotch' spearmint and all strains of the two species were susceptible. Several strains of *M. arvensis* were immune or highly resistant to rust, but cultivars of the species were not. Cultivars Japanese Arvensis, Northern Progress, and Brazil Arvensis were susceptible to rust, each receiving ratings of 3 or 4 during the study.

Reactions to rust by mint species identified as valuable germ plasm for reasons other than disease resistance are presented in Table 2. Of these, *M. rotundifolia, M. aquatica*, and *M. citrata* offer the most promising genetic source of rust resistance and immunity. Only four of 12 *M. rotundifolia* strains had ratings higher than 1, and the highest of any strain was 2. The other eight strains were immune to rust throughout the study. Six of 11 strains of *M. aquatica* were immune, and the highest rating received by five others was 2. Strains of *M. citrata* never received ratings higher than 2; three strains were recorded as immune.

This study confirms that immune and highly resistant strains of *Mentha* sp. exist and also indicates that host resistance or susceptibility to rust did not change during the 4-yr study. Rust immunity or resistance in mints may be stable and longer lasting than rust resistance bred into other crops. The presence of genetic diversity and a broad genetic base created by natural hybridization between species of *Mentha* subgenus *Menthastrum* (7) contribute to this

Table 1. Reaction of commercial mint cultivars (*Mentha* sp.) and strains to rust (*Puccinia menthae* Pers.) at Corvallis, OR

Mentha species	1976		1977		1978		1979		$\bar{x}$ of
Cultivar or strain	July	Sept.	July	Sept.	July	Sept.	July	Sept.	Sept.
M. spicata									
Native spearmint	2[a]	4	3	3	3	4	1	4	3.75
1	3	4	3	3	3	4	1	4	3.75
2	2	2	3	2	2	5	1	4	3.25
3	2	2	3	3	2	5	1	4	3.50
4	2	3	4	3	2	5	1	4	3.75
5	2	2	3	4	2	5	1	4	3.75
6	3	3	4	4	2	5	2	4	4.00
7	2	2	2	3	2	4	1	2	2.75
8	2	2	4	1	3	5	2	5	3.25
9	3	3	4	4	3	5	1	5	4.25
10	3	3	4	4	3	5	2	5	4.25
11	2	3	2	3	3	3	1	3	3.00
12	2	2	3	4	2	5	1	4	3.75
13	2	2	3	3	2	5	2	5	3.75
14	3	3	4	4	3	5	2	5	4.25
15	3	3	3	4	3	5	1	5	4.25
16	3	3	3	4	3	5	1	5	4.25
17	3	3	4	4	3	5	1	4	4.00
18	2	3	3	4	2	5	1	4	4.00
19	2	3	3	4	2	5	1	4	4.00
20	2	2	2	2	3	3	1	3	2.50
M. cardiaca									
Scotch spearmint	1	1	2	2	1	3	2	3	2.25
1	2	2	2	2	1	2	1	4	2.50
2	3	4	4	3	2	5	1	4	4.00
3	3	4	3	3	2	5	1	2	3.50
4	3	3	2	3	2	5	1	3	3.50
M. piperita									
Mitcham	2	2	2	1	1	5	1	4	3.00
Murray Mitcham	2	2	2	1	1	3	2	2	2.00
Todd's Mitcham	2	2	2	1	2	2	2	3	2.00
1	2	2	1	2	2	5	2	4	3.25
2	2	2	2	1	2	4	2	3	2.50
3	2	3	4	1	2	3	1	3	2.50
4	2	3	4	1	2	3	2	2	2.25
5	2	2	2	1	2	3	2	2	2.00
6	2	2	2	1	1	4	2	2	2.25
7	2	2	2	1	1	3	2	2	2.00
8	2	2	2	1	1	3	1	2	2.00
9	2	2	2	1	2	3	2	2	2.00
10	2	2	2	1	2	2	2	2	1.75
11	2	2	2	1	1	3	1	2	2.00
12	2	2	2	1	1	3	2	2	2.00
13	2	2	2	1	1	2	1	2	1.75
14	2	2	2	1	2	2	1	2	1.75
15	2	2	2	1	1	2	1	2	1.75
M. arvensis									
Japanese Arvensis	2	2	4	3	2	4	...	...	3.00
Northern Progress	2	2	2	2	2	4	1	3	2.75
Brazilian Arvensis	2	2	2	3	2	...	1	3	2.67
1	2	2	1	1	1	3	1	2	2.00
2	...[b]	...	1	1	1	...	1	1	1.00
3	1	1	1	1	1	...	1	1	1.00
4	1	1	1	1	1	...	1	1	1.00
5	2	2	1	1	1	1	1	1	1.25
6	2	1	1	1	1	...	1	...	1.00
7	1	1	1	1	...	...	1	1	1.00
8	1	1	1	1	...	...	1	1	1.00
9	1	1	1	1	1	...	1	1	1.00
10	1	2	1	1	1	1	1	1	1.25
11	1	1	1	1	1	1	1	1	1.00
12	2	1	1	1	1	1	1	1	1.00

[a] 1 = no symptoms, 2 = less than 20 pustules per 1-m^2 plot, 3 = up to 20% of the leaves infected, 4 = 20–50% of leaves infected, and 5 = 50–100% of leaves infected.

[b] ··· = cultivar died from other diseases or could not adapt to the area.

Table 2. Reaction of *Mentha* species to rust (*Puccinia menthae* Pers.) at Corvallis, OR

***Mentha* species**	**1976**		**1977**		**1978**		**1979**		**$\bar{x}$ of**
Strain	**July**	**Sept.**	**July**	**Sept.**	**July**	**Sept.**	**July**	**Sept.**	**Sept.**
M. rotundifolia									
1	2[a]	2	1	1	1	1	1	1	1.25
2	1	1	1	1	1	1	1	1	1.00
3	1	1	1	1	1	1	1	1	1.00
4	2	2	1	1	2	1	1	1	1.25
5	1	2	1	1	1	1	1	1	1.25
6	1	2	1	1	1	1	1	1	1.25
7	1	1	1	1	1	1	1	1	1.00
8	1	1	1	1	1	1	1	1	1.00
9	1	1	1	1	1	1	1	1	1.00
10	1	1	1	1	1	1	1	1	1.00
11	1	1	1	1	1	1	1	1	1.00
12	1	1	1	1	1	1	1	1	1.00
M. longifolia									
1	2	2	2	2	2	3	1	3	2.50
2	2	2	2	2	2	3	2	3	2.50
3	2	3	3	2	2	4	1	3	3.00
4	2	2	2	2	2	3	1	2	2.25
5	2	2	2	2	1	2	1	2	2.00
6	1	3	2	3	2	3	2	3	3.00
M. niliaca									
1	2	3	2	2	2	5	1	4	3.50
2	2	3	2	2	2	5	1	4	3.50
3	2	3	2	2	2	4	1	4	3.25
4	3	3	3	3	2	4	2	4	3.50
5	2	3	2	3	2	4	2	4	3.50
6	2	2	2	2	2	4	1	4	3.00
7	2	2	2	2	2	4	2	4	3.00
8	2	2	2	3	2	4	2	4	3.25
9	2	2	2	2	2	4	2	4	3.00
10	2	2	2	3	2	...	2	4	3.00
11	2	3	3	3	3	4	3	5	3.75
M. aquatica									
1	1	1	1	1	1	...	1	1	1.00
2	2	2	1	1	1	1	1	1	1.25
3	1	1	1	1	1	...	1	1	1.00
4	2	2	1	1	1	1	1	1	1.25
5	1	1	1	1	1	1	1	1	1.00
6	2	2	1	1	1	...	1	1	1.34
7	2	2	1	1	...[b]	...	1	1	1.34
8	1	1	1	1	...	1	1	1	1.00
9	1	1	1	1	...	1	1	1	1.00
10	2	2	1	1	1	2	1	2	1.75
11	1	1	1	1	1	...	1	1	1.00
M. citrata									
1	2	2	1	1	1	1	1	1	1.25
2	1	1	1	1	1	1	1	1	1.00
3	1	2	1	1	1	1	1	1	1.25
4	2	2	1	1	1	1	1	1	1.25
5	2	2	1	1	1	1	1	1	1.25
6	2	2	1	1	1	1	1	1	1.25
7	2	2	1	1	1	1	1	1	1.25
8	2	2	1	1	1	1	1	1	1.25
9	1	1	1	1	1	1	1	1	1.00
10	1	1	1	1	1	...	1	1	1.00

[a] 1 = no symptoms, 2 = less than 20 pustules per 1-m^2 plot, 3 = up to 20% of the leaves infected, 4 = 20–50% of leaves infected, and 5 = 50–100% of leaves infected.

[b] ... = cultivar died from other diseases or could not adapt to the area.

stability. *M. piperita, M. niliaca*, and *M. cardiaca* are recognized as natural hybrid species with pedigrees of *M. aquatica* × *M. spicata, M. spicata* × *M. rotundifolia*, and *M. arvensis* × *M. spicata*, respectively.

Even though we identified rust resistance in several different species, it should be possible to combine the genetic sources of resistance into new cultivars by interspecific hybridization. Interspecific hybridization offers a means of breeding for rust resistance while broadening the genetic base of the crop.

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