Pathogenic Variability in *Plasmopara halstedii* in Western Canada

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Downy mildew in sunflower is a worldwide disease caused by the fungus *Plasmopara halstedii* (Farl.) Berl. & de Toni. This fungus can survive in the soil for several years. Conditions of high soil moisture and low temperature of 15-18 C at the seedling stage are favorable for disease development. Until recently, the north American race (Race 2) of *P. halstedii* dominated the fungus population in the Red River valley of the United States and Canada. The development and introduction of sunflower hybrids with resistance to race 2 have resulted in a steady decline of the incidence of downy mildew in USA and Canada in recent years. New races of *P. halstedii* have been identified over the years (Carson 1981, Gulya & Urs 1985, Gulya et.al. 1991, Rashid 1993). Several new races are virulent on all commercial sunflower hybrids in north America.

Materials and Methods

Downy mildew infected leaves were collected from infested fields surveyed from 1988 to 1997. Zoosporangia collected from single infected plants were increased on the susceptible cultiva Peredovik and constituted the individual isolates. Each isolate was tested on a set of sunflower differential inbred lines (Gulya et al. 1991) which are characterized by uniform reaction to the seven *P. halstedii* races in north America (Table 1). Three-day old seedlings of each inbred line were inoculated by immersion for 3 hr in an aqueous spore suspension of 20,000 zoosporangia per ml. The inoculated seedlings were transplanted into wooden flats with a 1:1 mixture of sand and perlite, and were kept in a growth cabinet for 14 days at 20/18 C of day-night temperature and a 16 hr photoperiod. After 14 days, the flats were incubated overnight at 100 % relative humidity to enhance sporulation of the fungus. Susceptibility was assessed on the basis of the presence of sporulating fungus on the leaves, and hybrids were characterized as resistant or susceptible based on the percentage of resistant/susceptible plants (Rashid, 1993).

Results

Races 3 and 4 were identified as early as 1988 and were the only races identified in the 1988 and 1989 *P. halstedii* collections (Rashid, 1993). Races 3 and 4 were predominant in the 1990-91 collections of isolates (Tables 2-3). However, a few isolates were identical to races 3 or 4 and most isolates had variable reaction on one or two differential inbred lines, different from the typical reaction of races 3 or 4. Races 2, 6 and 7 were found at low frequencies among the fungus population in 1990-91 (Rashid, 1993).

Table 1. Reaction of sunflower differentia inbred lines to seven races of *P. halstedii*

Inbred	Races						
Line	1	2	3	4	5	6	7
DM-2	R	R	R	S	S	S	S
DM-3	R	R	R	S	S	Sg	Sg
HA300	S	S	S	S	S	S	S
HA337	R	R	R	R	R	R	R
HA340	R	R	R	R	R	R	R
RHA266	R	S	S	S	S	S	S
RHA274	R	R	S	S	S	R	R
RHA325	R	R	S	S	S	S	R
PERED.	S	S	S	S	S	S	S

S= susceptible; R= resistance; Sr= predominantly susceptible; Rs= predominantly resistant; SR= mostly susceptible; RS= mostly resistant.

Table 2. Reaction and predominant races among isolates of *P. halstedii* from the eastern Canadian prairies in 1990

Differential	Reaction of groups of collections*						
lines	I	II	III	IV	V	VI	VII
HA 300	S	S	S	S	S	S	S
RHA 266	S	S	S	S	S	S	S
RHA 274	S	S	S	S	S	R	R
DM-2	R	R	Rs	S	Rs	Rs	R
DM-3	R	Rs	Rs	S	S	S	Rs
RHA 325	nt	S	nt	nt	S	R	nt
RHA 340	R	R	R	R	R	R	R
Designated race*	3	3	3	4	4	2	2
Mixed with		6/7	4/6/7		3/6	3/7	6/7
No. of isolates	1	4	1	4	1	1	2

R = resistant; Rs = mostly resistant with a few susceptible plants; S = susceptible; nt = not tested.

* The R/S reactions indicate those of the designated main race, while the Rs reaction may indicate the mixed race(s) in each collection. From Rashid (1993)

Table 3. Reaction and predominant races among isolates of *P. halstedii* from the eastern Canadian prairies in 1991

Differential	Reaction of groups of collections[‡]											
lines	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
HA 300	S	S	S	S	S	S	S	S	S	S	S	S
RHA 266	S	S	S	S	S	Sr	S	Sr	S	S	S	R
RHA 274	S	S	S	S	Sr	Sr	S	Rs	R	Rs	R	R
DM-2	R	R	Rs	S	S	S	Sr	Sr	R	Rs	S	S
DM-3	R	Rs	Rs	S	S	S	Sr	Sr	Rs	Rs	S	Sr
RHA 325	nt	S	S	S	S	S	S	Sr	S	S	S	S
RHA 340	R	R	R	R	R	R	R	R	R	R	R	R
Designated												
Main race	3	3	3	4	4	4	4	4	2	2	6	6
Mixed with		6/7	4/6/7		6	1/6	3	1/2/7	3/6	3/4/6		1/7
#of isolates	5	13	1	9	2	1	2	1	3	2	2	1

R= resistant; Rs = resistant with a few susceptible plants; S = susceptible; Sr = susceptible with a few resistant plants; nt = not tested. The R/S reactions indicate those of the designated main race, while the Rs and Sr reactions may indicate the mixed race(s) in each collection. From Rashid (1993).

Table 4. Reaction and predominant races among isolates of P. halstedii in 1994, 1996, and 1997.

Inbred	1994 Isolates/Races					1996 Isol./Races				1997 Isol./Races		
Diff	4/6	3/6	6/4	2	4	2/7	7	6	2/6	2/1	7	1
DM-2	S	Rs	S	R	S	R	S	S	R	R	Sr	R
DM-3	S	RS	S	R	S	S	S	S	S	Rs	S	R
HA300	S	S	S	R	S	S	S	S	S	S	Sr	R
HA337	R	R	R	R	R	R	R	R	R	R	R	R
HA340	R	R	R	R	R	R	R	R	R	R	R	R
RHA266	Sr	SR	Sr	Rs	S	S	S	S	S	Rs	Sr	Rs
RHA274	SR	RS	RS	R	S	Rs	R	S	S	R	Rs	Rs
RHA325	S	S	S	Rs	S	R	Rs	Rs	R	R	R	R
PERED.	S	S	S	Rs	S	S	S	S	S	S	S	R
Total	12	3	4	1	1	1	3	4	2	1	1	1

R= resistant; Rs = resistant with a few susceptible plants; S = susceptible; Sr = susceptible with a few resistant plants; nt = not tested. The R/S reactions indicate those of the designated main race, while the Rs and Sr reactions may indicate the mixed race(s) in each collection.

Downy mildew was prevalent in 94 % of sunflower fields in southern Manitoba in 1994 with severity ranging from trace to 60 % infection (Rashid and Platford, 1995). Race 4 was predominant in 62 % of the 21 isolates collected in 1994, while race 6 was predominant in 19 % of the isolates (Rashid 1995). Races 3, 2 and 1 were less frequent among the isolates collected in 1994. Most isolates had variable reaction on one or two differential inbred lines, different from the typical reaction of the designated races (Table 4).

In the 1996 collection of isolates, Race 6 was present in 6 isolates while race 7 was present in 4 isolates and race 2 in three isolates (Table 4) Among the few isolates in 1997 only races 1, 2 and 7 were identified. There was no evidence of races 3 or 4 in 1996 and 1997. This perhaps is due to the low incidence and severity of downy mildew in these two years and the limited collections of isolates.

The results from the race mapping of the fungus population during the last 9 years in 1994 seems to indicate a general low frequency of races 1 and 2 in the eastern Canadian Prairies, and an increased frequency of races 3, 4, 6 and 7. This confirms the change in virulence in the population of *P. halstedii* towards races 3, 4, 6 and 7.

Acknowledgement

The technical assistance of L.J. Wiebe and generous seed supply by Tom J. Gulya are gratefully acknowledged.

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