Downy Mildew Incidence on Pearl Millet Cultivars and Pathogenic Variability among Isolates of *Sclerospora graminicola* in Rajasthan

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Introduction

Downy mildew (DM), caused by *Sclerospora graminicola* (Sacc.) Schroët, is the most important and widespread biotic constraint to the sustained high productivity of pearl millet [*Pennisetum glaucum* [(L.) R. Br.] hybrids in India. The fungus, *S. graminicola*, is an obligate heterothallic oomycetes (Michelmore et al. 1982) that reproduces by both sexual (oospores) and asexual (zoospores) means and thus produces large genetic variability in the progenies. Because of this large genetic variability in the pathogen, several host-specific pathotypes have been identified (Thakur and Rao 1997; Thakur et al. 2003). Rajasthan is one of the major pearl millet growing states in India and during the past 5 years increased DM incidence has been reported in several of the commercial hybrids. Under the ICAR-ICRISAT partnership project, on-farm surveys for DM incidence were conducted in the major pearl millet growing districts of Rajasthan during the 2001–2004 rainy seasons. Studies were also conducted to understand virulence diversity in *S. graminicola* populations especially from western Rajasthan.

Materials and Methods

On-farm downy mildew survey. Roving field surveys were conducted during the four rainy seasons of 2001 to 2004 covering 585 pearl millet fields in 52 taluks (a revenue unit) of 16 districts of Rajasthan (Alwar, Barmer, Bikaner, Churu, Dhaulpur, Dausa, Hanumangarh, Jaipur, Jalore, Jhunjhunun, Jodhpur, Karauli, Nagaur, Pali, Sikar and Tonk). In each field, five random subplots (four at the corners and one in the middle) were selected, and within each subplot, a minimum of 50 plants were counted in 2–3 rows to record diseased and healthy plants. The sum totals of healthy and diseased plants from 5 subplots of each field were used to determine the DM incidence percent. Thirty-seven DM-infected leaf samples as oosporic isolates from highly susceptible (>20% incidence) hybrids and the local cultivars were collected to study their pathogenicity and virulence diversity.

Pathogenic variability. Sporangial inocula were raised on seedlings of a highly susceptible genotype 7042S in isolation chambers in a greenhouse from the 12 selected isolates obtained from four districts (Barmer – 4, Bikaner – 1, Churu – 2 and Jodhpur – 5) of western Rajasthan and three controls (one isolate each from Jodhpur, Durgapura and Patancheru). Pot-grown 48h-old seedlings of seven pearl millet differential lines (IP 18292, IP 18293, P 7-4, P 310-17, 700651, 852B and ICMP 451) were spray-inoculated with sporangial suspension (1×10^6 sporangia mL^{-1}) of each of the above 15 isolates. The experiment was conducted in a completely randomized design with three replications, 100 seedlings per replication. Data were recorded for disease incidence 14 days after inoculation. The experiment was repeated once to confirm the results.

Data analysis. Data sets were subjected to ANOVA to determine significant differences among different isolates for DM incidence. The DM incidence data from two experimental runs were subjected for homogeneity test using the F-test of significance before pooling them. The DM incidence was subjected to hierarchical cluster analysis using the average linkage method with Euclidian distances to classify the pathotypes.

Results and Discussion

Downy mildew incidence. Of the 585 pearl millet fields surveyed in 16 districts, 59% of these showed DM infection. The mean DM incidence across pearl millet cultivars over four seasons varied from low to moderate (1–21%) in 14 districts, and no DM was recorded in Alwar and Karauli districts (Table 1).

A total of 26 hybrids, one open-pollinated variety (ICTP 8203), and several unknown cultivars were observed during the 4-year surveys. Of the 26 hybrids, only 9 were common in 2–3 years, and six of these (Pusa 23, JKBH 26, Proagro 9444, Pioneer 7688, PAC 931 and HHB 67) were highly resistant with mean DM incidence of ≤ 5% compared with 2–56% incidence on ICMH 451 (Table 2). Thirteen hybrids (Bioseed 8448, GS 7788, ICMH 356, Kaveri 434, MLBH 319, MRB 2210, Nandi 5, VBMH 304, Pioneer 83M54, Proagro 7701, Pusa 23, Sona 288 and Swaminath) grown in any one season were DM-free, while the remaining five hybrids (VF 4112, Eknath 301, MLBH 308, PG 5822 and BK 560) also grown in one season were susceptible with 12 to 76%

mean incidence. ICTP 8203 recorded 1% mean incidence while locals and unknown varieties showed 3–21% DM. In general, the DM incidence levels were higher in pearl millet hybrids in Sikar, Churu, Jodhpur and Barmer than in other districts. This could be due to more congenial weather conditions prevailing at the seedling stage in the above districts. Hybrids that recorded more than 20% mean DM incidence (highly susceptible) may be considered for withdrawal from cultivation to avoid the occurrence of epiphytotics in the near future.

Pathogenic variability. All the 12 isolates from western Rajasthan were maintained on 7042S through asexual generations. The DM incidence varied from 2 to 100% across isolate × host differential combinations, with mean DM incidence of 15 isolates across host differentials varied from 20 to 81% (data not shown). The quantitative DM incidence data were defined for qualitative resistant (R) reaction (≤ 20% mean incidence) and susceptible (S) reaction (≥ 20% mean incidence) to understand the virulence pattern of the isolates. Based on the R:S ratios across seven host differentials, isolates Sg 384 and Sg 385 from Barmer were most virulent (0R:7S) while some others, such as Sg 138, Sg 145 and Sg 381 from Jodhpur; Sg 382 and Sg 383 from Barmer; and Sg 388 from Churu were also highly virulent (1R:6S) (Table 3). These isolates were more virulent than the control isolates from Jodhpur (Sg 139) that was known to be highly virulent until recently (Thakur et al. 1999). Using hierarchical cluster analysis of the mean disease incidence data, the 15 isolates were classified into five virulence groups (Fig 1). Seven isolates (Sg 138, 381, 382, 383, 384, 385 and 388) belonged to highly virulent group; two (Sg 407 and 409) to virulent group; another two (Sg 139 and 145) to moderately virulent group; and four (Sg 144, 148, 212, and 406) to low virulent group. Two isolates from Barmer (Sg 384 and 385) were more virulent than those from Jodhpur, Churu and Bikaner, and therefore, one of these isolates should be used in resistance screening of breeding lines targeted for western Rajasthan. Collection and evaluation of more isolates from western Rajasthan may be required to better understand their virulence diversity.

Table 1. On-farm pearl millet surveyed for prevalence of downy mildew (DM) in 16 districts of Rajasthan during the 2001–04 rainy seasons.

District	Year	No of fields		DM incidence (%)	
		Surveyed	With DM	Mean	Range
Alwar	2002	17	0	0	0–0
Barmer	2003–04	55	39	15	0–67
Bikaner	2003	13	13	15	0–54
Churu	2003	92	85	21	0–76
Dhaulpur	2002	7	2	1	0–2
Dausa	2002	20	1	1	0–12
Hanumangarh	2003	59	38	2	0–17
Jaipur	2001–02	103	31	5	0–56
Jalore	2002, 2004	9	8	17	0–41
Jhunjhunun	2001	1	1	2	2–2
Jodhpur	2003–04	84	66	14	0–69
Karauli	2002	21	0	0	0–0
Nagaur	2003–04	25	13	5	0–21
Pali	2004	19	7	2	0–17
Sikar	2003	46	38	15	0–78
Tonk	2002	14	2	1	0–10
Total	-	585	344	7	0–78

Table 2. Downy mildew incidence on pearl millet cultivars in farmers' fields in Rajasthan, 2001–2004.

Cultivar	Downy mildew incidence (%)				
	2001	2002	2003	2004	Range
Pusa 23	0 (1)[1]	-[2]	-	0 (1)	0-0
Proagro 9444	-	0 (12)	0 (3)	1 (2)	0-1
Pioneer 7688	0 (16)	1 (27)	-	-	0-1
JKBH 26	2 (7)	0 (35)	-	-	0-2
PAC 931	-	2 (1)	-	0 (1)	0-2
HHB 67	<1 (28)	0 (3)	5 (44)	3 (22)	0-5
Proagro 9330	-	-	10 (1)	0 (1)	0-10
Bioseed 8434	-	5 (3)	11 (4)	21 (5)	5-21
ICMH 451	56 (3)	2 (2)	39 (35)	-	2-56
VF 4112	-	-	12 (3)	-	12
MLBH 308	-	-	21 (1)	-	21
PG 5822	28 (6)	-	-	-	28
Eknath 301	-	-	-	19 (7)	19
BK 560	76 (5)	-	-	-	76
ICTP 8203	-	1 (9)	-	-	1

1. Number of fields.
2. Not found.

Table 3. Differential virulence reactions of 13 isolates of *Sclerospora graminicola* from western Rajasthan on seven host differential lines evaluated in greenhouse during 2004.

Isolate	Location	Cultivar	Downy mildew reactions on host differential lines[1]							
			IP 18292	IP 18293	P7-4	P 310-17	700651	852B	ICMP451	Ratio (R : S)
Sg 138	Jodhpur	Mixture	S	S	S	S	R	S	S	1 : 6
Sg 144	Jodhpur	81A	R	R	R	S	R	S	R	5 : 2
Sg 145	Jodhpur	HB 3	S	S	S	S	R	S	S	1 : 6
Sg 148	Jodhpur	Mixture	S	R	R	R	R	S	R	5 : 2
Sg 381	Jodhpur	OPY 97	R	S	S	S	S	S	S	1 : 6
Sg 382	Barmer	Mixture	S	S	S	S	R	S	S	1 : 6
Sg 383	Barmer	ICMH 451	S	S	S	S	R	S	S	1 : 6
Sg 384	Barmer	Local	S	S	S	S	S	S	S	0 : 7
Sg 385	Barmer	Local	S	S	S	S	S	S	S	0 : 7
Sg 388	Churu	Local	S	S	S	S	R	S	S	1 : 6
Sg 406	Bikaner	Local	R	R	R	R	S	R	S	5 : 2
Sg 407	Churu	Gachri local	R	S	S	S	S	R	S	2 : 5
Sg 139[2]	Jodhpur	Nokha local	S	S	S	R	R	S	S	2 : 5
Sg 212[2]	Durgapura	Plant gene	R	R	R	R	R	R	S	6 : 1
Sg 409[2]	Patancheru	PMB 11571-2	R	S	S	S	S	R	S	2 : 5

1. Based on the mean of 2 experimental runs, 3 replications in each experimental run.
2. Controls.

R (resistant)= ≤20%, S (susceptible)= >20% incidence.

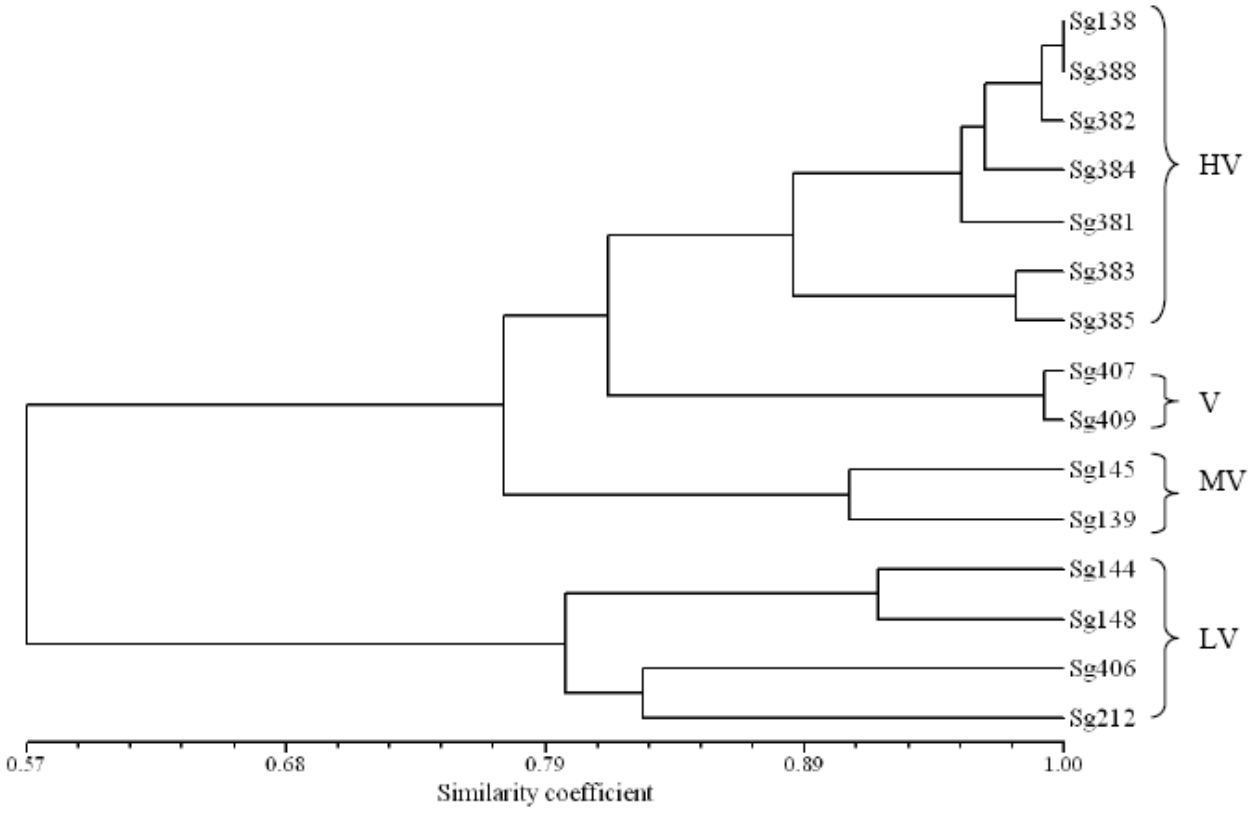

Figure 1. Classification of 15 isolates of *S. graminicola* based on downy mildew incidence on seven host differential lines into highly virulent (HV), virulent (V), moderately virulent (MV) and low virulent (LV) groups.

References

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