Reactions of Pearl Millet Germ Plasm from the World Collection to Maize Dwarf Mosaic Virus Strains A and B

STANLEY G. JENSEN, Research Plant Pathologist, Agricultural Research Service, U.S. Department of Agriculture, and Associate Professor, Department of Plant Pathology, University of Nebraska, Lincoln 68583, DAVID J. ANDREWS, Program Leader and Breeder, Pearl Millet Improvement Program, ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India, and NANCY E. DeVRIES, Research Technician, Department of Plant Pathology, University of Nebraska, Lincoln

ABSTRACT

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Fifty land races and 49 breeder lines of pearl millet (*Pennisetum americanum*) from the world collection at ICRISAT in India were tested for reaction to maize dwarf mosaic virus strains A (MDMV-A) and B (MDMV-B). A small number of plants in 29 entries became infected with MDMV-A and a small number of plants in 58 entries, with MDMV-B. Twenty-five of 29 entries with susceptibility to MDMV-A were also susceptible to MDMV-B. Susceptibility was not related to area of origin. Seventy-six entries from North America showed similar trends, but two highly susceptible lines were identified. Symptoms consisted of a mild mosaic appearing in 7–10 days. In the highly susceptible lines, mosaic symptoms appeared sooner, were more severe, and were accompanied by mild stunting.

Because of its great yield potential and resistance to drought, pearl millet (*Pennisetum americanum* (L.) Leeke) has been of increasing interest around the world, particularly in areas subject to drought stress. When pearl millet is introduced into a new area of the world, the threat always exists of exposing susceptible material to existing pathogens and suffering setbacks in establishing this new crop.

Pearl millet is widely grown in Africa and the Indian subcontinent, where only occasional virus problems have been reported (4,6,7,9). Sorghum grown in these areas is also relatively free from viral problems. Sorghum grown in other parts of the world, however, has had problems with viruses (2,5). Because pearl millet is now being introduced into some areas where viruses of sorghum have been a problem and may pose a significant threat, it is desirable to explore the susceptibility of pearl millet to maize dwarf mosaic virus (MDMV). This virus causes a significant disease in sorghum in the Americas and elsewhere. Reports about the susceptibility of pearl millet to MDMV are limited to studies on experimental infections (1,3).

In a preliminary test with one group of 46 U.S. lines, 21 lines (45%) had some plants infected with MDMV-A and 30 lines (65%) with MDMV-B. Two of these lines were highly susceptible to both strains, with most plants being infected. In response to infection by either strain, a severe mosaic and mild stunting developed in 5–7 days. In a second group of 30 lines, only seven could be infected with MDMV-B and none with MDMV-A. These results suggested that a broader investigation would be in order.

MATERIALS AND METHODS

Ninety-nine entries from the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Hyderabad, India, were tested. Fifty were land race varieties supplied by the Genetic Resources Unit from the world collection held at ICRISAT and selected to represent the geographic and genetic diversity of cultivated pearl millet. The remaining 49 entries were chosen to represent a wide range of breeder-generated material from various sources, varieties, and parental lines of hybrids in current use. These materials were all grown out at ICRISAT prior to dispatch to the United States.

Plants were grown in controlled environment rooms with temperatures of 27 ± 2 C under high-intensity lights with 16 hr of light and 8 hr of darkness each day. Seeds were planted in flats of sterilized greenhouse soil. Each flat contained 10 rows of millet, each row representing a separate entry, and one row of grain sorghum (Asgrow Bugoff hybrid) serving as an indicator for observing the quantity and quality of symptoms. The sorghum hybrid used is well known for a strong mosaic reaction to both MDMV-A and MDMV-B and a "red leaf" reaction to strain B after chilling (8).

Virus isolates were obtained from J. Hill of Iowa State University, Ames. Six days after planting, when the seedlings were in the two-leaf stage, three replicates of each entry were inoculated with MDMV-A and three, with MDMV-B; one replicate was left as a control. The inoculum was sap from infected plants diluted 1:10 with tap water. Inoculation was accomplished by dusting the plants lightly with 600-mesh Carborundum and rubbing the dusted leaves lightly with fingers dipped in the inoculum.

Notes were taken on the virus symptoms and other general conditions of the plants 10 and 11 days after inoculation, then two replicates from each viral treatment were chilled by reducing the growth chamber temperature to 15 ± 2 C. The purpose of the chilling was to determine if the temperature-sensitive necrotic response known as a red leaf reaction in sorghum also occurred in millet. After 3 days of chilling, then 3 days at the original warmer temperature, notes were taken again on virus symptoms and the general condition of the plants.

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Table 1. Reaction of 50 land races of pearl millet (*Pennisetum americanum*) to the A and B strains of maize dwarf mosaic virus

Land races				No. of plants infected/ no. of plants inoculated	
IP no.	Study no.	Pedigree	Origin	MDMV-A	MDMV-B
3122	1	SAR-116	Rajasthan, India	1/25	2/28
3314	2	SAR-338	Rajasthan, India	0/30	0/29
3471	3	SAR-696	Tamil Nadu, India	2/18	2/20
3743	4	SAR-1133	Gujarat, India	0/29	0/31
4138	5	SAR-987	Maharashtra, India	0/32	1/30
4088	6	SAR-1509	Madhya Pradesh, India	0/32	0/37
6114	7	P-2	Cameroun	0/36	0/37
6479	8	P-511 (Sanio)	Mali	1/31	1/30
5351	9	P-2692 (Bodendji)	Niger	1/35	2/30
5533	10	P-2829 (Maewa)	Niger	3/30	1/30
5408	11	P-2694 (Guero)	Niger	2/23	2/24
5621	12	P-2917 (Bazaome)	Niger	0/30	3/29
6102	13	P-938 (Timia)	Niger (oasis)	4/37	1/35
5805	14	P-1381 (Souna)	Senegal	1/40	2/34
5876	15	P-1479 (Sanio)	Senegal	0/31	1/33
6574	16	Sauoga local-1	Upper Volta	0/36	0/35
6575	17	Sauoga local-2	Upper Volta	0/39	2/40
5797	18	WJR-16/119989	USSR	0/31	0/35
5799	19	WJR-33/210779	USSR	1/35	2/36
5804	20	Australia-243	Australia	0/40	1/42
5692	21	45-324	Nigeria	1/39	1/34
5738	22	45-388	Nigeria	1/40	3/35
7359	23	M-3	Tanzania	0/36	0/39
7447	24	M-70-1	Tanzania	1/33	1/34
6590	25	SAD-28	Malawi	0/35	0/33
6735	26	SAD-343	Malawi	0/34	3/39
6893	27	ACC-154	Kenya	0/41	3/44
227	28	IP-227	Uganda	0/30	1/39
2789	29	IP-2789	Mauritania	0/32	3/38
4945	30	Serere-34	Uganda	0/39	3/24
4990	31	700278	Nigeria	0/35	0/39
5105	32	D-232	Niger	0/27	0/22
5129	33	D-264	Niger	0/35	0/34
5173	34	D-21	Niger	0/25	0/29
5218	35	D-132	Niger	0/28	0/27
5262	36	D-224	Niger	0/32	0/35
6036	37	P-151	Central African Republic	1/26	2/23
6040	38	P-155	Central African Republic	0/31	2/25
6085	39	P-200	Central African Republic	0/29	0/32
6131	40	P-23	Cameroun	0/40	0/38
6141	41	P-35	Cameroun	1/36	0/35
6269	42	P-240	Mali	1/29	2/28
8848	43	ZM-028	Zambia	1/42	1/23
8856	44	ZM-233	Zambia	0/43	0/41
8517	45	ABM-3	Rayalaseema, India	0/36	0/37
8609	46	ABM-129	Rayalaseema, India	0/38	0/41
8632	47	PGI-76-2	Sudan	0/31	2/31
8641	48	PIA-89-D-2	Sudan	1/30	1/27
8762	49	PM-53	Botswana	0/40	1/39
8774	50	PM-70	Botswana	1/35	5/36

RESULTS AND DISCUSSION

The results are summarized in Tables 1 and 2. Among the inoculated sorghum indicator plants, 246 of 300 (82%) were infected with MDMV-A and 229 of 306 (75%) were infected with MDMV-B.

Many of the entries were susceptible to the two virus strains, but the number of diseased plants was usually quite small. Plants in 29 entries became infected with MDMV-A and plants in 58 entries became infected with MDMV-B. Since diagnosis was made strictly on the appearance of symptoms, latent or symptomless infections may have occurred in additional plants, but recovery trials were not attempted. Had each plant been inoculated a second time or challenged with a more concentrated virus preparation, a larger number of plants probably would have developed symptoms and more entries would have been classified as susceptible. Observations of this type are common with sorghum.

Susceptibility to MDMV-A was generally accompanied by susceptibility to MDMV-B. Twenty-five of 29 entries were susceptible to both virus strains, which was highly significant by chi-square analysis. Some collections carried a fairly high level of susceptibility. For example, entries 9 through 13 from Niger were susceptible to MDMV-B and, except for entry 12, to MDMV-A also, whereas entries 32 through 36 from Niger had no infection by either virus. In general, two or three entries from each country or state were included in the 50 land races, and in nearly every case, at least one developed some diseased plants. The same observation was generally true of the plant breeders' material in that susceptibility occurred in virtually every classification included in the collection.

One of the most notable attributes of this collection was the heterogeneity observed. Notes were taken but not reported on plant size, vigor, pigmentation, germination, and pubescence. Approximately half the entries contained some plants with albinism, chlorosis, or necrosis. Some of the chlorotic mutants developed a mosaic pattern that superficially resembled virus symptoms. Careful observation made the distinction possible, however. Entries 77 and 79 had many plants with a genetically controlled small chlorotic leaf fleck type of pattern that masked the virus symptoms.

Table 2. Reaction of 49 breeder lines of pearl millet (*Pennisetum americanum*) to the A and B strains of maize dwarf mosaic virus

Breeder lines			No. of plants infected/ no. of plants inoculated	
Group	Study no.	Pedigree	MDMV-A	MDMV-B
Male-sterile A&B pairs (A_1 cytoplasm)	51	ICM ms 81A	0/30	0/31
	52	ICM ms 81B	0/38	2/36
	53	5054A	0/44	0/42
	54	5054B	0/38	0/41
	55	5141A	0/41	1/37
	56	5141B	0/44	0/41
	57	111A	1/33	3/35
	58	111B	0/35	1/35
Maintainer (B line)	59	CD5B (551)	0/28	5/30
	60	CD5B (562)	1/25	5/24
Varieties/synthetics	61	WC-C75	0/37	0/34
	62	I CMS 7703	0/34	0/31
	63	I CMS 7819	0/34	3/31
West African dwarfs	64	3/4 Seno 72-2 (37)	0/25	3/19
	65	3/4 Seno 22-1 (9)	0/09	0/17
	66	3/4 HK-B78	0/27	1/26
	67	3/4 EB-B78	0/34	0/34
Restorers (A_1 cytoplasm)	68	J104	0/30	2/25
	69	CM 46	1/36	3/32
	70	B 282	3/29	0/30
	71	I CP 220	0/37	0/38
	72	I CP 226	0/41	1/43
	73	I CP 383	0/40	0/39
	74	I CP 412	1/48	0/49
	75	E 298-2	0/54	2/54
	76	J 41	0/53	2/48
	77	J 1532	9/54	7/36
	78	J 2049	0/51	3/46
	79	7152	3/47	1/49
Germ plasm accessions used as parents in crosses	80	P-242	0/44	3/42
	81	Tiotioni-1 (male)	0/29	2/30
	82	Tiotioni-2 (male)	0/31	3/32
	83	Siria Korola Souna (199)	0/38	0/37
	84	Souna-38 (294)	3/36	2/34
	85	Souna-39 (295)	0/38	0/36
	86	P538 (chalky bold grain, Mali)	0/28	0/36
	87	P541 (chalky bold grain, Mali)	0/38	0/31
	88	Togo (414)	1/28	4/32
	89	Togo (405)	0/32	1/26
Inbred lines with diverse parentage	90	NEP7-5603 × Saria Synthetic 48-40-4-1 (773)	0/38	5/39
	91	GAM 75 × 3/4 Souna 121-14-3 (778)	1/37	2/36
	92	J1281 × Saria Synthetic 40-2-3-16 (780)	0/43	0/40
	93	P_3 Kolo × GAM 73-11-2 (783)	0/50	0/62
	94	B282 × 3/4 Ex Bornu-100-11-9-2(786)	0/54	2/48
	95	3/4 Ex Bornu × HKP-13 (803)	0/51	1/47
	96	PIB 228 × 3/4 Ex Bornu 108-2-3-5 (806)	0/49	3/57
	97	Souna B × LCSN 1173-1-9-2-4 (871)	0/53	0/49
	98	J 1912 × 111B-2-2 (788)	0/15	0/33
	99	B282 × 3/4 Heine Kheri-84-7-2 (797)	2/18	0/25

Compared with the sorghum indicator plants, which were 75–82% infected, none of the lines from the world collection showed high susceptibility to infection by either of the virus strains. Usually less than 10% of the plants developed symptoms, and symptoms were generally mild. Chilling had no significant effect on the symptoms in millet but killed sorghum plants of the Bugoff hybrid infected with MDMV-B. In this and other trials, we have not demonstrated a temperature sensitivity in the symptom response of millet to MDMV.

Although a few entries in preliminary tests were highly susceptible to MDMV, it appears that, in general, susceptibility to these two common strains of MDMV should not be a major concern to millet breeders. However, there are several other strains of MDMV and a number of strains of the closely related sugarcane mosaic virus. Thus, the potential exists for a problem to develop if breeders select material that includes susceptible individuals. It would seem wise for breeders to challenge their material in an early generation with viruses common to their area and discard germ plasm that shows susceptibility.

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