NOTES

A SINGLE DOMINANT GENE FOR RUST RESISTANCE IN PEARL MILLET[1]

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Abstract

Pearl millet rust (*Puccinia penniseti* Zimm = P. *substriata* var. *indica*) can reduce yields in hybrid seed production fields, quality in forage, and occasionally grain yields. Results are reported on the inheritance of a source of rust resistance discovered in crosses which involved one S_2 progeny, #2696-1-4, selected from a pearl millet [*Pennisetum americanum* (L.) Leeke] germplasm accession originating from Chad. F_1, F_2, BC_1, BC_2 plants and the parents of crosses between the resistant source and two different susceptible male sterile lines were evaluated under severe rust pressure at three locations in India. Progeny of 2696-1-4 and the F_1 hybrids between 2696-1-4 and male sterile lines were all resistant, while the male sterile lines were severely rusted at each location. In general, F_2 populations from susceptible × resistant crosses showed a good fit to a 3 resistant: 1 susceptible ratio and the backcrosses involving susceptible male-sterile lines as recurrent parents showed a reasonably good fit to 1 resistant:1 susceptible, indicating that rust resistance is conferred by a single dominant gene and susceptibility by its recessive allele. We propose the symbols Rpp_1 and rpp_1 for these genes.

Additional index words: **Pearl millet, Bulrush millet, *Pennisetum americanum* (L.) Leeke, Rust resistance, *Puccinia penniseti* Zimm, *Puccinia substriata* var. *indica*.**

PEARL millet [*Pennisetum americanum* (L.) Leeke] is grown as a food grain crop over an estimated 26 million hectares in the African semiarid tropics and on the Indian sub-continent. It is also grown to a lesser extent as a forage crop in India, USA and Australia. Pearl millet leaf rust is known to occur in all areas where the crop is grown (1). In India, it is caused by *Puccinia penniseti* Zimm (= *P. substriata* Ell. and Barth. var. *indica* Ram. and Cumm.) and there are indications of racial differentiation (2,4). There are no published reports on the extent of losses caused by this leaf disease, although occasional outbreaks may lead to severe losses in grain yield and forage quality (6). Ramakrishnan and Sunderam (4) observed that all growth stages of the plant are susceptible to rust attack, and under the environments favorable for rust infection, plants can wither before flowering due to severe rust incidence. In the rainy season in India, rust generally occurs after anthesis resulting in little or no reduction in grain yield, though there may be substantial reduction in fodder quality. However, rust is a major grain yield reducer in the post-rainy season crop (H.R. Dave, 1981, personal communication) when hybrid seed is produced to plant about 2 million ha annually. Resistance to rust would therefore be desirable, at least in male-sterile lines which, if resistance were controlled by dominant gene(s), would also provide protection to the hybrids. The purpose of this note is to report preliminary investigations on the inheritance of rust resistance identified in a pearl millet germplasm accession from the Republic of Chad.

Materials and Methods

During the 1982 rainy season (July-October) at ICRISAT Center (17°20′ N, 78°20′ E), 46 plants from three early maturing S_2 progenies selected from the world collection accession, IP 2696, a landrace population from Chad, were used to pollinate two unrelated male-sterile lines, ms 1108A and ms 81A. The hybrids thus produced were planted at ICRISAT Center for agronomic evaluation in single-row plots of about 40 plants each in the post-rainy season of 1982 to 1983 (November-February) as part of a larger breeding nursery. Severe leaf rust developed and it was noted that hybrids with 9 of the 46 S_2 plants (7 crossed on ms 1108A and 2 crossed on ms 81A) were completely free of rust, one hybrid had 31 out of 35 plants free of rust, while all other hybrids were heavily rusted. The 10 hybrids showing resistance were all made with plants from one (2696-1-4) of the three S_2 progenies.

To further investigate the nature of this resistance, three of the single plant selections derived from 2696-1-4, two

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Table 1. Observed segregation ratios of rust resistant (R) and rust susceptible (S) plants in pearl millet F_2 and BC_1 populations at three locations.

Cross	Location	Generation	No. of plants R	No. of plants S	χ^2	P
ms 1108A × 2696-1-4-6	Patancheru	F_2	396	136	(3:1) 0.08	0.90–0.75
		BC_1	94	71	(1:1) 3.2	0.10–0.05
	Bhavanisagar	F_2	317	96	(3:1) 0.68	0.50–0.25
		BC_1	42	49	(1:1) 0.54	0.50–0.25
	Kovilpatti	F_2	102	25	(3:1) 1.94	0.25–0.10
		BC_1	34	34	(1:1) 0.0	>0.995
ms 1108A × 2696-1-4-4	Patancheru	F_2	340	133	(3:1) 2.45	0.25–0.10
		BC_1	128	96	(1:1) 4.6	0.05–0.025
	Bhavanisagar	F_2	301	101	(3:1) 0.003	>0.975
		BC_1	119	89	(1:1) 4.32	0.05–0.025
	Kovilpatti	F_2	48	17	(3:1) 0.05	0.90–0.75
		BC_1	63	72	(1:1) 0.06	0.50–0.25
ms 81A × 2696-1-4-10	Patancheru	F_2	389	106	(3:1) 3.4	0.10–0.05
		BC_1	136	100	(1:1) 5.49	0.025–0.01
ms 2068A × 2696-1-4-3	Patancheru	F_2	336	92	(3:1) 1.02	0.50–0.25

male-sterile lines (1108A and 81A) and three F_1 hybrids (1108A × 2696-1-4-4; 1108A × 2696-1-4-6 and 81A × 2696-1-4-10) were grown using the remnant seed stocks to produce three sets of F_1, F_2, BC_1, and BC_2 generations. Both parents, the F_1, F_2, BC_1, and BC_2 generations in each set were planted at ICRISAT Center on 25 Oct. 1983. To ascertain whether the resistance was effective elsewhere, the trial was also planted at Bhavanisagar (11°20′ N, 77°0′ E) and Kovilpatti (9°10′ N, 77°50′ E), on 12 Oct. 1983, and 19 Oct. 1983, respectively. Both locations are considered rust endemic areas in the southern Indian state of Tamil Nadu. The F_2 and BC_1 populations of cross 81A × 2696-1-4-10 however, could not be evaluated at Bhavanisagar and Kovilpatti. A fourth cross was made with another unrelated male sterile line, ms 2068A, and 2696-1-4-2, and sufficient F_2 seeds were available for a test at ICRISAT Center by 19 Dec. 1983.

In the post-rainy season at ICRISAT Center rust may appear in a severe form, but its occurrence is unpredictable (5). To ensure severe rust incidence, heavily rusted leaves were spread in the trial 31 and 33 days after planting (DAP). At 34, 43, and 49 DAP, the trial was inoculated with uredospores suspended in water. High humidity necessary for rust development (3) was provided by sprinkler irrigation operated three times a week at sunset from 46 to 100 DAP.

Parents and F_1 plants were planted in 4-row plots, F_2 plants in 16-row plots and each BC generation in 8-row plots. Each 4 m row was thinned to single plants about 10 cm apart within 18 DAP. At Bhavanisagar and Kovilpatti poor emergence reduced the expected numbers of plants. Rust incidence was recorded after flowering on all plants at each location. Plants without pustules were classified as resistant, although necrotic flecking generally developed on these plants, while those with pustules, regardless of number or size, were scored as susceptible. At ICRISAT Center, plants were examined for infection three times (61, 81 and 106 DAP) and susceptible plants were tagged. At Bhavanisagar and Kovilpatti, rust scoring was done only at 74 and 69 DAP, respectively.

Results and Discussion

At each of the three locations, all plants (total 427) of both male-sterile lines (ms 1108A and ms 81A) were heavily infected with rust while all plants (total 599) of the 2696-1-4 progeny and the F_1's (total 1082 plants) were resistant (except 5 at Kovilpatti which were attributed to volunteer plants). These data imply that the rust resistance carried in 2696-1-4 is dominant to susceptibility. If resistance is dominant, all BC_2 plants should be resistant where 2696-1-4 is the recurrent (pollen) parent. Results, however, showed about 1 to 3% of the plants in each BC_2 population were susceptible out of a combined total of 2317 plants. The most likely cause is that while making the backcrosses (where the female parent is also male fertile, unlike the F_1 crosses), selfing to the extent of about 4 to 12% occurred in the late flowering basal florets which would produce 1 to 3% susceptible segregants in the BC_2.

The segregation ratios of resistant and susceptible plants in F_2 and BC_1 generations where susceptible male sterile lines were recurrent parents, are given in Table 1 for each set of crosses. In the cross ms 1108A × 2696-1-4-6, the F_2 segregations showed a good fit (between $P=0.10$-$P=0.90$) to a 3 resistant:1 susceptible ratio and the BC_1 showed a good fit ($P=0.05$-0.995) to a 1 resistant:1 susceptible ratio at each location. This implies that resistance is conferred by a single dominant gene and susceptibility by its recessive allele. The F_2 segregation behavior of the cross ms 1108A × 2696-1-4-4 at each location also showed a good fit to a 3 resistant:1 susceptible ratio and hence confirmed the genetic expectation derived from the previous cross. However, in the BC_1 of this cross a good fit (P=0.25-0.50) to a 1:1 ratio was obtained only at Kovilpatti. In the ms 81A × 2696-1-4-10 cross, the F_2 segregation at ICRISAT Center had a good fit to a 3 resistant:1 susceptible ratio but the BC_1 showed a poor fit ($P=0.01$-0.025) to a 1 resistant:1 susceptible ratio. The F_2 of the fourth cross, ms 2068A × 2696-1-4-3 also showed a good fit to a 3 resistant:1 susceptible ratio.

The overall results provide good evidence that a single dominant gene conditions rust resistance in 2696-1-4 which is effective against rust populations in at least three locations in peninsular India, and which operates in different genetic combinations. The symbol, Rpp_1, is proposed for this dominant gene conditioning rust resistance in pearl millet.

References

1. Commonwealth Mycological Institute. 1967. Distribution maps for plant diseases. Map no. 225, 2 ed., issues 30 June. Commonwealth Mycological Institute, Kew, England.
2. Kapooria, R.G. 1978. Studies on physiological variability in *Puccinia penniseti*. Indian Phytopathol. 31:372–374.
3. Muthusamy, S., D. Padmanabham, R. Nagarajan, and N. Raghupathy. 1981. Incidence of pearl millet rust in relation to sowing time and relative humidity. Madras Agric. J. 31:372–374.
4. Ramakrishnan, T.S., and N.V. Sunderam. 1956. Further studies on *Puccinia penniseti*. Zimm. Proc. Indian Acad.Sci.Sect.B. 43:190–196.
5. Suresh, S. 1969. A preliminary study on the reactions of pearl millet *Pennisetum typhoides* (S and H) inbreds and open pollinated lines to green ear and rust diseases. Madras Agric. J. 56:88–90.
6. Wells, H.D., G.W. Burton, and W.W. Hanna. 1973. *Puccinia substriata* var. *indica* a new rust with devastating potential on pearl millet in the southeast. Phytopathology. 63:449. (Abstr.).