Pl. Dis. Res. 3(2), 1988 : 192-197

INHERITANCE OF SMUT RESISTANCE IN PEARL MILLET

S. B. CHAVAN, R. P. THAKUR AND K. P. RAO

Cereals Program, International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh-502324, India

ABSTRACT

Inheritance of smut resistance was studied in pearl millet by a diallel analysis, involving four resistant and four susceptible inbred lines. Among the four susceptible lines, two were restorers and two were maintainers All the crosses involving both resistant parents were, in general, less susceptible (<1% severity) than those involving one or both susceptible parents. However, a cross involving J 104 and 843 B, both susceptible parents, showed less disease (1.7% severity) as well as a negative specific combining ability (SCA) value, indicating a good possibility of utilizing it to isolate new smut-resistant B and R lines. The results indicate that inheritance to smut is dominant or partially dominant, with both additive and nonadditive gene effects

KEY WORDS : Pearl millet, Smut, *Tolyposporium penicillariae*, Inheritance.

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is an important staple cereal in the semi-arid tropical regions of the world, and smut, caused by *Tolyposporium penicillariae* Bref., is an important yield-reducing disease. Pearl millet florets infected by *T. penicillariae* produce smut sori instead of grains. The disease is prevalent in most pearl millet growing areas. In India the disease is endemic in parts of Delhi, Haryana, Punjab, Rajasthan and Uttar Pradesh ; it is also endemic in several countries in West Africa, particularly parts of Burkina Faso, Niger, Nigeria and Senegal (Rachie and Majmudar, 1980). This disease has epidemic potential, particularly because all hybrids and their parents have shown high levels of smut susceptibility under artificial screening (ICRISAT, 1987).

Chemical control of smut is costly and only partially successful. Growing resistant varieties is the most effective and economical way to control this disease. A systematic approach to indentify sources of resistance to smut was initiated at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in 1976 and an effective screening technique was subsequently developed (Thakur *et al.*, 1983). Pearl millet lines with stable resistance were identified (Thakur *et al.*, 1986) and are being utilized in the ICRISAT pearl millet breeding program (Andrews *et al.* 1986).

Submitted as ICRISAT Journal Article No. 803

Information on the nature of inheritance of smut resistance, which is of vital importance in a resistance breeding program, is inadequate. Published information (Yadav, 1974) suggests that the inheritance of smut is simple and governed by one or two major genes. The present studies were undertaken to further our understanding of the nature of genetic resistance in some of the smut-resistant lines recently identified at ICRISAT Centre.

MATERIALS AND METHODS

Eight pearl millet inbred lines, four smut-susceptible (81B, 843B, B 282 and J 104) and four smut-resistant (SR 13, SR 14, SR 15 and SR 16), were crossed in a diallel fashion to produce 28 F_1s. Among the susceptible inbreds, B 282 and J 104 are restorers (R lines) and 81B and 843B are maintainers (B lines). Smut-resistant (SR) lines were selected based on their high levels of resistance under artificial inoculation at ICRISAT Centre and in multilocational testing in the International Pearl Millet Smut Nursery (Table 1).

TABLE 1. The pedigree and smut reactions of smut-resistant (SR) lines in the International Pearl Millet Smut Nursery, 1983 to 1986

Line	Pedigree	Mean smut severity (%)			
		1983[1]	1984[2]	1985[3]	1986[4]
SR 13	[(EB 137—1 × EB 132 – 2) 1] - 5 – 4	1	<1	<1	1
SR 14	[Ex B 132—2 × (J25 1 × 700797 – 1 – 5 - 2) — 3] — 1 — 2	1	<1	<1	1
SR 15	[EBS 137—2 × (J1623 × WC 6—3)] — 3 – 4 — 1	2	<1	8	1
SR 16	[(EB 137—1—1 × WC FS 139) — 1] — 4 — 3	1	5	—	—
BJ 104 (Check)	5141 AXJ 104	48	52	63	49

1 Across 9 locations in India, Niger and Nigeria
2 Across 4 locations in India
3 Across 4 locations in India, Senegal and Niger
4 Across 6 locations in India, Senegal, Niger and Nigeria
5. Not tested

The crosses were made in the 1985 dry season, and the material was screened for smut reaction in the 1985 rainy season. The test material, consisting of 28 F_1 and 8 parental lines, was grown in two 4-m rows for each entry. A standard susceptible check, BJ 104, was sown in one row after every 16 rows, and on the border of the experiment. The row to row distance was 75 cm, and there were 10 cm between plants in a row. The experiment was sown in a randomized complete block design, with three replications. The normal agronomic practices necessary to raise a good crop were followed. Smut inoculations were done by injecting a sporidial suspension of *T. penicillariae* (1 × 10^6 sporidia ml^{-1}) into the boot of a plant and bagging the boot with parchment paper bags (Thakur *et al.* 1983). Twenty plants were inoculated in each plot. Twenty days after inoculations bags were removed, and smut severity rating scale of 0-100%, with 0 indicating highly resistant and 100 as highly susceptible (Thakur and Williams, 1980).

The percentage severity data were transformed to arcsines (Steel and Torrie, 1956) for statistical analysis. The combining ability analysis was performed according to Griffing (1956 Method 2, Model 1.

RESULTS AND DISCUSSION

There were significant differences among parents (Table 2). All four resistant parents showed high levels of resistance (0.0 to 0.9% smut severity) and the four susceptible parents showed smut severity in the range of 8.7 to 67.7%, compared with 87% smut in the susceptible check, BJ 104 (Table 3). Among the susceptible parents, two restorer lines, J 104 and B 282, showed less smut than the maintainer lines, 81B and 843B (Table 3). More smut was recorded on three of the four susceptible parents, 81B, 843B, and B 282 that possess a d_2 dwarfing gene than on a non-d_2 parent, J 104.

TABLE 2. Analysis of variance and variances associated with combining ability for smut severity in an 8 × 8 half diallel cross in pearl millet

Sources of variation	df	MS
Replications	2	1.076
Parents vs. F_1s	1	1078.85**
Parents	7	1327.59**
F_1s	27	437.6**
Error	70	11.369
GCA	7	831.89**
SCA	27	56.168**
Error	70	11.36

**Significant at $P=0.01$

Crosses involving both resistant parents showed high levels of resistance, with 0.0 to 0.3% smut severity, while those involving both susceptible parents showed a wide range of smut severity, with 1.7% for cross J 104 × 843B to 36.7% for cross J 104 × 81B (Table 3). The low smut severity in F_1s might indicate different complementary genes for resistance in the parental lines.

In 16 crosses involving one resistant and one susceptible parent, smut severity ranged from 0.3% to 26.0%. The highest severity (26.0%) was recorded in cross SR 14 × 81B, while the lowest severity (0.3%) was recorded in cross SR 13 × 843B.

TABLE 3. Mean smut severity (arcsine transformed values of percentage severity) of eight inbred lines (diagonal) and their crosses (off diagonal) in F_1 progenies of an 8×8 half diallel cross in pearl millet

Parents	81 B	843 B	B 282	J 104	SR 13	SR 14	SR 15	SR 16
81 B	55.4 (67.7) a							
843 B	33.9 (31.7)	40.6 (42.3)						
B 282	32.0 (28.3)	33.6 (30.7)	29.1 (24.3)					
J 104	37.3 (36.7)	7.3 (1.7)	27.9 (22.0)	17.0 (8.7)				
SR 13	5.5 (0.9)	1.8 (0.3)	3 6 (0.6)	5.6 (1.0)	0.0 (0.0)			
SR 14	30.2 (26.0)	7.5 (1.9)	11.5 (4.0)	8.9 (2.7)	0.0 (0.0)	0.0 (0.0)		
SR 15	13.7 (5.7)	3.6 (0.6)	3.7 (0.6)	5.5 (0.9)	0.0 (0.0)	1.8 (0.3)	1.8 (0.3)	
SR 16	15.9 (7.7)	4.4 (0.9)	3.7 (0.6)	6.5 (1.3)	0.0 (0.0)	1.8 (0.3)	1.8 (0.3)	5.5 (0.9)

S.E.=1.0

a=Mean per cent smut severity of 60 inoculated panicles from 3 replications; mean smut severity of BJ 104 (Check)=87%

In all these crosses, mean smut severity was within the limit of parental value for each cross and these values were more towards the resistant parent. Eleven of the 16 crosses in this group showed near complete dominance for resistance, while the remaining showed partial dominance. The cross, SR 14 × 81B, which had highest smut severity of 26.0%, had a susceptible parent that also had highest smut severity (67.7%). Among the resistant parents, SR 13 seems to combine well with all susceptible parents in imparting resistance in F_1s, compared with other resistant lines, therefore, SR 13 could be extensively used in a breeding program.

A combining ability analysis revealed significant differences for parents *vs.* F_1 crosses, parents. F_1 crosses and general combining ability (GCA) and specific combining ability (SCA) effects (Table 2). The combining ability analysis revealed that both additive and non-additive gene actions were important. Inbred 81B showed the highest and positive value of 16.4, while J 104 had the lowest positive GCA effect of 1.8 (Table 4). On the other hand, the resistant parents SR 13 and SR 15 had the highest negative GCA effects, with — 9.8 and — 8.1 values, respectively; and all the GCA effects were significant ($P = 0.01$), indicating that parents differ genetically and accordingly give different smut-severity reactions.

The SCA effects were significant for 19 of the 28 crosses (Table 4). The two crosses with highest positive SCA effects were B 282 × 843B (9.0) and J 104 × B 282 (7.4) In these crosses, both parents were susceptible. The significant SCA effects of higher negative values (indicating resistance) were recorded for crosses SR 13 × 81B (−13.8) and J 104 × 843B (−13.2) followed by SC 16 × B 282, SR 15 × 81B, SR 13 × 843B. and SR15 × 843B, all of which had one susceptible parent. All the crosses involving 843B (except with B 282) recorded significantly negative SCA effects. A cross, J 104 × 843B with both susceptible parents, has high negative SCA effects (−13.2); and it can be used very effectively to isolate new B and R lines with smut resistance.

TABLE 4. General and specific combining ability effects for smut severity in an 8×8 half diallel millet cross

	81 B	843 B	B 282	J 104	SR 13	SR 14	SR 15	SR 16
81 B	16.4**							
843 B	−1.3	5.9**						
B 282	−3.1*	9.0**	5.9**					
J 104	6.2**	−13 2**	7.4**	1.8**				
SR 13	−13.8**	−7.1**	− 5.2**	0.9	−9.8**			
SR 14	6.3**	−5.9**	− 1.9	−0.3	2.4	−5.3**		
SR 15	−7.4**	−7.0**	−6.9**	−0.9	5.2**	2.5	−8.1**	
SR 16	−6 5**	−6.4**	−8.1**	− 1.2	3.9*	1.2	4.0*	−6.9**

S.E. (gi) = 0.576 S.E. (sij) = 1.536
GCA effects = diagonal
SCA effects = off diagonal
*Significant at $P=0.05$; **Significant at $P=0.01$

The results indicate that inheritance of smut resistance was relatively simple and dominant in 11 of the 16 crosses (susceptible × resistant) and partially dominant in the remaining 5 crosses. The possibility of complete dominance and additive gene action together giving partial dominance in a few of the crosses needs further investigation. However, the lines having both dominant and additive gene effects for smut resistance could be utilized through population improvement. The agronomic eliteness of the parental lines in terms of maturity, height, seed size, and seed set are good and these can be effectively utilized in breeding programs to select smut-resistant R and B lines.

REFERENCES

Andrews, D.J., King, S.B., Witcombe, J.R., Singh, S.D., Rai, K.N., Thakur, R.P., Talukdar, B.S., Chavan, S.B., and Singh, P. 1986. Breeding for disease resistance and yield in pearl millet. *Field Crops Res.* 11 : 241-58.

Griffing, B. 1956. Concept of general and specific combining ability in relaton to diallel crossing system. *Aust. J. Biol. Sci.* 9 : 463-93.

ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1987. *Annual Report* 1986. Patancheru, A.P. 502 324, India : ICRISAT.

Rachie, K. and Majmudar, J.V. 1980. *Pearl Millet.* Pennsylvania State University Press, University Park, PA, USA.

Steel, R.G.D. and Torrie, J H. 1956. *Principles and Procedures of Statistics.* McGraw-Hill Book Co., New York, USA.

Thakur, R.P. and Williams, R.J. 1980. Pollination effects on pearl millet ergot. *Phytopathology* 70 : 80-84.

Thakur, R.P., Subba Rao, K.V., and Williams, R.J. 1983. Evaluation of a new field screening technique for smut resistance in pearl millet. *Phytopathology* 73 : 1255-58.

Thakur, R P., Subba Rao, K.V., Williams, R.J., Gupta, S.C., Thakur, D.P., Nafade, S.D., Sundaram, N.V., Frowd, J.A. and Guthrie, J.E. 1986. Identification of stable resistance to smut in pearl millet. *Pl. Dis.* 70 : 38-41.

Yadav, R.P. 1974. Inheritance of smut resistance in pearl millet. *Agra Univ. J. Res.* 23 : 37-39.