Journal of Ecobiotechnology 2/1: 16-20, 2010
ISSN 2077-0464
http://journal-ecobiotechnology.com/

Improvement of agronomicaly desirable genotypes for downy mildew disease resistance in Pearl millet [*Pennisetum glaucum* (L.) R. Br.] By recombination breeding

G.V. Shelke, A.M. Chavan*
Dr. Babasaheb Ambedkar Marathwada University, Aurangabad-431 004, India

**Corresponding Author, Email: shelkegv@rediffmail.com*

Keywords

Pennisetum glaucum
Yield
downy mildew disease
Pearl millet

Abstract

In the present study gene action assessed by hybridizing the five female lines (one resistant and four susceptible) and eight male lines (six resistant and two susceptible) in Line x tester design was studied. The study indicated additive gene action playing predominant role in the control of yield and four yield contributing traits in addition to downy mildew resistance while fodder yield and days to 50 per cent flowering were controlled by non-additive gene effects. Among the 40 crosses, APMB 89 x APMR 70 and APMB 89 had non-significant sca and highly significant gca for yield and yield contributing traits along with downy mildew resistance and it is therefore, expected to throw superior segregants for the development of lines with desirable traits.

1. Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a staple food crop in arid and semi-arid areas of Africa and Asia. In addition, as being the principal food cereal in arid and semi-arid regions and as forage, it also has a potential as an early-maturing summer grain crop in temperate regions (Anand Kumar and Andrews, 1993; Yoshida and Sumida, 1996). Pearl millet has high yield potential and responds well to water and soil fertility (Poelhman, 1994).

Downy mildew caused by an obligate parasite *Sclerospora graminicola is* quite wide spread and economically most important disease of pearl millet (*Pennisetum glaucum*) in India and several countries in Africa. In India, the disease is prevalent in almost all pearl millet growing states and causes substantial annual losses. The disease is particularly more serious on single-cross F1 hybrids than on open pollinated varieties (OPVs). This is due to narrow genetic base and uniformity of the hybrids than those of OPVs that are highly heterogeneous. Currently, about 50% of the 9 million ha area under pearl millet cultivation is grown with single cross hybrids in India (Rai et al. 2006). The downy mildew incidence has been quite variable on different hybrids and more than 90% incidence has been recorded on some hybrids in farmers' field (Thakur et al. 2003, Rao et al. 2007). The estimated annual grain yield loss due to downy mildew is approximately 20-40% (Singh 1995, Hash et al. 1999, Hess et al. 2002) but this could be much higher under favourable conditions of disease development (Singh 1995, Thakur 1998, 2008). Most seed companies treat the seed with a systemic chemical fungicide metalaxyl to protect the crop from downy mildew (Thakur et al. 2003, Rao et al. 2007). However, they reported that chemical treatment is effective only in case of moderately resistant hybrids in certain environments. The fungicide is ineffective in susceptible hybrids, in which the crop is protected only up to 40 days after emergence and the disease appears on nodal tillers and as 'green-ear' at the later stages of crop growth. The cost of the treated seed is much higher and farmers have to pay additional price for such seed. This chemical approach to downy mildew management may also lead to the emergence of more virulent pathotypes.

With the increasing area under hybrid cultivation since the 1970s, the disease has become severe and more widespread (Thakur et al. 2006). The most cost-effective management of the disease can be obtained by breeding downy mildew resistant pearl millet hybrids. There has been considerable success in breeding for downy mildew resistance using conventional pedigree breeding, and a large number of disease resistant hybrids have been developed and deployed (Khairwal et al. 2004).

The choice of selection and breeding procedure to be used for genetic improvement of any crop plant largely depends on the magnitude of genetic variability and the nature of gene action governing inheritance of the desirable traits. The present study was made to assess the nature of combining ability for downy mildew resistance and four yield contributing traits using five lines and eight testers.

2. Materials and Methods

Five pearl millet lines used as female parents and eight lines used as testers were selected from the Research Division of Ankur Seeds Pvt. Ltd Nagpur (Maharashtra).

Using these lines, 40 F1's were produced by Line x Tester mating design in June, 2007. The thirteen parents, forty crosses and one susceptible check APMS 321, were evaluated using Randomized Block Design with three replications at downy mildew hot spot location Sahapur Dist. Mathura (UP) during Summer 2008 for disease reaction and for yield evaluation at Ankur Seeds Research Farm, Inzapur Dist. Wardha (Maharashtra). The evaluations were done to estimate the gene effects for controlling the downy mildew resistance, yield and yield contributing traits.

Number of diseased plants showing downy mildew symptoms expressed as a percentage of total number of plants in a plot were assessed at dough stage by scoring for green ears. Downy mildew incidence was computed using the formula developed by James, as the number of diseased plants expressed as:

$$\mathrm{DMI} = \frac{\text{Number of diseased plants}}{\text{Total number of plants}} \times 100$$

Estimation of gene effects based on combining ability analysis was calculated as by Kempthrone (1957). Parents and F1's means and variances of each cross were used to determine gene action.

3. Results and Discussion

Concept of combining ability helps in the identification of parents with good general and specific combining ability and also to determine the gene action involved in the expression of important quantitative traits. Recombination breeding makes use of a fixable additive gene action. To obtain outstanding recombinations in segregating generations, the parents of hybrids must be good general combiners for the trait whose improvement is sought. In addition, the SCA effect should not be significant because the selection of superior recombinations will be hindered by significant SCA effect and it will therefore only be used to select only those hybrids with non-significant SCA effects and having parents with significant GCA effects (Nadarajan, 1986). The segregants of these hybrids are likely to throw recombinants possessing favourable additive genes from both the parents (Sakila et al, 2000).

The combining ability analysis for various characters is presented in Table 1. The higher magnitude of estimates of variance for gca for grain yield, 1000 grain weight, panicle length, panicle girth, number of effective tillers, downy mildew incidence and plant height indicated the presence of predominantly additive gene action controlling these traits. The presence of high gca variances and additive genes indicated that these characters can be further improved in the parental lines by selection. The sca variance was more than gca for days to 50 per cent flowering and fodder yield, indicating non-additive gene action also involved in controlling these traits. A greater improvement for these traits may be brought about by developing hybrids and exploitation of hybrid vigour by other breeding methods.

The gca effects of promising parents are given in Table 2. All the resistant lines, such as APMR 52, APMR 70, ICMB 90111 P-6 and P-1449-2 P-1 having high downy mildew resistance showed negative significant gca effects for this trait which was maximum in APMR 52 followed by ICMB 90111 P-6, P 1449-2 P-1 and APMR 70. In lines, APMR 41 and APMR 57 are good general combiners for yield and yield contributing traits in addition to plant height and dry fodder yield except panicle girth and number of effective tillers per plant respectively. Positive and high gca effects for grain yield and yield contributing traits was observed in APMB 89. In testers, APMR 70 was good general combiner for grain yield, 1000 grain weight, panicle length, panicle girth, number of effective tillers, plant height, dry fodder yield and downy mildew resistance except days to 50 per cent flowering and ICMB 90111 P-6 was good general combiners for grain yield, 1000 grain weight, panicle girth, number of effective tillers, plant height, dry fodder yield, days to 50 per cent flowering and downy mildew resistance except panicle length. The tester P 1449-2 P-1 is good general combiner for yield and yield contributing traits in addition to days to 50 per cent flowering. Best eleven crosses, superior in per ser performance, significant gca and non significant sca are listed in Table 3. Cross APMB 89 x APMR 70 was significantly superior in per se performance with significant gca for yield and yield contributing traits along with downy mildew resistance and therefore it is expected to throw superior segregants for development of lines.

Table 1. Combining ability analysis for 9 characters in Pearl millet

Source	df	Mean sum of square								
		Grain Yield/ Plant	1000 grain weight	Panicle length	Panicle girth	Number of effective tillers	Downy mildew	Plant height	Days to 50% flowering	Dry fodder weight/ plant
Replication	2	1.122	0.104	0.175	0.025	0.029	17.059	10.491	1.662	2.952
Treatment	52	83.072**	8.354**	41.105**	0.432**	0.324**	2708.09**	1594.22**	6.921**	744.38**
gca	12	44.721**	9.638**	68.312**	0.409**	0.602**	3381.18**	1338.29**	5.466**	481.95**
sca	39	13.986**	2.765**	13.88**	0.233**	0.208**	2393.52**	1309.55**	6.699**	527.70 **
Error	104	0.496	0.077	0.204	0.015	0.011	41.20	11.368	0.899	2.410

* Significant at P = 0.05
** Significant at P = 0.01

Table 2. General combining ability effects of parental lines

Parents	Grain yield/ Plant (g)	1000 Grain weight(g)	Panicle length (cm)	Panicle girth (cm)	Number of effective tillers/plant	Downy mildew (%)	Plant height (cm)	Days to 50% 50 % flowering	Dry fodder weight/plant (g)
APMB 89	0.39**	0.38**	0.60**	0.068**	0.14**	3.23*	-19.21**	0.28	-6.88**
	(36.5)	(8.3)	(27.9)	(2.5)	(2.0)	(71.2)	(116.1)	(52.0)	(40.7)
APMR 41	0.42**	0.18**	0.57**	-0.089**	0.08**	0.129	14.67**	-0.54**	8.09**
	(35.1)	(9.9)	(25.4)	(2.0)	(2.3)	(54.5)	(167.7)	(49.0)	(76.6)
APMR 57	0.37**	0.28**	0.75**	0.064*	-0.17**	7.08**	8.79**	1.07**	4.19**
	(34.3)	(11.8)	(25.5)	(2.7)	(2.0)	(68.3)	(146.5)	(52.3)	(53.7)
SE ±	0.118	0.043	0.097	0.025	0.023	1.512	0.696	0.204	0.329
CD 5%	0.238	0.086	0.194	0.050	0.046	3.013	1.387	0.407	0.656
CD 1%	0.313	0.114	0.258	0.067	0.061	4.004	1.843	0.541	0.871
APMR 52	1.44**	0.35**	0.51**	-0.18**	-0.11**	-14.6**	-10.3* *	-1.00**	-11.22**
	(32.0)	(6.1)	(22.6)	(1.7)	(2.9)	(1.2)	(137.4)	(51.3)	(50.3)
APMR 70	2.21**	1.38**	1.43**	0.44**	0.09**	-13.9*	9.03**	-0.10	8.045**
	(32.3)	(12.0)	(24.6)	(2.6)	(3.0)	(3.4)	(163.5)	(50.3)	(72.7)
ICMB 90111 P-6	1.01**	0.64**	-1.59**	0.15**	0.23**	-14.5**	7.81**	-0.63**	7.54**
	(26.1)	(8.0)	(13.5)	(1.8)	(3.4)	(0.0)	(174.7)	(51.3)	(81.9)
P 1449-2 P-1	0.43**	0.14**	3.84**	0.24**	0.27**	-14.4**	-9.39**	-0.57**	-1.69**
	(35.6)	(8.7)	(26.9)	(2.2)	(3.0)	(0.0)	(136.9)	(51.3)	(54.3)
SE ±	0.053	0.019	0.044	0.011	0.010	0.676	0.311	0.091	0.147
CD 5%	0.105	0.038	0.087	0.022	0.020	1.347	0.62	0.182	0.293
CD 1%	0.140	0.051	0.115	0.030	0.027	1.79	0.824	0.242	0.389

Figures in parentheses are mean value ** Significant at 1% & * Significant at 5%

SCA effects of promising crosses for yield & yield contributing traits

Promising crosses	Grain yield/ Plant (g)	1000 Grain weight(g)	Panicle length (cm)	Panicle girth (cm)	Number of effective tillers/plant	Downy mildew (%)	Plant height (cm)	Days to 50 % flowering	Dry fodder weight/ plant(g)
APMB 89 x APMR 70	0.038	0.027	0.020	0.005	0.039	-3.46	-27.26**	-0.354	-14.11**
	(45.2)	(13.1)	(28.8)	(3.1)	(3.2)	1.9	(138.5	(49.7)	69.4
APMB 89 x IP 9011 P-6	0.265	0.127	2.54**	0.032	0.092	-3.07	-9.78**	1.179	-0.932
	(43.8)	(12.5)	(26.0)	(2.8)	(3.4)	(1.7)	(198.7)	(50.7)	(82.1)
APMB 89 x P 1449-2P-1	0.378	0.167	0.007	0.005	0.015	-3.39	8.37**	-0.554	8.00
	(43.4)	(11.8)	(31.2)	(2.9)	(3.3)	(1.4)	(155.5)	(49.7)	(69.4)
APMR 41 x APMR 52	0.145	0.087	0.13	-0.11	-0.113	-1.21	1.53	-0.954	0.637
	(44.1)	(12.0)	(27.9)	(2.2)	(2.8)	(0.3)	(181.6)	(47.3)	(79.9)
APMR 41 x APMR 70	0.151	0.06	0.203	-0.17	0.08	-0.79	0.31	0.146	-3.86
	(45.1)	(13.0)	(28.7)	(2.8)	(3.2)	(1.4)	(196.1)	(49.3)	(94.7)
APMR 41 x ICMB 90111 P-6	0.177	0.06	0.19	-0.243	0.04	-0.3	0.49	-0.321	0.63
	(43.8)	(12.2)	(25.9)	(2.4)	(3.3)	(1.4)	(198.7)	(48.3)	(98.7)
APMR 41 x P 1449-2P-1	0.091	0.001	0.29	-0.103	0.014	-0.68	1.64	-0.054	6.07
	(43.1)	(11.7)	(31.1)	(2.6)	(3.3)	(1.0)	(182.7)	((48.7)	(94.9)
APMR 57 x APMR 52	0.02	0.024	0.043	0.036	-0.24**	-4.38	2.01	-0.913	-0.49
	(44.3)	(12.0)	(28.0)	(2.5)	(2.4)	(1.5)	(176.2)	(51.3)	(74.9)
APMR 57 x APMR 70	0.292	0.031	0.016	0.009	0.130	-4.99	1.1	0.188	1.36
	(44.9)	(13.0)	(29.0)	(3.1)	(3.0)	(1.6)	(194.7)	51.3)	(96.0)
APMR 57 x IP 9011 P-6	0.219	0.131	0.436	0.069	-0.087	-4.93	2.41	-0.946	5.76
	(43.8)	(12.4)	(26.0)	(2.9)	(2.9)	(1.1)	(194.8)	(56)	(99.9)
APMR 57 x P 1449-2P-1	0.366	0.038	0.003	0.009	0.07	-5.25	1.22	(-0.346)	11.19**
	(43.4)	(11.8)	(31.3)	(2.9)	(3.1)	(0.8)	(176.4)	(53.7)	(73.7)
SE	0.333	0.122	0.250	0.071	0.065	0.578	1.968	0.931	4.277
CD 5%	0.665	0.243	0.499	0.143	0.131	1.153	3.924	1.855	8.524
CD 1%	0.883	0.324	0.663	0.190	0.174	1.532	5.213	2.465	11.32

Figures in parentheses are mean value; ** significant at 1% & * significant at 5% level

Also, this cross posses negative sca effects for days to 50% flowering, indicating their importance for developing early lines. APMR 57 x APMR 70 had shown non significant sca for all the characters studied with significantly superior per se performance. APMB 89 x P 1449-2P-1 had non significant sca effect for yield and yield contributing traits along with downy mildew in addition to days to 50 percent flowering and dry fodder yield.

Crosses, APMR 57 x APMR 52 and APMR 57 x ICMB 90111 P-6 also indicate their usefulness for improvement of yield and yield contributing traits except number of effective tillers and are useful in development of early lines along with plant height. These crosses had not contributed substantially in grain yield per se performance because significant negative gca for number of effective tillers and through panicle girth in APMR 41 x ICMB 90111 P-6 and APMR 41 x P 1449-2 P-1. APMR 57 x P1449-2 P-1 showed non significant sca effect for yield and yield contributing traits, downy mildew resistance along with plant and days to 50 per cent flowering.

Resistance to DM appeared to be a dominant character, as the crosses involving one highly resistant and one highly susceptible parent generally showed low DM incidence and negative sca effects for this trait (Singh et, al. 1988). The parents APMR 52, APMR 70, ICMB 90111 P-6 and P 1449-2 P-1 which showed high resistance to DM with significant negative gca effects, were involved in 20 crosses as parent, 16 of which showed negative sca effects for DM resistance. The present study clearly shows the value of combining ability analysis in identifying potential parents for crossing programme to combine desirable traits such as downy mildew resistance, yield and yield contributing traits. This indicated the possibility of improving pearl millet for these traits through selective crossing programme.

References

Anand Kumar K. and Andrews DJ. 1993. Genetics of quantitative traits in pearl millet: A review. Crop Sci., 33: 1-20.

Hash CT, Singh SD, Thakur RP and Talukdar BS. 1999. Breeding for disease resistance. Pages 337-379 in Pearl millet breeding (Khairwal IS, Rai KN, Andrews DJ and Harinarayana G. eds.). New Delhi, India:Oxford & IBH.

Hess DE, Thakur RP, Hash CT, Sereme P and Magill CW. 2002. Pearl millet downy mildew: Problems and control strategies for a new millennium. Pages 37-42 in Sorghum and millets diseases (Leslie JE, ed.). Ames, Iowa, USA: Iowa State Press.

Izge AU, Kadams AM and Gungula DT. 2007. Heterosis and inheritance of quantitative characters in diallel cross of pearl millet (*Pennisetum glaucum* L.). Journal of Agronomy Volume: 6 /Issue:2/ Page No. 278-285

Khairwal IS, Rai KN, Yadav OP and Bhatnagar SK. 2004. Pearl millet cultivars. Mandor, Jodhpur, India: All India Coordinated Pearl Millet Improvement Project, Indian Council of Agricultural Research. 22 pp.

Poelhman JM. 1994. Breeding field crops. 3rd Edn., AVI Pub., Connecticut.

Rai KN, Kulkarni VN, Thakur RP, Haussmann BIG and Mgonja MA. 2006. Pearl millet hybrid parents research: approaches and achievements. Pages 11-73 in Hybrid parent research at ICRISAT (Gowda CLL, Rai KN, Reddy Belum VS and Saxena KB, eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Rao VP, Kadwani DL, Sharma YK, Sharma R and Thakur RP. 2007. Prevalence of pearl millet downy mildew, *Sclerospora graminicola* in Gujarat and pathogenic characterization of its isolates. Indian Journal of Plant Protection 35:291-295.

Singh BB and Singh SD. 1988. Combining ability analysis of downy mildew resistant and susceptible lines of pearl millet (*Pennisetum americanum* (L.) Leeke. Indian Journal genet., 48(2): 171-174.

Singh SD. 1995. Downy mildew of pearl millet. Plant Disease 79:545-550.

Thakur RP, Rao VP, Amrutesh KN, Shetty HS and Datar VV. 2003. Field surveys of pearl millet downy mildew – effects of hybrids, fungicide and cropping sequence. Journal of Mycology and Plant Pathology 33:387-394.

Thakur RP, Shetty HS and Khairwal IS. 2006. Pearl millet downy mildew research in India: progress and perspectives. International Sorghum and Millets Newsletter 47:125-130.

Thakur RP. 1998. Disease management in pearl millet. Pages 53-76 in Disease of field crops and their management (Thind TS, ed.) Ludhiana 141 001, Punjab, India: National Agricultural Technology Information Centre.

Thakur RP. 2008. Pearl millet. Pages 21-41 in Disease management in arid land crops (Lodha satish, Ritu Mawar and Rathore BS, eds.). Jodhpur, India: Scientific Publishers (India).

Yoshida J. and Sumida K. 1996. Mass selection and grain yield of improved population in pearl millet (*Pennisetum typhoides* Rich). Japan J. Crop Sci., 48: 148-155.

Nadarajan N. 1986. Genetic analysis of fibre characters in *Gossypium hirsutum*. Ph.D. Thesis, Tamil Nadu. Agric. Univer., Coimbatore, India.

Sakila M., Ibrahim S.M., Kalamani A. and Backiyarani S. 2000. Evaluation of sesame hybrids through Line x Tester analysis. Sesame and Safflower Newsletter No. 15, 2000. Institute of Sustainable Agriculture (IAS), CSIC, Apartado 4084, Cordoba, Spain.