

Line X Tester studies on combining ability in Pennisetum typhoides.

by

R.P. Jain and J.V. Majmudar^{*}
International Crops Research Institute for
the Semi-Arid Tropics, Hyderabad, India.

The availability of three cytoplasmic male sterile lines, Tift 23, Tift 18D₂A and 23D₂A has permitted the full exploitation of heterosis in Pearl Millet. For a successful breeder and breeding program, it is necessary to select inbreds with high general combining ability against the available male sterile tester parents. The selected inbred lines based on such studies can be used for population improvement program - ie. composites and synthetics development. Information on combining ability of new inbreds received by ICRISAT from Africa, USA and India is essential for the efficient breeding plans. A group of 81 elite inbreds with a high degree of geographic, morphological and genetic divergence were chosen and crossed with three male sterile lines and examined for the nature and magnitude of general combining ability effects of parents and specific combining ability effects of hybrids. Since in the present study a large number of pollen parents were used, it is expected that the conclusions drawn from the study will have wide applicability in comparison to earlier reports on a few parents in a diallel cross (Ahluwalia, Shanker, Jain and Joshi 1962.)

Materials and Methods

The experimental material comprised 81 pollinators and three

* Research Associate and Associate Breeder, Pearl Millet Improvement Program

testers.

The geographic origin of pollen parents is given below.

<u>Country of origin</u>	<u>No. of lines</u>	<u>Name of lines</u>
India	46	J 29-1, J 41, J 87, J 87-2, J 104, J 104-1, J 108, J 151, J 464-1, J 934, J 998, J 1143, J 1204, J 1240, J 1266, J 1301, J 1333, J 1352, J 1372-1, J 1380, J 1610, J 1644, J 1720, J 1811, J 1814, J 1848-1, J 1925, J 1931, J 1963, J 1996, J 2002-4, J 2003, J 2105, J 2158, Bil 3B, Bil 3B-1, A 635, K 559, K 559-1, 71A-97, 71A-722, P5-32, MJA 333, 4912, 7235, 7236.
U.S.A.	22	M 2423, M 2591, M 2675, M 2679, M 2686, M 2687, M 2692, 02935, M 3590, M 3637, M 3642, M 5050, M 5053, M 5055, M 5056, M 5057, M 5062, M 5074, M 5084, M 5095, M 5096, M 5101.
West Africa	11	KG 70, 700481, 700269, 700544, 700688, 700723, MDB 72-47-51, Gero New Strain, Maiwa Composite, Maiwa New Strain, 4912.
Central Africa	2	Ghana via. Nigeria, 7237.

243 crosses were made in rabi, 1973 and they were grown in a replicated experiment in summer, 1974. The observations were recorded on four characters viz., plant height (cm), ear girth (cm), ear length (cm) and grain yield (gm). The method outlined by Kempthorne (1957) was used for obtaining estimates of general and specific ability effects.

Results and discussion

The analysis of variance (Table 1) revealed that hybrids differed significantly among themselves for plant height, ear length and grain yield, and did not differ significantly for ear girth.

In the analysis of variance for combining ability (Table 2) the variance due to general combining ability of the females were higher than males and female X male interaction for all the three characters studied. However variance due to hybrids was higher than males for ear length and grain yield.

Table 1 : ANOVA FOR FOUR CHARACTERS IN 243 HYBRIDS OF PEARL MILLET.

Source of variation	D.F.	Plant Height	Mean squares		Grain Yield
			Ear girth	Ear length	
Blocks	2				
Hybrids	242	1913**	0.12	59.02**	39980**
Error	484	334	0.36	4.40	12992
Total	728				

** Significant at 1% level.

Table 2 : ANOVA OF COMBINING ABILITY FOR THREE CHARACTERS IN PEARL MILLET.

Source	D.F.	Plant Height	Mean squares		Grain Yield
			Ear length		
Male	80	1241**	17.6**		22000**
Female	2	6274**	1231.4**		130000**
Male x Female	160	263	29.3**		66000**
Error	484	111	1.47		433

** Significant at 1% level.

On the basis of general combining ability effects the pollen parents were grouped in classes for all the three characters and are presented in Table 3. The general combining ability of males are presented in Table 4.

GCA for males:

Plant height: Twenty six inbreds showed significant positive g.c.a. effect and 23 inbreds showed significant negative g.c.a. effect. Highest g.c.a. effect was observed for 700481, 700544 and MDB 72-47-51. High negative g.c.a. effect was observed for J 2002-4, J 1931 and this indicated that lines from African origin are good combiners for plant height. If a breeder wants to increase the height of his pearl millet population, he should use inbreds of African origin. For dwarfness lines of Indian origin were better.

Ear length: 20 male parents have expressed significant positive g.c.a. effects and 21 showed significant negative g.c.a. effects. Relatively superior general combiners were 4912, 700544, 700269 and J 1266 respectively while among poor combiners J 104-1, Bil 3B and J 1380 were on the top. African lines were good combiners for ear length while Indian lines were poor combiners for this character.

Grain Yield: 13 inbreds were found to be significantly good general combiners while 12 were significantly poor combiners. Among the good combiners Ghana via, Nigeria, Gero New Strain and J 1301 were on the top and the poor combiners were 700481, J 104-1 and M-5062. Although, two African lines were best combiners for yield ~~but~~ many Indian inbreds were also good combiners. The top ^{four} poor combiners represented Africa, India and U.S.A. A perusal of the g.c.a. effects for males revealed that African and Indian types represent contrasting characteristics.

Table 3: General combining ability of 81 males for three characters in Pearl Millet.

Mean range of each class	GCA class	Lines in class
<u>Plant Height</u>		
204-203.8	58.5 - 41.1	700481 ^{**} , 700544 ^{**}
194.7 - 192.6	41.0 - 27.4	MDB 72-47-51 ^{**} , 700723, 700688 ^{**} Maiwa composite ^{**}
183.4 - 172.2	27.3 - 13.7	M 5084 ^{**} , Gero New Strain ^{**} , M 5055, 700269 ^{**} J 1143 ^{**} , M 2679 ^{**} , P 5-32 ^{**} , M 5095 ^{**} M 5053 ^{**} , M 2591 ^{**} , M 5101 ^{**} , M5096 ^{**} KG 70 ^{**} , 4912 ^{**} , M 5056 ^{**} , Maiwa New Strain ^{**}
171.3 - 158.7	13.7 - 0	M 2423 ^{**} , J 87 ^{**} , 7235 ^{**} , M 5050 ^{**} , M5062, 02925, 71A 966, 71A-97, K 559-1, M 5074, J 998, J 1240, J 1644, M 5051, M 2675, J 87-2, Ghana via. Nigeria, M 2692, M 2686.
155.0 - 144.9	00.0 - 13.7	A 635, J 41, J 1848-1, 7237, J 151, K 559 J 1352, 71A-722, J 464-1, J 104, J 2158, M 3642, M 3590, J 1333, MJA 333, Bil 3B-1, J 1301, J 108 ^{**} , J 1204 ^{**} , J 2105 ^{**} , J 1811 ^{**} M 3637 ^{**} , Bil 3B ^{**} , J 1848 ^{**} , J 104-1 ^{**} .
<u>Ear length:</u>		
27.6 - 28.6	6.40 - 4.81	4912 ^{**} , 700544 ^{**} , 700269 ^{**} , J 1266 ^{**}
25.5 - 26.8	4.80 - 3.21	Maiwa composite ^{**} , MDB 72-47-51 ^{**} , M 242-3 ^{**} , KG-70 ^{**} , J 87-2, J 2105 ^{**} , J 1814 ^{**} , Gero New Strain ^{**} .
24.2 - 24.3	3.20 - 1.61	700723 ^{**} , Maiwa New Strain ^{**} , J 1204 ^{**} , J 1240 ^{**} , 700688 ^{**} , J 998 ^{**} .
22.4 - 23.9	1.60 - 0	7235 ^{**} , J 87 ^{**} , K 559-1, P-5-32, J 2003 M 2591, MJA 333, J 1610, J 1848-1, 7237, M 5056, M 5101, J 2158, Ghana via. Nigeria, 7266, 700481-1, M 5084.
22.3 - 20.8	- to 1.60	J 1352, M 5062, J 1963, J 1143, M 5050, M 5095, 71A-722, J 1996, J 1925, M 5096, M 5055, Bil 3B-1, J 934, J 1720, J 1333 M 2679, J 464-1, 71A 96-6, M 5053, 71A-97, J 1372-2, M 2686, K 559, A 63, J 29-1, J 1811 ^{**} , M 3590 ^{**} , J 193 ^{**}

Mean Range of each class	GCA class	Lines in class
20.7 - 19.1	-1.61 to 3.20	M 3637*, M 3642**, M 2687**, 0-295** M 2675**, M 5074**, M 2002-4**, M2692**, J 1644**, J 108**, M 5057**.
19.0 - 18.6	-3.21 to 4.80	J 151**, J 1301**, J 41**, J 104**, J 1380**, Bil 3B**.
18.6 - 16.4	-4.81 to 7.40	J 104-1**
<u>Grain Yield:</u>		
654 - 621	258.0 - 172.1	Ghana Via. Nigeria**, Gero New Strain**.
607 - 546	172.0 - 86.1	J 1301**, J 1352, 4151**, J 2105**, J 2158**, J 1811*, J 998**, J 1266**, MDB 72-47-51**, J 1240**, K 559-1**.
519 - 549	86.0 to 0	02935, M 2679, J 1143, MJA 33B, J 1610, J 1372-2, J 1333, J 87-2, Maiva New Strain, J 2002-4, 7235, J 1204, J 29-1, K 559, 700544, 71A 96-6, A 635, Bil 3B-1, J 934, J 1848-1, J 87, P 5-32, 7236 4912, Maiva composite, M 2591, M 2423, 71A-97, J 1996, J 1380.
444-- 365	0 to 86.0	J 1644, J 108, 7237, J 104, M 5057, M 5095, 71A-722, J 1925, J 464, J 12.0 M 5055, 700688, Bil 3B, J 1931, J 41, M 5084, J 2003, M 3590, KG 70, M 2692, M 2686, M 5096, J 1963, 700723 M 37 M 5050, 700269*, M 5101*.
360 - 305	-86.1 to -172.0	M 5056*, M 2675**, M 3642**, J 1814** M 5053**, M 2687**, M 5074**, M 5062**, J 104-1**
307 - 149	-258.0 to -344.0	700481**

Table 4 : General combining ability effects of females for three characters in Pearl Millet.

	<u>Plant Height</u> GCA effects	<u>Ear length</u> GCA effects	<u>Grain Yield</u> GCA effects
18D ₂ A	-3.58**	-4.50**	-46.04**
23D ₂ A	10.16**	2.36**	27.49**
23A	-6.24**	2.13**	18.53**
SE ±	1.17	0.134	7.31
LSD at 5%	3.23	0.37	20.23
LSD at 1%	4.25	0.49	26.58

The material from African continents ~~is tall~~ is tall with long heads while the material from Indian continent is relatively dwarf and bears small to medium size heads. It will be very interesting if these two groups are crossed and from the segregating populations selection is made for long head and short stature types. It is clear from the combining ability for yield that both tall and dwarf types can give high yield. The reason may be that dwarf types have more number of heads while tall types have a few long heads. The harvest index may be increased if long head characteristic is introduced in short stature genotypes. Therefore, African material could be used in intervarietal combination to develop new inbreds having desirable characters from exotic material and the improved inbred should be used to find out elite restorers.

The estimates of s.c.a. effects for best three hybrids with each male sterile line for three characters are given in Table 5. It is noteworthy that the crosses which had high significant s.c.a. effects for grain yield were not highly significant for plant height and ear length. For grain yield the combinations of J 998, Ghana via. Nigeria and J 1301 on ms 23A, M 2675, J 1352 and MDB 72-47-51 on ms 23D₂A and J 151, J 2158 and K 559 on ms 18D₂A were promising.

GCA for females:

Among the females, 23D₂A was found to be best general combiner for plant height, ear length and grain yield. MS 18D₂A was poor combiner for all the three characters as evident by negative gc.a. effects. MS 23A was good combiner for grain yield and ear length. MS 23D₂A which is best combiner for all the three characters is highly susceptible to downy mildew disease. Hybrids developed by

Table 5 : SPECIFIC COMBINING ABILITY EFFECTS OF 3 BEST HYBRIDS FOR THE THREE CHARACTERS IN PEARL MILLET.

	18D ₂ A	SCA effect	23D ₂ A	SCA effect	23A	SCA effect
Plant height.	700544	48.5	700481	49.8	Maiva New Strain	32.7
	02935	47.8	71A 96-6	29.9	02935	22.1
	Gero New Strain	40.9	700723	27.8	J 464-1	31.7
	SE \pm 0.67	LSD 5% 1.86			LSD 1% 2.45	
Ear length	Tall long head	11.3	M 3590	3.8	J 87-2	8.2
	700269	10.3	700544	2.9	J 132	3.3
	71A-722	9.4	J 934	2.6	J 1266	3.1
	SE \pm 0.077	LSD 5% 0.22			LSD 1% 0.28	
Grain Yield	J 1516	188.89	M 2675	157.62	J 998	259.60
	J 2150	146.89	J 1352	136.62	Ghana via. Nigeria	219.0
	K 559	160.89	MDB 72-47-51	132.12	J 1301	180.60
	SE \pm 42.2	LSD 5% 11.70			LSD 1% 15.38	

using this line will also be susceptible to downy mildew. Therefore, incorporating resistance to downy mildew into 23D₂A is suggested to obtain resistant hybrids. As regards MS 23A which is second good combiner, some resistant mutants have been identified at Indian Agricultural Research Institute, New Delhi and this ms line is ^{now} used in all the released hybrids of India. As regards 18D₂A, a dwarf and downy mildew resistant ms line but is a poor combiner with long ear head. This ms line in combination gives hybrids having loose head, sparse seed setting and poor grain quality.

From the above studies, it is possible to select good inbreds. They can be used to develop composites, synthetics and hybrids. This work has already been initiated at this Institute and selected inbreds are being used in the population improvement program. Murty, Tiwari and Marinarayana (1967) have also indicated the possibility of creating germ plasm complexes from the material involving desirable inbreds and hybrids. The advance material from the composite may be used to develop inbreds by the breeders.

Summary

Nature and magnitude of combining ability in 243 crosses of Pearl Millet involving 3 female parents and 81 male parents was studied in respect of four characters viz., plant height, ear length, ear girth and grain yield. Hybrids did not differ significantly for ear girth. Therefore, combining ability was estimated for three characters. Good general combiners and specific combiners for each characters was identified and were used for composite and hybrid development program. The possibility for the development of new good inbreds has been discussed.

ACKNOWLEDGEMENTS

We are grateful to Dr. R.W. Cummings, Director and Dr. J.S. Kanwar, Associate Director, for providing the necessary facilities, Dr. Hugh Doggett, Leader of Cereals Improvement Program and Mr. D.J. Andrews, Millet Breeder for their encouragement.

REFERENCES

- Ahluwalia, M., Shanker, K; Jain, S.K., and Joshi, A.B. (1962) A diallel cross study of combining ability for some quantitative characters in Pearl Millet. II. Tiller, height and yielding ability. Indian J. Genet. 22: 45-53.
- Kempthorne, O. 1957. An introduction to Genetic Statistics. 1st edition. PP 458-71. John Wiley and Sons, New York.
- Murty, B.R., Tiwari, J.L. and Harinarayana, G. 1967. Line X Tester analysis of combining ability and heterosis for yield factors in Pennisetum typhoides (Barn) S & H. Indian J. Genet. 27: 238-245.