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Line x Tester Analysis in Pearl Millet

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Abstract: Nine male sterile lines and six pollinators were crossed in line x tester fashion to develop 54 single hybrids. The combining ability analysis revealed the significance of lines, testers and line x tester, indicating the presence of diversity among parents and hybrids. Contribution of line x tester was highly significant for all the characters. Non-additive gene effects were predominant for effective tillers whereas substantial additive gene effects were noted for days to flower and ear length. A_1 cytosterile system male sterile lines were found to be good general combiners for grain yield and dry fodder yield. Lines HMS 1A, HMS 2A, HMS 9A and MS 81A combined significantly better for earliness. The testers ICR 161, HTP 31, H 94/36 showed significantly positive GCA effects for grain yield as well as dry fodder yield.

Key words: Combining ability, cms systems, pearl millet.

Pearl millet hybrid breeding program was initiated with the development of first male sterile line Tift 23A (Burton, 1958). With the availability of Tift 23A, development of fodder hybrids in USA and grain hybrids in India increased significantly. In India first grain hybrid HB 1 was released in 1965. Since then thousands of hybrids have been developed and tested and about 60 released in the country.

So far, most of the commercial grain hybrids released are based on a single source of A_1 cytoplasm from Tift 23A. The diversification of cytoplasmic male sterile (cms) sources is essentially needed for reducing the risk and stability of hybrid breeding research in pearl millet. There have been reports of existence of diverse types of cytoplasms in pearl millet, for instance A_1 (Burton, 1965 a, b), A_2 and A_3 (Burton and Athwal, 1967), A_4 (Hanna, 1989), A_5 (Rai, 1995), Ex-Bornu (Aken'Ova, 1985), PT732A (Appadurai *et al.*, 1982), but practically A_1 system has been exploited for the development of productive pearl millet hybrids. Therefore, the present study was aimed to identify the combining ability of diverse male sterile lines and pollinators and to identify superior hybrid combinations.

Materials and Methods

Nine male sterile lines (representing various cytosterile systems), viz., HMS 7A, HMS 9A, MS 89111A and MS 81A (A_1), 81A4 (A_4), 81A5 (A_5), HMS 1A, HMS 2A, 81A$_{egp}$ (different system) with six pollinators namely, CSSC 46-2, ICR 161, HTP 31, H 94/46, H 94/36 and H 94/56 were crossed in line x tester fashion. The 54 F_1 hybrids thus developed were sown in randomized block design with three replications in 4 m long, two-row plots, with 60 cm row spacing, and 15 cm plant to plant spacing at CCS Haryana Agricultural University Research Farm, Hisar, in 1998 kharif season following

recommended agronomic practices. The data were recorded on five competitive plants in each replication on days to 50% flowering, grain yield, dry fodder yield, plant height, ear length and effective tillers per plant. The analysis of variance was carried out according to Panse and Sukhatme (1967), while the combining ability analysis was done according to Kempthorne (1957).

Results and Discussion

The analysis of variance of lines x testers mating design indicated significant mean squares due to lines, testers and lines x testers (Table 1). This warranted estimation of general combining ability (GCA), specific combining ability (SCA) variances and GCA and SCA effects. The differences due to testers and lines, when tested against interaction, were significant for all the characters except effective tillers per plant. This shows that gene effects are not underestimated.

The predictability ratio based on the estimates of GCA and SCA variances revealed preponderance of non-additive genetic components for grain yield/plant, dry fodder yield/plant, plant height and effective tillers/plant. Substantial additive gene effects were noted for days to flowering and ear length. The predictability ratio estimated according to Baker (1978) vouched for the gene effects estimated through $\bar{\sigma}$SCA/$\bar{\sigma}$GCA ratio. Similar results for yield and its contributing traits in this crop have been reported earlier by Virk (1988), Singh (1996) and Kerale *et al.* (1998).

GCA effects presented in Table 2 showed that only females HMS 7A, HMS 9A, MS 89111A and 81A of A_1 system combined significantly better for grain yield and dry fodder yield. HMS 1A and HMS 2A of other system and HMS 9A, 81A of A_1 system with significant negative SCA effects were good general combiners for earliness. The lines 89111A, $81A_1$, $81A_{egp}$, $81A_4$ and $81A_5$ combined significantly better for ear length. For plant height HMS 7A, 89111A and $81A_5$ and for effective tillers $81A_{egp}$ shows that 81A is a very good combiner for grain yield and several other traits. Several hybrids based on 81A, i.e., MH 179, HHB

Table 1. Analysis of variance for combining ability in pearl millet

Sources of variation	df	Mean sum of squares					
		Days to 50% flowering	Grain yield	Dry fodder yield	Plant height	Ear length	Effective tillers/ plant
Replications	2	3.930	0.068	0.212	111.068	0.295	2.990
Lines	8	177.817**	1.397**	8.373**	3982.949**	110.308**	7.214**
Testers	5	568.273**	1.876**	13.531**	3557.045**	40.461**	5.624**
Lines x testers	40	26.714**	0.465**	2.862**	915.484**	12.029**	4.268**
Error	106	1.366	0.026	0.166	137.376	1.838	1.268
Predictability ratio		1.046	0.560	0.568	0.736	1.073	0.371
$\bar{\sigma}$SCA/$\bar{\sigma}$GCA		0.912	2.566	2.520	1.718	0.865	4.388

** Significant at 0.1% level.

Table 2. General combining ability effects of lines and testers in pearl millet

	Days to 50% flowering	Grain yield	Dry fodder yield	Plant height	Ear length	Effective tillers/ plant
Lines						
HMS 1A	-1.401*	-0.301*	-0.832*	-23.153*	-4.769*	0.306
HMS 2A	-4.457*	-0.251*	-0.768*	-17.053*	-3.036*	0.422
HMS 7A	1.876*	0.202*	0.293*	7.002*	-1.052*	-0.178
HMS 9A	-1.290*	0.161*	0.499*	-0.086	0.070	-0.167
MS 89111A	2.988*	0.421*	1.071*	23.875*	1.236*	-0.344
81A	-1.901*	0.271*	0.470*	3.514	1.798*	-0.278
$81A_{egp}$	5.988*	0.274*	-0.837*	-9.175*	1.748*	1.356*
$81A_4$	1.901*	0.042	-0.073	-0.014	2.242*	-0.889*
$81A_5$	0.098	-0.270*	0.177	15.091*	1.764*	-0.228
Testers						
CSSC 46-2	-2.327*	-0.156*	-0.582*	-6.172*	0.546*	-0.113
ICR 161	3.080*	0.241*	0.493*	2.362	-0.577*	-0.439*
HTP 31	-5.809*	0.089*	0.229*	-2.361	-1.484*	-0.172
H 94/46	2.858*	-0.154*	-0.166*	6.062*	1.472*	0.868*
H 94/36	5.895*	0.331*	0.973*	16.976*	1.138*	-0.217
H 94/56	-3.698*	-0.352*	-0.947*	-16.868*	-1.095*	0.072
SE± (lines)	0.275	0.038	0.096	2.766	0.320	0.265
SE± (testers)	-0.225	0.038	0.078	2.259	-0.261	0.216

* Significant at 0.5% level.

50, HHB 60, AHB251, GHB 235, RHB 58 have been released and notified in India. MS 89111A has shown good results and one productive hybrid HHB 94 has been released in Haryana state for general cultivation. Among the testers ICR 161, HTP 31 and H 94/36 showed significantly positive GCA effects for grain and dry fodder yield. These three testers can prove to be ideal restorers.

The number of crosses showing desirable significant SCA effects for various characters were 19, 19, 16, 10, 10 and 5 for days to 50% flowering, grain yield/plant, dry fodder yield/plant, plant height, ear length and effective tillers/plant, respectively. Unfortunately the crosses were never the same for all the characters, showing different gene combinations were responsible for the inheritance of the characters. However, the crosses presented in Table 3 showed significant desirable SCA effects and high *per se* performance for number of characters. These crosses may be exploited to developed hybrids for a particular trait.

Table 3. Best crosses selected on the basis of high per se and significant SCA effects

Sr. No.	Superior crosses	Characters
1.	HMS 1A x HTP 31	Grain yield
2.	HMS 1A x H 94/56	Effective tillers and earliness
3.	HMS 2A x CSSC 46-2	Earliness
4.	HMS 2A x H 94/46	Effective tillers and earliness
5.	HMS 2A x H 94/36	Dry fodder yield and tall
6.	HMS 7A x CSSC 46-2	Earliness, grain yield, dry fodder yield
7.	HMS 7A X ICR 161	Dry fodder yield
8.	HMS 7A x H 94/46	Tall
9.	HMS 9A x ICR 161	Grain yield, dry fodder yield, tall
10.	HMS 9A x HTP 31	Earliness, effective tillers
11.	HMS 9A X H 94/46	Earliness
12.	HMS 9A X H 94/56	Tall
13.	89111A x CSSC 46-2	Grain yield, dry fodder yield, ear length
14.	89111A x HTP31	Earliness, ear length
15.	89111A x H 94/36	Tall
16.	89111 x H 94/56	Effective tillers
17.	81A x ICR 161	Grain yield, dry fodder yield
18.	81A x H 94/46	Grain yield, dry fodder yield
19.	81A x H 94/36	Grain yield
20.	81A x H 94/56	Earliness
21.	$81A_{egp}$ x CSSC 46-2	Tall
22.	$81A_{egp}$ x H 94/36	Ear length, effective tillers
23.	81 A_4 x ICR 161	Ear length
24.	81 A_4 x H 94/56	Earliness, tall, ear length
25.	81 A_5 x HTP 31	Dry fodder yield, tall, ear length
26.	$81A_5$ x H 94/36	Ear length
27.	$81A_5$ x H 94/56	Earliness

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