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Combining Ability Analysis of Newly Developed Male Sterile Lines of Pearl Millet

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Abstract: Seven newly developed male sterile lines and eleven advanced inbreds of pearl millet (*Pennisetum glaucum*) were crossed in a line x tester fashion at Haryana Agricultural University, Hisar, to develop 77 single cross hybrids. The combining ability analysis revealed the significance of lines, testers and lines x testers, indicating the presence of diversity in parents and hybrids as well. The preponderance of non-additive component for grain yield and that of additive for days to 50% flowering and earhead length was observed. Estimates of GCA effects revealed that among females (lines) ICMS 93111A, followed by ICMS 92777A were good general combiners for grain yield and earhead length. ICMS 94222A was top general combiner for earliness, followed by ICMS 95444A. Among the male (testers) parents the good combiners were ICR 161, CSSC 46-2, HTP 91/32 for grain yield, H 90/4-5, H 77/371, H 77/29-2 and IH 8 for earliness and CSSC 46-2 and HTP 91/34 for earhead length.

Key words: Pearl millet, combining ability, male sterile lines.

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is the staple food and feed crop of the inhabitants of world's hottest and driest areas. Major breakthrough in its productivity and production was observed following the release of single cross hybrids in mid-sixties. A glance at hybrids developed and released in India clearly indicates the utilization of only a few male sterile lines viz., Tift 23A, MS 5141A, MS 81A, MS 843A during 1965-1990 (Khairwal *et al.*, 1990). Large-scale cultivation of hybrids based on a single male sterile line resulted in devastating epidemics of downey mildew caused by *Sclerospora graminicola* (Sacc.) J. Schrot. The crop was nearly wiped out in 1970 and 1975 due to susceptibility of Tift 23A and MS 5141A, respectively. The studies by Anand Kumar *et al.* (1983), Yadav *et al.* (1993) and Dave (1987) indicate that main reason of downy mildew epidemic was lack of genetic diversity. Therefore, the present study was aimed to identify diverse male sterile lines and elite inbred pollinators that can be utilized to produce superior hybrid combinations.

Materials and Methods

Seven newly developed cytoplasmic male sterile lines (ICMS 92777A, ICMS 93111A, ICMS 94111A, ICMS 94222A, ICMS 95111A, ICMS 95444A and ICMS 95555A) bred at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) were crossed in a line x tester fashion with eleven diverse elite inbreds (ICR 161, HP 8603, H 77/371, H 77/29-2, G 73-107, H 90/4-5, IH 8, CSSC 46-2, HTP 91/32, HTP 91/34 and HTP 94/2) developed at the CCS Haryana Agricultural University, Hisar. The 77 F_1 hybrids thus developed were sown during 1997 rainy season in randomized adjacent blocks in 2 x 5 meter row plots with three replications. Spacing between and within row was 50 cm and 15 cm, respectively. The experiment was conducted at the Research Farm of CCS HAU, Hisar. For recording observations on 50% flowering and earhead length, five competitive plants were randomly selected in each plot. The data thus gathered were subjected to combining ability analysis following Kempthorne (1957).

Results and Discussion

The analysis of variance for line x tester mating design indicated significant mean squares due to lines, testers and line x tester interactions (Table 1), indicating thereby sufficient amount of genetic variability in the material used. This warranted estimation of general combining ability (GCA), specific combining ability (SCA), variances and GCA and SCA effects. The mean squares due to lines (females) were much higher than testers (males) only for grain yield, indicating thereby that a large portion of variation was accounted for by the differences among male sterile lines. For other characters mean squares due to both line and testers were largely at par, however, the latter had a slight edge.

The computation of predictability ratio based on estimates of GCA and SCA variances revealed preponderance of non-additive genetic component for grain yield and that of additive component for days to 50% flowering and ear length. The results on preponderance of non-additive component for grain yield and that of additive for days to 50% flowering and earhead length are in agreement with those of Kerale *et al.* (1998).

The estimates of GCA effects in respect of 7 females (lines) and 11 males (testers) (Table 2) revealed that among line ICMS 93111A, followed by ICMS 92777A, were the top general combiners for high grain yield and increased earhead length. ICMS 95555A and ICMS 93111A were good combiners for late flowering, whereas ICMS 94222A and ICMS 95444A with negative

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

Source of variation	df	Mean squares		
		Grain yield	Days to 50% flowering	Ear length
Lines	6	118.257**	32.830**	24.552**
Testers	10	52.085**	44.753**	35.710**
Lines x Testers	60	54.083**	4.817*	3.923**
Error	76	2.782	1.866	1.761
σ^2gca		3.065	1.087	0.821
σ^2sca		25.651	1.476	1.081
σ^2gca/σ^2sca		0.119	0.736	0.759
Predictability ratio		0.213	0.848	0.863

Table 2. General combining ability effects of line and testers of pearl millet for three traits

Line/Tester	Grain yield	Days to 50% flowering	Earhead length
Line			
ICMS 92777A	1.429**	-0.3777	1.344**
ICMS 93111A	1.797**	1.169**	1.799**
ICMS 94111A	-1.111**	-0.195	0.117
ICMS 94222A	-2.649**	-2.558**	-2.701**
ICMS 95111A	-1.816**	0.987**	0.162
ICMS 95444A	0.348	-1.558**	-0.974**
ICMS 9555A	1.203**	2.532**	0.258
SEm±	0.356	0.291	0.283
Tester			
ICR 161	3.098**	4.065**	-0.253
HP 8603	-0.987**	0.208	-1.396**
H 77/371	-0.714	-3.078**	0.104
H 77/29-2	-1.545**	-2.935**	0.104
G 73-107	0.425	1.493**	0.604
H 90/4-5	-0.274	-3.649**	-4.110**
IH 8	-1.490**	-1.078**	-4.390**
CSSC 46-2	0.253	2.351**	-1.968**
HTP 91/32	1.471**	-0.221	0.104
HTP 91/34	0.330	2.636**	2.890**
HTP 94/2	-0.567	0.208	-0.468
SEm±	0.446	0.365	0.356

GCA effects were the good general combiners for early flowering. Among male parents ICR 161 and HTP 91/32 for grain yield, H 77/371 and H 90/4-5 for early flowering and CSSC 46-2 and HTP 91/34 for earhead length were among the top good general combiners (Table 2).

The estimates of ten top crosses selected on the basis of SCA effects (Table 3) revealed that the cross combinations ICMS 93111A x HP 8603, followed by ICMS 95555A x H 90/4-5 and ICMS 93111A x HTP 91/32 for grain yield, ICMS 93111A x HTP 91/34, followed by ICMS 94222A

Table 3. Top ten crosses selected on the basis of desirable sca effects and high per se performance

	Days to 50% flowering	Earhead length
ICMS93111A x HP8603 (8.782; 42.36)*	ICMS94222A x H77/371 (-6.013; 37.00)	ICMS93111A X HTP91/34 (4.701; 31.00)
ICMS95555A X H90/4-5 (7.787; 40.61)	ICMS95444A X H90/4-5 (-4.442; 39.00)	ICMS94222A X IH8 (3.559; 20.50)
ICMS93111A X HTP91/32 (6.113; 41.94)	ICMS94222A X ICR161 (-4.156; 46.00)	ICMS95111A X H77/371 (3.123; 25.00)
ICMS95111A X H77/29-2 (4.762; 27.56)	ICMS94222A X HTP94/2 (-3.532; 43.00)	ICMS94111A X HTP91/34 (2.883; 27.50)
ICMS95555A X ICR161 (4.695; 41.70)	ICMS95555A X CSSC46-2 (-3.532; 50.00)	ICMS95444A X HTP91/32 (2.760; 23.5)
ICMS92777A X HTP91/34 (4.388; 35.47)	ICMS92777A X H77/29-2 (-3.338; 50.00)	ICMS95444A X HTP91/32 (2.532; 24.50)
ICMS92777A X HTP91/32 (3.91; 36.81)	ICMS94111A X ICR161 (-2.519; 50.00)	ICMS92777A X CSSC46-2 (2.156; 29.50)
ICMS94222A X HTP94/2 (3.823; 26.03)	ICMS95444A X H77/29-2 (-2.156; 42.00)	ICMS95111A X HP8603 (2.123; 22.50)
ICMS95444A X HTP91/32 (3.677; 34.17)	ICMS95111A X G73-107 (-2.130; 49.00)	ICMS95444A X ICR161 (2.117; 22.50)
ICMS95555A X HTP91/34 (3.533; 33.31)	ICMS95444A X IH8 (-2.012; 49.00)	ICMS95444A X H77/371** (1.759; 22.50)

* Figures in parenthesis denote the sca effects and mean per se performance q ha^{-1} grain yield, days for time to flowering and cm for earhead length),

** Non-significant - sca effect.

x IH 8 and ICMS 95111A x H 77/371 for ear length were the top specific cross combinations. For early flowering ICMS 94222A x H 77/371, followed by ICMS 95444A x H 90/4-5 ICMS, 94222A x ICR 161 were the best crosses with negative SCA effects.

From Table 3 it can be concluded that in order to get good specific cross combinations, at least one of the parents should have high GCA effect. Further, an examination of rank correlation between 10 crosses, selected on the basis of SCA effects, and their mean *per se* revealed that performance and SCA effects of the crosses are significantly correlated in case of grain yield (r = 0.71), days to flowering (r = 0.48) and ear length (r = 0.35). This clearly indicate that instead of working out SCA effects one can depend on the *per se* performance of the crosses.

Preponderance of non-additive type of gene-effects for grain yield clearly indicates that present material can be best exploited for the development of hybrids like ICMS 93111A x HP 8603 (42.36 q ha^{-1}), ICMS 93111A x HTP 91/32 (41.94 q ha^{-1}) and ICMS 95555A x ICR 161 (41.70 q ha^{-1}).

All these hybrids possessed very high grain yield as against the best hybrid check HHB50 (30.12 q ha^{-1}). These hybrids can be evaluated in time and space to confirm their superiority over a wide range of environments before they are finally released for general cultivation.

The preponderance of additive type of gene-effects for days to 50% flowering and ear length can be best exploited by random mating of the parents ICMS 94222B, ICMS 95444B, H 90/4-5, H 77/371 for grain yield and ICMS 92777B, ICMS 95111B, CSSC-46-2 and HTP 91/34 for earhead length. The random mated population thus developed can be best exploited by drawing good inbreds from this population. These inbreds can be further used in developing superior hybrids.

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