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Combining Ability and Gene Action Studies for Grain Yield and Component Characters in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.] Under Arid Condition of Rajasthan

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ABSTRACT

The experiment was conducted with 50 hybrids which were generated through L × T mating design using 10 lines and 5 testers as parental material along with 3 standard check hybrids and evaluated in RBD with 3 replications during kharif 2014 season to study combining ability along with inheritance of grain yield and component characters of pearl millet. The analysis of variance revealed significant difference among all the hybrids for all the characters studied. Ratio of GCA and SCA variances was below unity for all the characters which indicate of greater role of non-additive genetic variance in the inheritance of these traits. The per cent contribution of lines to total variance in hybrids were higher in magnitude as compared to testers for the characters ear head length (cm), test weight (g) and harvest index while testers were higher for the characters days to 50% flowering, days to maturity, plant height (cm), no. of effective tillers/plant, ear head diameter, biological yield/plant (g) and seed yield/ plant (g) and lines × testers were higher for characters viz. harvest index, ear head diameter (cm) and ear head length. The degree of dominance ($\sigma^2D/\sigma^2A)^{0.5}$ was found greater than unity for all the characters, indicating the over dominance. Among the female parents, RMS 6A, ICMA 92777 and JMSA 20073 were identified as good general combiners for grain yield per plant and some other component traits. Amongst male parents, H77/833-2 and RIB 57SO5 were good general combiner for most of the characters. Among the fifty hybrids, nine hybrids showed the best performance with significantly positive sca effect for grain yield. The cross combinations JMSA 20073 × RCB-IC 925 S3 19-3-1, ICMA 04999 × H77/833-2 and RMS 6A × MIR 97092-2-4 were recorded the significant sca effect in desirable direction for grain yield and some other important characters. Thus, these hybrids can be commercially exploited through heterosis breeding programme after testing in multi-locational trial.

Key words: *Pennisetum glaucum, Combining ability, L × T mating design, GCA, SCA.*

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INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R.Br.], is an annual tillering diploid (2n=2x=14) crop, belongs to family Poaceae, subfamily Panicoidae, commonly known as bajra, believed to be originated in West Africa and from there it was introduced to India. Pearl millet is of great importance in the arid and semi-arid tropics, where it is a staple food for millions of people and also form an important fodder crop for livestock population in arid and semi-arid regions of India. The crop is generally grown in area where environmental conditions, especially rainfall, temperature and soil fertility, are too harsh to grow other cereal crops. The improvement in bajra crop in India started as early as in 1920, but the real breakthrough was made when the first, and the most widely used cytoplasmic genetic male sterile line Tift 23A was utilized[6], which permitted development of hybrids in India. Subsequently, availability of several cytoplasmic genetic male sterility sources has facilitated development and release of number of high yielding hybrids with increased drought tolerance and resistance to biotic stress[1,7].

India is the largest producer of pearl millet with an annual production of 9.25 mt from an area of 7.8 mha with productivity being 1270 kg/ha. [2]. Five states viz. Rajasthan, Maharashtra, Gujrat, U.P. and Haryana accounts for nearly 90% percent of the total of the 10 mha cultivable pearl millet area in India.

Rajasthan occupies first position in area and production of pearl millet in India, Which contribute more than 50% pearl millet area of the country. In Rajasthan, it is cultivated on 4.07 mha area with the production of 4.45 mt and productivity 1093 kg/ha [3].

It is well known fact that high yielding parent or line may or may not combine well, when used in hybridization. Therefore, a study on general combining ability and specific combining ability effects for quantitative traits of parents is essential. Since, general combining ability (gca) estimate the average performance of a line in crosses, it reflects the breeding value of the line. Such studies also elucidate the nature and magnitude of gene actions involved in the inheritance of grain yield and its components, which will decide the breeding programme to be followed in segregating generations. Good combining ability of improved inbreds is essential because inbreds are used to produce hybrids and synthetics. Both GCA and SCA are important, depending on the use of the inbred and traits of interest. Many biometrical procedures have been developed to obtain information on combining ability, a Line × Tester analysis is one among them which is widely used to study combining ability of the parents to be chosen for heterosis breeding. It also provides a guideline to determine the value of source populations and appropriate procedures to use in crop improvement programme. This design is useful in evaluation of large number of germplasm lines at a time in terms of combining ability variances and effects[25]. This knowledge in fact helps in exploiting heterosis for commercial purpose.

In pearl millet selection of parents, for hybridization is an important aspect for crop improvement programme. Selection of parents based on their per se performance and combining ability is a pre- requisite for development of new inbreds as parents. As such study indented to determine combining ability, which not only provides information regarding choice of parents, but it also simultaneously illustrates the nature and magnitude of gene effects.

Material and methods

Parental line and Hybrid development

Present investigation comprised 10 male sterile lines viz., RMS 6A, RMS 7A, RMS 18A, RMS 21A, ICMA 843-22, ICMA 92777, ICMA 93333, ICMA 97111, JMSA 20073 and ICMA 04999 were crossed with 5 diverse restorer lines viz., H77/833-2, RIB 57SO5, MIR 97092-2-4-1, RCB-IC 925 S3 19-3-1 and BIB I 6 in a line x tester mating design during summer 2014 at ICRISAT.

Field layout

The resultant 50 cross combinations along with the standard check, were grown in a randomized block design with three replications during *Kharif* 2014 at Agricultural Research Station, Bikaner, SKRAU, Bikaner (Rajasthan), India. Each entry was planted in a 4 meter long row with inter and intra row spacing of 50 × 15 cm. Two row of each entry was planted in each replication. Recommended agronomic practices and plant protection measures were adopted to raise healthy crop.

Data analysis

The observations were recorded on individual plant basis on 10 randomly selected plants for each entry, in each replication for characters *viz.*, plant height, number of effective tillers per plant, ear head diameter, ear length, 1000-seed weight, biological yield per plant, harvest index (%), and seed yield per plant while two characters namely days to 50 per cent flowering and days to maturity were recorded on whole plot basis.

Statistical Analysis

The mean values of the characters measured in 50 genotypes in each replication were analyzed for analysis of variance, estimation of standard error and critical difference by adopting the method suggested by Panse and Sukhatme[18]. The combining ability analysis was carried out using line x tester mating design as per the procedure suggested by Kempthorne[13].

Result and discussion

The analysis of variance for combining ability (**Table.1**) revealed that mean square due to crosses were highly significant for grain yield and its components which indicated that there were significant differences in hybrids for all the characters. Thus, it revealed the presence of significant variability in the material studied. When the effects of crosses was partitioned in to lines, testers and line x tester effects, the lines recorded significant differences for plant height, ear head length (cm) and test weight (g). Mean sum of squares due to testers were significant for all the characters except ear head length, harvest index which signifies that testers were diverse for these characters. The interaction effects (lines x testers) were found to be significant for all the traits. The above results suggested that the parents used in this study were diverse and significant difference exists between them and also resulted in creation of substantial genetic variability in the crosses. Such variations in parents have also been reported earlier by Rathore[23] *et al.* and Patel[20] *et al*. However, mean squares due to testers were larger than those due to lines for all the characters except plant height indicating more diversity among the testers for these characters.

Analysis of variance for combining ability indicated that the variance due to sca was higher than gca for all the character (**Table 1**). Whereas, gca and sca ratio (σ^2_{gca}/ σ^2_{sca}) was less than unity for all the characters. This indicated that non-additive components played greater role in the inheritance of these characters. This showed the possibility of improvement of these traits through heterosis breeding. The presence of predominantly large amount of non-additive gene action would be necessitating the maintenance of heterozygosity in the population. Breeding method such as biparental mating followed by reciprocal recurrent selection may increase frequency of genetic recombination and hasten the rate of genetic improvement. The present findings are akin to those reported by Yadav[30] *et al.*, and Unnikrishnan[27] *et al.*, Vaghasiya[29] *et. al.*, Chaudhary[8] *et al.* and Bhadalia[4] *et al*. Analysis also revealed higher magnitude of mean sum of squares for SCA than GCA for all characters, indicated the preponderance of non-additive gene action to control these characters[9] and therefore, heterosis breeding will be rewarding.

The degree of dominance ($\sigma^2 D/ \sigma^2 A)^{0.5}$ was found greater than unity for all the characters, indicating the over dominance behavior of interacting alleles. Similar results were also observed by Rathore[23] *et al.* and Patel[20] *et al*. Since over dominance gene action is involved for inheritance of grain yield, heterosis breeding would be most effective approach to improve the character. Pearl millet is cross pollinated crop; hence, heterosis can be effectively utilized for development of hybrids.

General Combining Ability (GCA) effects:

In a crop improvement programme, much of the success depends upon isolation of valuable genes combinations as determined in the form of lines with a good combining ability. The combining ability analysis is a powerful tool to discriminate good as well as poor combiners and to choose appropriate parental material in breeding programme. The concept of general and specific combining ability as a measure of gene action was proposed by Sprague and Tatum[25]. The general combining ability is an average performance of a line in hybrid combinations, and can be recognized as a measure of additive gene action and specific combining ability is the deviation in a performance of a hybrid from expected value on the basis of general combining ability effect of lines involved, and can be regarded as a measure of non-additive gene action. The predominance of non- additive action in the expression of several of the yield component characters suggest that it can be commercially exploited through the production of hybrids. However, for the development of high yielding varieties general combining ability was more important[22].

The estimate of GCA effects for ten characters are presented in **Table 2**. In the present investigation, among the female parents RMS 6A, JMSA 20073 and ICMA 92777 were the best general combiner for seed yield per plant. The female parents RMS 6A also had significantly desirable gca effects for plant height, no. of effective tiller per plant ear head length, ear head diameter, test weight and biological yield per plant and desirable negative significant GCA effect for days to 50% flowering and days to maturity. Line JMSA 20073 also exhibited desirable and significant GCA effect for no. of effective tillers per plant, harvest index and biological yield per plant. Line ICMA 92777 exhibited desirable and significant gca for plant height, ear head length, test weight and biological yield per plant also.

Amongst the testers, positive and highly significant gca effects for grain yield per plant were exhibited by H77/833-2 and RIB 57SO5. Tester H77/833-2 also had significant gca effects for no. of effective tiller per plant, ear head diameter, test weight, harvest index and biological yield per plant. RIB 57SO5 also exhibited positive and significant gca effect for plant height, ear head length and biological yield. Significant positive gca effects for yield and its components were observed by Karad and Harer[12], Madhusudhana and Govila[16], Dutt[10] *et al.* and Lakshmana[15] *et al*.

The data on GCA effects indicated that the effects varied significantly for different characters and in different parents. High general combining ability effects mostly contribute either additive gene effect or additive x additive interaction effect or both and represent fixable portion of genetic variation. Hence the parents viz., RMS 6A, ICMA 92777 and JMSA 20073, H77/833-2 and RIB 57SO5 offer the best possibilities of exploitation for the development of improved lines with enhanced yielding ability in pearl millet. These genotypes can be exploited through hybridization. Further, the lines showing good general combining ability for particular components may be utilized in component breeding programme for improving specific trait of interest.

Specific Combining Ability (SCA) effects:

Sprague and Tatum[25] reported that the SCA effect is due to non-additive genetic proportion. It is an important parameter for judging and selecting superior cross combinations, which might be exploited through heterosis breeding programme. The crosses which showed highest significant positive SCA effects for grain yield per plant presented in **Table 3**. Amongst the crosses, nine cross combinations exhibited significant positive sca effects for seed yield per plant. The combination JMSA 20073 × RCB-IC 925 S3 19-3-1 was the best specific combination for seed yield per plant. It was followed by combination ICMA 843-22 × RIB 57SO5,

ICMA 04999 × H77/833-2, RMS 18A × BIB I6 and RMS 6A × MIR 97092-2-4-1 showed the best performance with significantly positive sca effect for grain yield. The genotypes with high gca effects for many characters did not always produce combinations with high sca effects. These crosses were derived from the parents having high x low, low x low and high x high gca effects for seed yield per plant. Navale and Harinarayana[17] reported that the high sca effects involved combinations with good x good, good x medium and poor x medium combining parents indicating presence of higher order interactions for grain yield and other characters. While Garten[11] *et al.,* and Pethani[21] *et al.,* observed that use of at least one good general combining parent in a cross is essential for improving grain yield. The results are comparable with the results, Lakshmana[15] *et al.,* Rathore[23] et al., Sushir[26] *et al.,* Karad and Harer[12] and Dhuppe[9] *et al.* who reported non additive gene action for grain yield per plant.

The top three crosses had atleast one parent as good general combiners for seed yield. The crosses which show higher sca effects for different characters does not had G x G combination of parents in other way it good general combiners when crossed may not always produce the best hybrid. Marked negative effects in crosses between good x good were noteworthy, which could be attributed to the lack of complementation between favourable alleles of the parents involved. Marked positive sca effects in crosses between good x poor and poor x poor could be ascribed to better complementation between favourable alleles of parents involved. These findings are in agreement with the earlier findings of Pethani[21] *et al.*, Bhanderi[5] *et al.*, Vagadiya[28] *et al.*, Lakshmana[14] *et al.* and Parmar[19] *et al*.

Therefore, while selecting the parents for hybridization programme due weightage given to average or poor combiners. While those crosses having both good general combiner parents need to be advanced for desired transgressive segregants and/or to develop new CGMS lines and restorers in addition to exploitation of heterosis, as their heterotic effects could be because of pseudo-additive interalleliec interaction. Therefore, while selecting the parents for hybridization programme due weightage given to average or poor combiners. Those crosses having both good general combiner parents need to be advanced for desired transgressive segregants and/or to develop new CGMS lines and restorers in addition to exploitation of heterosis, as their heterotic effects could be because of pseudo- additive interalleliec interaction. Whereas, crosses those having atleast one parent as average or poor general combiner could be exploited for heterosis breeding as their seed parents are CGMS lines. The CGMS lines having desired gene effects for various attributes could be inter mated with uses of their maintainer lines, and desirable CGMS recombinants could be identified from the segregating populations.

From the present findings it can be concluded that for the all characters displayed higher sca effect than gca effect indicated that there was substantial role played by dominance gene action. Such characters could be improve through heterosis breeding or through segregants in the segregating generations, which the breeder can handle through pedigree method for developing high yielding types in pearl millet. The most of the crosses exhibiting high sca effect involved either good x poor, poor x poor or good x good general combiners, for majority of the characters studied. The results suggested the presence of additive x dominance, dominance x dominance and additive x additive type of gene interactions. When epistasis is present, the recurrent selection followed by pedigree or biparental mating or diallel selective mating systems may prove to be effective in improvement of grain yield and its attributes in pearl millet.

Table 1: Analysis of variance for combining ability and variance components for different characters in pearl millet

Source	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of effective tillers/ plant	Earhead length (cm)	Earhead girth (cm)	Test weight (g)	Harvest index	Biological yield/plant (g)	Seed yield/ plant (g)
Replication	2	7.340	40.56	211.25	0.15	6.12	0.045	0.60	94.37	43.16	3.19
Crosses	49	78.99**	90.77**	615.41**	0.32**	17.54**	0.20**	3.94**	180.36**	265.88**	64.10**
Lines	9	59.78	86.46	821.85*	0.24	28.55*	0.16	8.59**	145.20	340.36	59.76
Tester	4	400.643**	435.16**	2505.06**	1.49**	28.69	0.59**	11.35**	296.07	796.77**	273.11**
L x Tester	36	45.05**	53.58**	353.88**	0.21**	13.55**	0.16**	1.96**	176.30**	188.28**	41.96**
Error	98	12.74	13.67	69.46	0.09	2.94	0.04	0.26	53.54	17.72	6.07
Variance Component											
σ^2 GCA (AV.)	-	0.46	0.55	3.87	0.001	0.06	0	0.03	0.06	1.15	0.33
σ^2 SCA	-	11.77	13.3	94.79	0.04	3.54	0.04	0.56	40.92	56.85	11.96
σ^2GCA / σ^2SCA	-	0.039	0.041	0.041	0.04	0.017	0.013	0.052	0.001	0.02	0.027
σ^2 A	-	1.829	2.199	15.465	0.007	0.236	0.002	0.117	0.240	4.589	1.309
σ^2 D	-	47.084	53.209	379.173	0.164	14.156	0.161	2.260	163.678	227.409	47.862
$(\sigma^2 D / \sigma^2 A)^{0.5}$	-	5.074	4.919	4.952	5.013	7.746	8.796	4.387	26.092	7.040	6.047
Proportional contribution for variation of lines, testers and lines x testers for different characters of pearl millet											
Line	-	13.9	17.49	24.53	13.78	29.89	15.36	40.02	14.79	23.51	17.12
Testers	-	41.41	39.14	33.23	37.97	13.35	24.25	23.5	13.4	24.46	34.78
Lines x Testers	-	44.7	43.37	42.24	48.25	56.76	60.39	36.48	71.81	52.02	48.1

*, ** Significant at 5 % and 1 % level, respectively.

Table 2: General combining ability effect of parents for different characters in pearl millet

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of effective tillers/plant	Earhead length (cm)	Earhead diameter (cm)	Test weight (g)	Harvest index	Biological yield/plant (g)	Seed yield/ plant (g)	GCA Status of parents
RMS 6A	-3.81**	-5.05**	16.37**	0.21**	1.71**	0.12*	0.54**	-2.24	10.96**	2.74**	H
RMS 7A	-0.88	-0.39	0.86	-0.05	0.07	-0.03	0.45**	4.74*	-3.87**	0.34	H
RMS 18A	-1.01	-1.32	-3.05	-0.11	-2.94**	0.04	1.16**	-1.03	-0.19	-0.43	L
RMS 21A	1.05	1.48	-7.67**	-0.03	1.05*	-0.14**	-1.19**	2.00	-1.45	0.35	L
ICMA 843-22	1.45	1.41	1.32	-0.05	-0.54	-0.19**	0.07	-3.98*	-2.58*	-1.92**	L
ICMA 92777	1.52	1.41	7.47**	0.11	0.96*	0.09	0.41**	2.23	3.33**	2.32**	H
ICMA 93333	1.59	2.41*	0.81	-0.11	0.02	0.01	-0.96**	-0.95	-0.65	-0.79	L
ICMA 97111	-1.55	-1.65	-2.73	-0.07	-0.54	0.1	0.45**	-3.2	-3.00**	-2.28**	L
JMSA 20073	-1.15	-1.19	-7.4**	0.20**	-1.11*	0.06	-0.17	4.35*	3.01**	2.38**	H
ICMA 04999	2.79**	2.88**	-5.98**	-0.1	1.32**	-0.06	-0.75**	-1.93	-5.55**	-2.72**	L
S.E.(Gi)	0.92	0.95	2.15	0.08	0.44	0.05	0.13	1.89	1.09	0.64	-
S.E. (Gi-Gj)	1.30	1.35	3.04	0.11	0.63	0.07	0.19	2.67	1.54	0.90	-
CD (5%)	1.82	1.89	4.26	0.15	0.88	0.10	0.26	3.74	2.15	1.26	-
CD (1%)	2.39	2.47	5.57	0.20	1.15	0.14	0.34	4.89	2.82	1.65	-
Males											
H77/833-2	-4.08**	-4.45**	-1.44	0.36**	-0.16	0.22**	0.90**	4.31**	7.48**	4.60**	H
RIB 57SO5	-3.85**	-3.72**	14.10**	0.02	1.72**	-0.10**	0.14	0.39	3.32**	1.29**	H
MIR 97092-2-4-1	2.09**	2.35**	1.58	-0.17**	-0.60	-0.12**	-0.71**	0.39	-4.10**	-1.67**	L
RCB-IC 925 S3 19-3-1	2.39**	1.95**	-10.95**	-0.03	-0.39	0.04	0.08	-0.58	-3.22**	-1.15*	L
BIB I 6	3.45**	3.88**	-3.29*	-0.19**	-0.58	-0.04	-0.41**	-4.51**	-3.48**	-3.07**	L
S.E. (Gi)	0.65	0.68	1.52	0.05	0.31	0.04	0.09	1.34	0.77	0.45	H
S.E. (Gi-Gj)	0.92	0.95	2.15	0.08	0.44	0.05	0.13	1.89	1.09	0.64	-
CD (5%)	1.60	1.66	3.74	0.13	0.77	0.09	0.23	3.29	1.89	1.11	-
CD (1%)	2.31	2.40	5.40	0.19	1.11	0.13	0.33	4.74	2.73	1.60	-

*, ** Significant at 5 % and 1 % level, respectively.

Table 3. Estimates of specific combining ability effects for different characters of pearl millet

S. No.	Genotypes	Days to 50% flowering	Days to Maturity	Plant height (cm)	No. of effective tillers per plant	Ear head length (cm)	Ear head diameter (cm)	Test weight (g)	Harvest Index (%)	Biological yield per plant (g)	Seed yield per plant (g)	GCA Status of parents
1	RMS 6A × H77/833-2	6.01**	7.59**	-17.30**	0.17	-4.68**	0.04	0.25	0.20	-5.99*	-1.76	H x H
2	RMS 7A × H77/833-2	-2.25	-1.41	5.95	0.04	-0.97	0.22	-0.05	8.31	-7.48**	0.51	H x H
3	RMS 18A × H77/833-2	1.55	1.19	5.29	-0.24	-0.78	0.09	-0.45	1.42	-6.00*	-1.6	L x H
4	RMS 21A × H77/833-2	-0.85	-1.61	-4.93	-0.14	3.48**	-0.17	0.61*	6.26	-5.51*	0.67	L x H
5	ICMA 843-22 × H77/833-2	-0.25	-2.55	-3.11	-0.16	-0.5	-0.08	-0.59*	9.12*	0.92	3.97**	L x H
6	ICMA 92777 × H77/833-2	0.35	1.12	-6.4	0.32	2.69**	0.09	0.42	-3.24	9.53**	2.71	H x H
7	ICMA 93333 × H77/833-2	-0.72	-0.55	0.95	-0.26	0.39	-0.07	0.1	0.02	-5.77*	-2.01	L x H
8	ICMA 97111 × H77/833-2	-0.59	-0.81	-1.74	-0.54**	-1.07	-0.44**	-0.15	-5.91	-10.50**	-6.40**	L x H
9	JMSA 20073 × H77/833-2	1.01	1.72	7.4	0.31	-1.78	0.08	-0.22	-10.99*	9.78**	-0.85	H x H
10	ICMA 04999 × H77/833-2	-4.25*	-4.68*	13.91**	0.49**	3.23**	0.24*	0.09	-5.19	21.01**	4.77**	L x H
11	RMS 6A × RIB 57SO5	-1.89	-4.15	29.77**	-0.03	1.83	0.22	-0.74*	-3.19	4.4	-0.2	H x H
12	RMS 7A × RIB 57SO5	3.51	3.19	3.81	-0.19	0.5	-0.18	-0.15	-8.56*	-0.67	-3.50*	H x H
13	RMS 18A × RIB 57SO5	-3.02	-3.55	-0.48	0	-2.11*	-0.18	-0.21	0.13	1.03	0.53	L x H
14	RMS 21A × RIB 57SO5	-0.42	0.32	-11.23*	0.09	-1.07	0.12	1.15**	4.11	-1.47	1.15	L x H
15	ICMA 843-22 × RIB 57SO5	1.85	3.39	0.6	0.41*	2.08*	0.06	0.17	8.49*	6.22*	5.75**	L x H
16	ICMA 92777 × RIB 57SO5	0.78	0.05	-7.48	0.04	1.8	0.42**	1.10**	10.01*	-5.69*	1.94	H x H
17	ICMA 93333 × RIB 57SO5	1.38	0.05	-0.37	0.05	-2.18*	-0.12	-1.06**	-7.24	-1.9	-3.77**	L x H
18	ICMA 97111 × RIB 57SO5	-6.49**	-4.21	-2.81	0.19	-1.09	-0.18	0.59*	6.78	3.46	4.31**	L x H
19	JMSA 20073 × RIB 57SO5	-0.22	-0.01	2.33	-0.40*	0.24	-0.04	-0.85**	-14.33**	-1.88	-6.47**	H x H
20	ICMA 04999 × RIB 57SO5	4.51*	4.92*	-14.13**	-0.15	0.01	-0.11	0	3.80	-3.5	0.27	L x H
21	RMS 6A × MIR 97092-2-4-1	-9.82**	-10.55**	-6.17	0.18	2.09*	0.43**	1.50**	-0.45	11.88**	4.31**	H x L
22	RMS 7A × MIR 97092-2-4-1	-0.42	-0.55	2.69	0.19	-1.63	-0.26*	-0.31	0.83	8.51**	4.09**	H x L
23	RMS 18A × MIR 97092-2-4-1	0.38	1.05	-5.2	0	0.81	-0.03	0.47	-5.73	-4.24	-3.23*	L x L
24	RMS 21A × MIR 97092-2-4-1	-1.69	-1.41	16.69**	0.12	-0.08	-0.03	-0.1	-5.74	6.80**	0.26	L x L
25	ICMA 843-22 × MIR 97092-2-4-1	-1.42	1.32	-13.99**	0.06	0.38	0.07	-0.09	-3.25	-1.85	-1.99	L x L
26	ICMA 92777 × MIR 97092-2-4-1	2.51	1.65	-2.35	-0.02	-1.42	-0.16	-1.10**	-3.95	1.64	-0.87	H x L
27	ICMA 93333 × MIR 97092-2-4-1	5.78**	6.32**	-0.23	-0.05	1.79	0.12	-0.51	1.88	-6.19*	-1.18	L x L
28	ICMA 97111 × MIR 97092-2-4-1	5.58**	4.39*	16.83**	0.1	0.41	0.02	-1.12**	-6.80	5.65*	-0.34	L x L
29	JMSA 20073 × MIR 97092-2-4-1	2.51	2.25	-16.88**	-0.38*	-2.07	-0.17	0.83**	21.30**	-14.05**	1.09	H x L
30	ICMA 04999 × MIR 97092-2-4-1	-3.42	-4.48*	8.6	-0.21	-0.28	0.02	0.42	1.91	-8.15**	-2.13	L x L
31	RMS 6A × RB-IC 925 S3 19-3-1	4.21*	3.85	0.04	-0.22	1.88	-0.42**	-0.68*	3.08	-5.96*	-0.92	H x L
32	RMS 7A × RCB-IC 925 S3 19-3-1	-1.72	-3.15	3.48	0.01	0.61	0.09	1.57**	-6.76	4.32	-1.45	H x L
33	RMS 18A × RCB-IC 925 S3 19-3-1	0.08	1.12	-2.27	0.06	-0.2	0.05	-0.63*	-3.99	4.91*	-0.33	L x L
34	RMS 21A × RCB-IC 925 S3 19-3-1	0.68	0.99	-9.37	-0.08	-2.27*	0.18	-0.28	-4.28	-4.04	-3.38*	L x L
35	ICMA 843-22 × RCB-IC 925 S3 19-3-1	-1.72	-2.61	10.39*	-0.26	-1.9	-0.07	0.11	-11.20**	-7.99**	-6.67**	L x L
36	ICMA 92777 × RCB-IC 925 S3 19-3-1	-3.45	-2.61	2.78	-0.29	-0.71	-0.07	-0.54	-1.92	-3.88	-2.62	H x L
37	ICMA 93333 × RCB-IC 925 S3 19-3-1	2.81	1.72	-2.41	0.08	-1.3	-0.13	0.22	6.53	4.25	4.17**	L x L
38	ICMA 97111 × RCB-IC 925 S3 19-3-1	2.95	4.12	-2.26	0.03	-0.23	0.22	0.60*	6.10	-0.71	1.69	L x L
39	JMSA 20073 × RCB-IC 925 S3 19-3-1	-7.12**	-8.01**	7.9	0.68**	4.73**	0.35**	0.46	7.40	11.28**	8.97**	H x L
40	ICMA 04999 × RCB-IC 925 S3 19-3-1	3.28	4.59*	-8.28	-0.01	-0.61	-0.19	-0.83**	5.04	-2.16	0.55	L x L
41	RMS 6A × BIB I 6	1.48	3.25	-6.33	-0.1	-1.12	-0.27*	-0.33	0.37	-4.33	-1.42	H x L
42	RMS 7A × BIB I 6	0.88	1.92	-15.93**	-0.05	1.5	0.14	-1.06**	6.18	-4.68	0.34	H x L
43	RMS 18A × BIB I 6	1.01	0.19	2.65	0.17	2.28*	0.06	0.81**	8.17	4.29	4.64**	L x L

S. No.	Genotypes	Days to 50% flowering	Days to Maturity	Plant height (cm)	No. of effective tillers per plant	Ear head length (cm)	Ear head diameter (cm)	Test weight (g)	Harvest Index (%)	Biological yield per plant (g)	Seed yield per plant (g)	GCA Status of parents
44	RMS 21A × BIB I 6	2.28	1.72	8.84	0	-0.06	-0.1	-1.39**	-0.35	4.22	1.31	L x L
45	ICMA 843-22 × BIB I 6	1.55	0.45	6.11	-0.04	-0.06	0.02	0.4	-3.17	2.71	-1.05	L x L
46	ICMA 92777 × BIB I 6	-0.19	-0.21	13.45**	-0.06	-2.36*	-0.27*	0.12	-0.90	-1.6	-1.16	H x L
47	ICMA 93333 × BIB I 6	-9.25**	-7.55**	2.07	0.18	1.31	0.21	1.25**	-1.18	9.61**	2.79	L x L
48	ICMA 97111 × BIB I 6	-1.45	-3.48	-10.02*	0.23	1.98*	0.39**	0.08	-0.17	2.1	0.74	L x L
49	JMSA 20073 × BIB I 6	3.81	4.05	-0.74	-0.22	-1.12	-0.21	-0.22	-3.39	-5.13*	-2.74	H x L
50	ICMA 04999 × BIB I 6	-0.12	-0.35	-0.1	-0.12	-2.35*	0.04	0.32	-5.56	-7.20**	-3.45*	L x L
	SE	**2.06**	**2.14**	**4.81**	**0.17**	**0.99**	**0.12**	**0.3**	**4.22**	**2.43**	**1.42**	

*,** Significant at 5 % and 1 % level, respectively.

CONCLUSION

It is concluded from present investigations that the female parents, RMS 6A, ICMA 92777 and JMSA 20073 were the best general combiner for almost all the characters. Amongst male parents, H77/833-2 and RIB 57SO5 were good general combiner for most of the characters. The cross combinations ICMA 92777 × H77/833-2 and JMSA 20073 × H77/833-2 were identified for getting trangressive segregants as the gca status of the parents is higher than the sca effects. While, cross JMSA 20073 × RCB-IC 925 S3 19-3-1 followed by ICMA 843-22 × H77/833-2 and ICMA 04999 × H77/833-2 were identified as potential crosses for commercial exploitation of heterosis in pearl millet as these crosses exhibited highest magnitude of standard heterosis and SCA effects. These hybrids can be recommended for wide spread cultivation in arid part of western Rajasthan after evaluation in multi-locational trails for increasing pearl millet production and productivity.

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