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Combining Ability Studies for Grain Yield and Associated Traits in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]

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ABSTRACT

The current investigation was undertaken during kharif-2023 at Bajra Research Scheme, College of Agriculture, Dhule. The experimental material for combining ability studies was developed during summer-2023 and evaluated for ten different characters in which twelve inbreds were used and crosses were made in a 12 X 12 half diallel mating design. The resulting sixty six hybrids along with twelve parents and two checks were grown in randomized block design, with three replications during kharif-2023. The σ^2GCA was higher than σ^2SCA for all yield and yield contributing characters indicating the presence of additive and nonadditive gene action, and could be improved through recurrent selection for SCA, by the way of inter-mating. The parents viz., DHLBI- 2201, DHLBI- 2212, DHLBI- 2210, and DHLBI- 967 possessed high concentrations of favorable genes for the respective traits as they are having good GCA and high mean performance which can be further utilized in crossing programs in order to generate wide genetic variability for developing high yielding, early maturing hybrids/ varieties/ populations of pearl millet. The cross combinations viz., DHLBI-2201 X DHLBI-1825, DHLBI-2201 X DHLBI-2210, and DHLBI-2205 X DHLBI-2208 were identified as best for SCA effects. GCA effect of both these parents involved in the above cross combination was also good x average combiner. Hence, these combinations can be suggested for future breeding strategies. Also, in pearl millet mostly CGMS system is used and there restorers play a major role. This research primarily focuses on the aspect of development of the restorer.

Keywords: *Pearl millet, general combining ability, specific combining ability, restorers, gene action.*

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a hardy cereal crop that can survive in the most hostile circumstances. It is typically grown in dryland settings, whispering tales of old civilizations and nourishing communities for centuries. It is frequently used interchangeably with *Cenchrus americanus* (L.) Morrone. It is also known as yellow bristle grass, bulbrush millet, cattail millet, and bajra in India and other places. Pearl millet is enriched with nutrients to mitigate malnutrition and hidden hunger and hence rightly designated as "nutricereal" [9]. Under the most unfavorable agro-climatic circumstances, it is extensively produced in the arid and semi-arid tropical regions of the African and Indian subcontinents, where other crops, such as sorghum and maize, are unable to generate profitable yields. As such, it is a highly suitable crop for short growing seasons when managed well [24].

Sixth in importance among cereals worldwide, pearl millet is mostly farmed as a rainfed crop in India's arid and semi-arid regions, which make up 80% of Asia's land area. India produces 8.6 million tonnes of pearl millet annually on 7 million hectares of land.

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More than 90% of the pearl millet acreage in India is shared by the major pearl millet-growing states of Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, and Haryana [1]. Considering nutrition, pearl millet grains tend to be lower in fat, bajra, with its 4-6% fat content, is an exception. It is high in omega-3 fatty acids, which are thought to be the healthiest, and contains 74% polyunsaturated fatty acids (PUFAs) [2]. These include linoleic acid (45%), oleic acid (25%), and linolenic acid (4%) [18] [16] [7] [21].

Due to its unique characteristics, such as the C_4 plant's high photosynthetic efficiency, greater capacity for producing dry matter, and ability to withstand harsh agroclimatic conditions with fewer inputs and greater financial returns, bajra outperforms all other cereals, including wheat, maize, rice, sorghum, and barley [15]. Genetic improvement through plant breeding has significantly contributed towards enhancing crop productivity [3]. In order to develop a sound breeding methodology for the development of high-yielding genotypes or hybrids in pearl millet, the research was conducted to generate information on the combining ability effects of parents and hybrids for grain yield and other nine component characters.

MATERIALS AND METHODS

The parental material for the present study comprised of two checks were obtained from Bajra Research Scheme, College of Agriculture, Dhule. The experimental material comprised of parents and hybrids 12 restorers (R lines) along with two released checks Phule Mahashakti and Dhanshakti were grown in Randomized Block Design (RBD) with three replications. The experimental material consisted twelve diverse restorer lines *viz*., DHLBI- 2201, DHLBI- 2205, DHLBI- 2208, DHLBI- 2210, DHLBI- 2212, DHLBI- 1603, DHLBI- 1035, DHLBI- 1822, DHLBI-1708, DHLBI- 1825, DHLBI- 967, and DHLBI- 1314 which were used as parent were crossed in half diallel fashion (12 X 12) excluding reciprocals. The total number of treatments were 80, comprising of 66 F_1's, 12 parents and 2 checks. The parents, F_1's and checks were planted in a plot of one row of 4.00 m length and having row to row spacing 50 cm and plant-to-plant spacing of 15 cm.

Observations were recorded on each of the five randomly selected competitive plants tagged in each replication of all the treatments. The border plants were excluded and data on different traits as described earlier were recorded and averages were worked out. The ten characters observed were days for 50% flowering, days to maturity, plant height (cm), number of effective tillers per plant, earhead length (cm), earhead girth (cm), 1000 grains weight (g), number of grains per cm^2, grain yield per plant (g) and fodder yield per plant (g). The mean values of all characters were statistically analyzed using the analysis of variance technique given by [17]. Combining ability in individual environments as per [10] and pooled analysis of variance for combining ability [20].

RESULTS AND DISCUSSION

Crosses were made in 12 X 12 half diallel fashion and resulting sixty six hybrids, their twelve parents along with two standard checks were evaluated in the replicated trial during *kharif*-2023, and ten observations were recorded for the estimation of combining ability. The data were subjected to [10] analysis, for the study of combining ability concerning important agronomic and biochemical parameters.

The analysis of variance showed that the mean sum of squares due to genotypes for all the ten characters was significant. This suggests that there is a sufficient amount of variability among the genotypes [11]. The replications were non-significant for all the ten characters indicating good homogeneity among replications. This feature showed that there are greater opportunities for selection-based improvement (Table 1).

The combining ability showed that the mean sum of squares owing to GCA for all characters, except days to 50% flowering, was highly significant. This suggests that both additive and non-additive types of gene actions are important for the expression of these traits. The σ^2GCA was higher than σ^2SCA for all yield and yield contributing characters indicating the presence of additive and nonadditive gene action (Table 2).

[22] developed the idea of general and specific combining ability as a measure of gene action. The specific combining ability, on the other hand, is a deviation from the expected performance of a particular hybrid combination based on the average performance of the parents involved and can be regarded as a measure of non-additive gene action resulting from both intra-allelic and inter-allelic gene interactions. The general combining ability is the average performance of a parental line in a series of hybrid combinations and can be recognized as a measure of the additivity of genes.

General combining ability

A statistical estimation was made for the general combining ability effects for each of the twelve characters of the twelve inbreds or parents. In addition to being good general combiners for grain production per plant, the parents in the current study showed good general combining capacity for five or more component attributes. The inbreds *viz*., DHLBI-1708, DHLBI-2208, DHLBI-1825, DHLBI-1314, and DHLBI-2201 had shown negative but non-significant effects for this character. The results were in agreement with the findings of [19] [14] [6] [23].

Out of twelve inbreds, only one inbred showed a significantly negative GCA effect for days to maturity which was -2.091 (DHLBI-2212). The parents for GCA effects were ranged between -2.091 (DHLBI-2212) to 1.218 (DHLBI-1603). Nonsignificant GCA effects were shown by ten parents. For plant height, significantly positive GCA effects were shown by inbreds *viz.,* DHLBI-2212 (5.298), DHLBI-1708 (5.155), and DHLBI-2205 (3.56). The highest significantly positive GCA effect shown was DHLBI-2210 (0.252) followed by DHLBI-967 (0.162), DHLBI-2201 (0.117), and DHLBI-1822 (0.074).

The only inbred DHLBI-2201 (1.288) showed a positive significant GCA effect for earhead length which was in a desirable direction. Significantly for earhead girth, positive GCA effects of earhead girth are favorable which was shown by four inbreds *viz*., DHLBI-1825 (0.501), DHLBI-1603 (0.349), DHLBI-1708 (0.335), and DHLBI-967. The GCA effects for 1000 grain weight were in the range of -0.681 (DHLBI-1314) to 1.327 (DHLBI-2201). For this, significant positive GCA effects are favorable which was shown by only two inbreds *viz*., DHLBI-2201 (1.327) and DHLBI-1825 (0.655). The general combining ability effects for the number of grains per cm^2 character revealed that eight parents exhibited significant GCA effects, in which parents DHLBI-2201 (2.173), DHLBI-967 (0.805), and DHLBI-2210 (0.710) shown significant positive values where parents DHLBI-2205 (-1.244), DHLBI-1822.

In the estimates of general combining ability effects for this trait, three parents recorded significantly positive GCA effects which were DHLBI-2201 (6.618), DHLBI-1314 (2.995), and DHLBI-2212 (1.983). The range of GCA effects was -5.811 (DHLBI-1822) to 6.618 (DHLBI-2201). GCA values for fodder yield per plant were shown by five inbreds and significant negative GCA values were shown by four inbreds. Three inbreds were found non-significant which were DHLBI-1314 (2.024), DHLBI-2205 (0.119), and DHLBI-1035 (-0.357). The range of GCA effects was -14.048 (DHLBI-2210) to 12.857 (DHLBI-2201). The highest positive GCA effects which are favorable are shown by DHLBI-2201 (12.857) followed by DHLBI-1822 (6.905), DHLBI-2208 (5.952), DHLBI-967 (4.881), and DHLBI-1825 (2.619).

For grain yield per plant, parents DHLBI- 2201, DHLBI- 2212, and DHLBI- 1314 were good general combiners. DHLBI- 2201 showed the highest GCA effect and was significantly positive for grain yield. It was also found desirable for seven other traits. Parent DHLBI-2212 showed good general combiner for days to maturity. Parents DHLBI- 2212, DHLBI- 2210 and DHLBI- 967 had shown good GCA for four other characters each. Similar results were also reported by [5] [9] [12].

Specific combining ability effects

The results as shown in table 4 revealed that for days to 50 percent flowering, four crosses *viz*., DHLBI-967 X DHLBI-1314 (-4.546), DHLBI-2210 X DHLBI-1708 (-3.26), DHLBI-1708 X DHLBI-967 (-3.165), and DHLBI-1035 X DHLBI-1822 (-2.593) had shown significantly negative SCA effects which were in the desirable direction. The range of SCA effects for this trait was between -4.546 (DHLBI-967 X DHLBI-1314) to 3.74 (DHLBI-2201 X DHLBI-967). Like days to 50 percent flowering, days to maturity also favour earliness. Hence negative SCA effects are considered in breeding programs.

Out of sixty-six hybrids, five hybrids had shown significantly negative SCA effects *viz.*, -7.341 (DHLBI-2212 X DHLBI-1822), -5.293 (DHLBI-2210 X DHLBI-1035), -4.888 (DHLBI-967 X DHLBI-1314), -4.555 (DHLBI-2205 X DHLBI-1314), and -4.198 (DHLBI-2212 X DHLBI-1035). Out of sixty-six cross combinations, significantly positive SCA effects were shown by nine hybrids for plant height and SCA effects were in the range of -25.423 (DHLBI-2208 X DHLBI-2210) to 27.005 (DHLBI-2205 X DHLBI-1603). Desirable significantly positive SCA effect was shown by 27.005 (DHLBI-2205 X DHLBI-1603), 24.077 (DHLBI-2210 X DHLBI-1035), 21.505 (DHLBI-2201 X DHLBI-2210), *etc*.
The SCA effects for a number of effective tillers per plant ranged between -0.521 (DHLBI-2201 X DHLBI-1822) to 0.762 (DHLBI-1603 X DHLBI-1035). For this trait, significant positive SCA effects are favorable which was shown by inbreds *viz*., 0.762 (DHLBI-1603 X DHLBI-1035), 0.541 (DHLBI-967 X DHLBI-1314), 0.498 (DHLBI-2210 X DHLBI-1603), 0.488 (DHLBI-2210 X DHLBI-1825), 0.474 (DHLBI-1825 X DHLBI-1314), 0.429 (DHLBI-1822 X DHLBI-1314), 0.424 (DHLBI-2205 X DHLBI-1708), and (DHLBI-2201 X DHLBI-1825). Desirable significant but positive effects were shown by twenty-two crosses and negative effects were shown by thirteen hybrids. Non-significant but positive SCA effects were shown by eleven hybrids and negative SCA effects were shown by twenty hybrids.
The total of fifteen hybrids recorded significantly positive SCA effects for earhead length in which highest significant positive SCA effect recorded was 4.04 (DHLBI-2201 X DHLBI-2210) and the range of SCA effects was -3.514 (DHLBI-2210 X DHLBI-967) to 4.04 (DHLBI-2201 X DHLBI-2210). For earhead girth, significant SCA effects were observed in the range of -1.659 (DHLBI-2210 X DHLBI-1708) to 1.858 (DHLBI-2205 X DHLBI-2210). Hybrids 1.858 (DHLBI-2205 X DHLBI-2210), 1.793 (DHLBI-2201 X DHLBI-2212), 1.655 (DHLBI-1708 X DHLBI-1825) showed desirable significantly positive SCA effects for this character. Among the cross combinations, 16 cross combinations showing SCA effects of 1.88 (DHLBI-2201 X DHLBI-1708), 1.852 (DHLBI-2201 X DHLBI-2210), 1.804 (DHLBI-2210 X DHLBI-1603), *etc.* exerted significant and positive SCA effects for 1000 grain weight trait.
The SCA effects for the number of grains per cm^2 trait varied in the range of -2.147 (DHLBI-2212 X DHLBI-1603) to 3.312 (DHLBI-1822 X DHLBI-1314). Fourteen hybrids exhibited significantly positive SCA effects which were in a desirable direction for future breeding programmes. The topmost in them were 3.312 (DHLBI-1822 X DHLBI-1314) and 3.005 (DHLBI-2208 X DHLBI-1825).
The highest SCA effect in a desirable positive direction was recorded for the grain yield per plant trait which was 31.622 (DHLBI-2201 X DHLBI-1825) followed by 20.855 (DHLBI-2201 X DHLBI-2210), and 20.364 (DHLBI-2212 X DHLBI-1822). Significantly positive SCA values were shown by twenty-one crosses. For fodder yield per plant, out of sixty six cross combinations, significantly positive SCA effects were shown by twelve hybrids which include crosses *viz*., 21.181 (DHLBI-2205 X DHLBI-1822), 17.729 (DHLBI-2201 X DHLBI-1825), 17.61 (DHLBI-2201 X DHLBI-1708), and 14.038 (DHLBI-2201 X DHLBI-1035). These findings of SCA effects were similar to the results obtained by following scientists [22][4][8].
Along with significant SCA effects for grain yield, hybrids DHLBI-2201 X DHLBI-1825, DHLBI-2205 X DHLBI-2208, and DHLBI-2210 X DHLBI-1825 had shown significant SCA effect in desirable directions for more than four other related traits. This was considered good for future breeding methodologies. In table 6, hybrids showing good SCA along with their performance for heterosis are mentioned. This helps to choose the best hybrid combination to be suggested for future breeding programmes.

CONCLUSION

The ANOVA revealed that the mean sum of square for hybrids was significant for all the characters, indicating the existence of considerable amount of variability. For grain yield per plant, parents DHLBI- 2201, DHLBI- 2212, and DHLBI- 1314 were good general combiner. DHLBI- 2201 showed the highest GCA effect and was significantly positive for grain yield. The parent also found desirable for other five traits *viz*., plant height, number of effective tillers per plant, earhead length, 1000 grain weight, number of grains per cm^2. The parents DHLBI-2201 for nine characters, and DHLBI-2212, DHLBI- 2210, and DHLBI-967 for four each characters were observed to be good general combiners with high *per se* performance and to show consistent performance for grain yield and most of the yield-contributing traits. These results suggest that these parents hold great potential and should be included in future breeding programs for pearl millet improvement. Hybrid DHLBI-2201 X DHLBI-1825 recorded the highest SCA effect for grain yield followed by DHLBI-2201 X DHLBI-2210 and DHLBI-2201 X DHLBI-967. Similarly, these cross combinations also showed substantial heterosis for traits that contribute to grain yield. To locate high-yielding superior genotypes and to obtain desirable transgressive segregants from segregating populations, these cross combinations may be further exploited. The characters in which the preponderance of non-additive gene action and significance of additive genetic variance were seen, they indicated that the hybridization programme would be more successful in producing superior crosses.

FUTURE SCOPE

The crosses found best could be exploited for obtaining transgressive segregants in segregating generations and also utilized for deriving yielding genotypes through reciprocal recurrent selection and heterosis breeding approaches. These lines will be further utilized as male restorers in development of hybrid pearl millet. These research findings provides a key aspect for further development of other restorers in pearl millet.

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AUTHORS CONTRIBUTION STATEMENTS

Author [Yogesh A. Shaniware] did all the research and analytical work. The Research work was conducted under the guidance of guide [Vikas Y. Pawar] and under the scheme headed by Professor [Khushal K. Barhate].

Table 1: Combining ability mean square values for ten different characters in pearl millet

Sources	D.F.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of effective tillers / plant	Earhead length (cm)	Earhead girth (cm)	1000 grain weight (g)	No. of grains per cm²	Grain yield/ plant (g)	Fodder yield/ plant (g)
GCA	11	1.589	11.101*	166.901**	0.261**	4.361**	1.815**	4.085**	11.449**	143.421**	851.623**
SCA	65	3.330**	9.415**	158.576**	0.103**	3.772**	0.578**	1.068**	2.305**	155.528**	72.353**
Error	154	1.283	5.179	47.169	0.016	0.645	0.149	0.238	0.680	11.873	16.374
σ^2GCA	-	0.022	0.423	8.552	0.018	0.265	0.119	0.275	0.769	9.396	59.661
σ^2SCA	-	2.047	4.236	111.407	0.087	3.127	0.429	0.830	1.625	143.656	55.979
σ^2GCA/ σ^2SCA	-	0.010	0.100	0.077	0.202	0.085	0.278	0.331	0.473	0.065	1.066
2σ^2GCA/(σ^2GCA +σ^2SCA)	-	0.021	0.182	0.143	0.343	0.156	0.434	0.498	0.642	0.123	1.032

**Significance at 0.05 level of probability, ** Significance at 0.01 level of probability, D.F.: Degrees of Freedom.*

Table 2: The estimates of general combining ability effects for different characters in 12 X12 diallel cross in pearl millet

Sr. No.	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of effective tillers / plant	Earhead length (cm)	Earhead girth (cm)	1000 grain weight (g)	No. of grains per cm²	Grain yield/ plant (g)	Fodder yield/ plant (g)
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1	DHLBI-2201	-0.119	0.742	5.298**	0.117**	1.288**	-0.061	1.327**	2.173**	6.618**	12.857**
2	DHLBI-2205	0.19	0.599	3.56*	-0.055	0.169	-0.549**	-0.129	-1.244**	-0.528	0.119
3	DHLBI-2208	-0.429	0.742	-4.107*	-0.2**	0.214	-0.644**	-0.059	-0.445*	-2.109*	5.952**
4	DHLBI-2210	0.5	-0.663	-3.893*	0.252**	-0.131	-0.318**	0.156	0.71**	1.279	-14.048**
5	DHLBI-2212	0.238	-2.091**	0.583	-0.119**	-0.193	0.158	-0.263*	-0.478*	1.983*	-4.762**
6	DHLBI-1603	0	1.218*	-1.321	0.019	0.371	0.349**	-0.029	0.084	0.740	-12.262**
7	DHLBI-1035	0.143	-0.091	0.393	-0.012	0.245	0.013	-0.473**	0.080	-1.126	-0.357
8	DHLBI-1822	0.476	0.052	-4.988**	0.074*	-0.867**	-0.158	-0.245	-0.877**	-5.811**	6.905**
9	DHLBI-1708	-0.548	0.266	5.155**	-0.167**	-0.007	0.335**	-0.379**	0.043	-3.029**	-3.929**
10	DHLBI-1825	-0.357	0.385	-1.964	0.029	0.067	0.501**	0.655**	-0.415	0.969	2.619*
11	DHLBI-967	0.071	-0.401	0.631	0.162**	-0.49	0.206*	0.12	0.805**	-1.98*	4.881**
12	DHLBI-1314	-0.167	-0.758	0.655	-0.1**	-0.667**	0.168	-0.681**	-0.436*	2.995**	2.024
	SE	0.290	0.582	1.757	0.032	0.206	0.099	0.125	0.211	0.882	1.035
	CD at 5%	0.573	1.150	3.472	0.064	0.406	0.195	0.246	0.417	1.742	2.045
	CD at 1%	0.756	1.519	4.584	0.084	0.536	0.258	0.325	0.550	2.300	2.701

**Significance at 0.05 level of probability, ** Significance at 0.01 level of probability.*

Table 3: Best performing hybrids based on SCA effects for grain yield and yield contributing characters in pearl millet

Character	Range of SCA effects	No. of hybrids having significant SCA effect in desirable direction	Best performing hybrids
Days to 50% flowering	-4.546 to 3.74	04	DHLBI-967 X DHLBI-1314 (-4.54) DHLBI-2210 X DHLBI-1708 (-3.26) DHLBI-1708 X DHLBI-967 (-3.17)
Days to maturity	-7.341 to 7.326	05	DHLBI-2212 X DHLBI-1822 (-7.34) DHLBI-2210 X DHLBI-1035 (-5.29) DHLBI-967 X DHLBI-1314 (-4.89)
Plant height (cm)	-25.423 to 27.005	09	DHLBI-2205 X DHLBI-1603 (27.00) DHLBI-2210 X DHLBI-1035 (24.08) DHLBI-2201 X DHLBI-2210 (21.00)
Number of effective tillers per plant	-0.521 to 0.762	22	DHLBI-1603 X DHLBI-1035 (0.76) DHLBI-967 X DHLBI-1314 (0.54) DHLBI-2210 X DHLBI-1603 (0.49)
Earhead length (cm)	-3.514 to 4.040	15	DHLBI-2201 X DHLBI-2210 (4.04) DHLBI-1603 X DHLBI-967 (3.75) DHLBI-1035 X DHLBI-1314 (3.45)
Earhead girth (cm)	-1.659 to 1.858	12	DHLBI-2205 X DHLBI-2210 (1.86) DHLBI-2201 X DHLBI-2212 (1.79) DHLBI-1708 X DHLBI-1825 (1.66)
1000 grain weight (g)	-2.688 to 1.88	16	DHLBI-2201 X DHLBI-1708 (1.88) DHLBI-2201 X DHLBI-2210 (1.85) DHLBI-2210 X DHLBI-1603 (1.80)
Number of grains per cm²	-2.147 to 3.312	14	DHLBI-1822 X DHLBI-1314 (3.31) DHLBI-2208 X DHLBI-1825 (3.00) DHLBI-1305 X DHLBI-1314 (2.91)
Grain yield per plant (g)	-20.989 to 31.622	21	DHLBI-2201 X DHLBI-1825 (31.62) DHLBI-2201 X DHLBI-2210 (20.86) DHLBI-2212 X DHLBI-1825 (20.36)
Fodder yield per plant (g)	-8.342 to 21.181	12	DHLBI-2205 X DHLBI-1822 (21.18) DHLBI-2201 X DHLBI-1825 (17.73) DHLBI-2201 X DHLBI-1708 (17.61)

Table 4: Cross combinations with significant SCA effects for grain yield and their performance for other traits in pearl millet

Cross	Mean Grain yield per plant (g)	SCA effect	GCA effect		Significant SCA effect in desirable directions to related character
			P_1	P_2	
DHLBI-2201 X DHLBI-1825	83.83	31.622**	G	A	NET, TGW, GPCM, FY
DHLBI-2201 X DHLBI-2210	73.37	20.855**	G	A	PH, EL, TGW
DHLBI-2212 X DHLBI-1822	61.16	20.364**	G	P	EG, NET, EG
DHLBI-2201 X DHLBI-967	68.75	19.488**	G	P	NET, TGW
DHLBI-1035 X DHLBI-1822	55.91	18.223**	A	P	DF, EL, TGW
DHLBI-2210 X DHLBI-1603	63.89	17.250**	A	A	NET, EL, TGW
DHLBI-2205 X DHLBI-2208	58.09	16.103**	A	P	NET, EL, TGW, FE
DHLBI-1603 X DHLBI-967	59.25	15.869**	A	P	NET, EL, TGW
DHLBI-2205 X DHLBI-1603	60.48	15.650**	A	A	PH
DHLBI-2201 X DHLBI-2212	68.58	15.358**	G	G	EG, TGW

DF:- *Days for 50% flowering,* ***DM***:- *Days to maturity,* ***PH***:- *Plant height (cm),* ***NET***:- *Number of effective tillers per plant,* ***EL***:- *Earhead length (cm),* ***EG***:- *Earhead girth (cm),* ***TGW***:- *1000 grain weight (g),* ***GPCM***:- *Number of grains per cm^2,* ***GY***:- *Grain yield per plant (g),* ***FY***:- *Fodder yield per plant (g),* ***FE***:- *Grain Iron (mg/kg),* ***ZN***:- *Grain Zinc (mg/kg).*

Note:- *G: Good General Combiner, A: Average General Combiner, P: Poor General Combiner.*

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