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Studies on heterosis for grain yield and its components in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract
The present study was carried out to estimate the nature and magnitude of heterosis for grain yield and its attributing traits through 9 x 9 diallel mating design along with nine inbreds and one standard check, *viz.*, Phule Aadishakti in pearl millet. The experiment was laid out in Randomized Block Design with three replications. The analysis of variance revealed that there were significant differences among the parents and crosses for all the characters studied. The magnitude of heterosis varied from cross to cross for all the characters studied. Maximum positive heterosis for grain yield per plant over better parent and standard check (Phule Aadishakti) was observed to be 69.66 and 32.76 percent, respectively. Considering the heterosis DHLBI-1708 x DHLBI-181138, DHLBI-1708 x DHLBI-18963 and DHLBI-181181 x DHLBI-181138 appeared to be the more promising hybrids for breeding.

Keywords: pearl millet, heterosis, grain yield, diallel analysis

Introduction
Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a highly cross-pollinated crop because of protogynous flowering condition and wind borne pollination mechanism, which satisfy one of the essential biological demands for hybrid development. The availability of cytoplasm genetic male sterile lines in this crop made feasible to exploit heterosis commercially and hybrid seed production on large scale. Heterosis breeding is an important one, among conventional breeding programme to identify the best hybrids which are promising. With this view the work was undertaken to investigate the heterobeltiosis and standard heterosis for quantifying the extent of heterosis for grain yield and its component characters in pearl millet.

Materials and Methods
The present investigation was carried out at Post Graduate Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, during *Kharif*-2019. The experimental material consisting of nine inbred lines *viz*., DHLBI-1103, DHLBI-967, DHLBI-1013, DHLBI-1708, DHLBI-18963, DHLBI-181181, DHLBI-181138, DHLBI-1035 and DHLBI-1603 which were obtained from Bajra Research Scheme, College of Agriculture, Dhule. Thirty six hybrids were produced through 9 x 9 half daillel mating design. A total of 46 treatments, including 36 F1s, nine inbred lines, and Phule Aadishakti as a standard check, were grown in a randomised block design with three replications. One row of each entry was planted in each replication, with a three meter row length and a 50 x 15 cm spacing between each entry. Five competitive plants from each replication were randomly selected to record the observations on ten characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of effective tillers/plant, earhead length (cm), earhead girth (cm), 1000-gain weight (g), grain yield/plant (g), grain iron (mg/kg) and grain zinc (mg/kg) content. Statistical analysis was done. Data was subjected to analysis of variance to find significant differences among genotypes for the recorded data. After obtaining, the significance, data recorded on parents and their F1s were subjected to combining ability analysis and the testing of significance of different genotypes was based on procedure given by Griffing (1956) [3] Model I (fixed effect model), Method II (parents and F1s excluding reciprocals).

Result and Discussion
The results of analysis of variance of Randomized Block Design showed highly significant differences due to genotypes for all the yield attributing characters under study.

This indicates that the parents as well as their hybrids under study have sufficiently high amount of genetic variability. Additionally, partitioning of mean sum of square (Table 1) due to genotypes showed that the differences among nine parents were also significant for all the traits. The presence of significant differences among parents showed greater diversity in the nine parental lines. Similarly, in case of hybrids, significant differences were found for all the characters. Mean sum of squares due to parents vs hybrids were significant for all the yield attributing characters except days to 50% flowering and days to maturity, which explained sufficient quantity of heterosis was depicted in crosses for many of the yield attributing traits.

With regard to heterosis over relative parent, better parent and commercial or standard heterosis, out of 36 hybrids, hybrids exhibited significant heterosis in desired direction for days to 50% flowering (07, 18, 04), days to maturity (07, 17, 05), plant height (30, 25, 03), number of effective tillers per plant (15, 08, 14), ear head length (26, 08, 11), ear head girth (19, 10, 19), 1000-grain weight (26, 17, 0), grain yield per plant (30, 27, 04), grain Fe (11, 05, 26) and grain Zn (17, 05, 25). (Table 3-7) For grain yield per plant, the relative heterosis varied from -18.01 percent (DHLBI-967 x DHLBI-1035) to 84.15 percent (DHLBI-1708 x DHLBI-181138). Out of 36 hybrids, 30 hybrids showed significant positive relative heterosis. The hybrid DHLBI-1708 x DHLBI-181138 (84.15%) exhibited highest significant average heterosis followed by DHLBI-1708 x DHLBI-18963 (77.72%) and DHLBI-1708 x DHLBI-1035 (76.30%). The range in heterobeltiosis varied from -29.00 percent (DHLBI-967 x DHLBI-1035) to 69.66 percent (DHLBI-1708 x DHLBI-181138). Twenty-seven hybrids recorded significant positive heterosis over better parent. The cross DHLBI-1708 x DHLBI-181138 (69.66%) exhibited highest significant heterosis over the better parent. The range of heterosis over standard checks, Phule Adishakti was from -47.32 percent (DHLBI-967 x DHLBI-1035) to 32.76 percent (DHLBI-1708 x DHLBI-181138). Among thirty-six hybrids, four hybrids recorded positively significant heterosis over Phule Adishakti. The highest standard heterosis in desirable direction was recorded in the cross DHLBI-1708 x DHLBI-181138 (32.76%).

The hybrid, DHLBI-18963 x DHLBI-181181 for days to 50% flowering, DHLBI-18963 x DHLBI-181181 for days to maturity, DHLBI-967 x DHLBI-181181 for plant height, DHLBI-1708 x DHLBI-18963 for number of effective tillers per plant, DHLBI-967 x DHLBI-181138 for earhead length, DHLBI-181138 x DHLBI-1603 for earhead girth, DHLBI-1103 x DHLBI-1603 for 1000-grain weight, DHLBI-1708 x DHLBI-181138 for grain yield per plant, DHLBI-181138 x DHLBI-1603 for grain Fe content and DHLBI-1013 x DHLBI-181138 for grain Zn content showed significant and maximum heterosis over better parent in desirable direction.

The hybrid, DHLBI-18963 x DHLBI-181181 for days to 50% flowering, DHLBI-18963 x DHLBI-181181 for days to maturity, DHLBI-1013 x DHLBI-181138 for plant height, DHLBI-1708 x DHLBI-181138 for number of effective tillers per plant, DHLBI-18963 x DHLBI-181181 for earhead length, DHLBI-181138 x DHLBI-1603 for earhead girth, DHLBI-1013 x DHLBI-181138 for 1000-grain weight, DHLBI-1708 x DHLBI-181138 for grain yield per plant, DHLBI-181138 x DHLBI-1603 for grain Fe content and DHLBI-1013 x DHLBI-181138 for grain Zn content showed significant and maximum heterosis over standard check Phule Adishakti in desirable direction. Similar results were also reported by Joshi *et al*. (2001a) [11], Joshi *et al*. (2001b) [10], Sidpara (2002) [19], Rasal and Patil (2003) [18], Lakshmana *et al*. (2003) [13], Dangaria *et al*. (2004) [7], Chotaliya (2005) [6], Bhadalia *et al.* (2014) [2], Patel and Patel (2014) [17], Patel B. C. *et al*. (2016) [16], Reshma M. R. *et al*. (2017) [19], Ladumor *et al*. (2018b) [12], Chaudhary A *et al.* (2019) [4] and Chaudhary Z. K *et al*. (2019) [5].

The cross DHLBI-1708 x DHLBI-181138 showed high *per se* performance and significant heterobeltiosis for grain yield per plant days to 50% flowering, days to maturity, number of effective tillers per plant, earhead girth and 1000-grain weight, also showed significant standard heterosis for grain yield per plant, plant height, number of effective tillers per plant and earhead girth.. The cross, DHLBI-1708 x DHLBI-18963 showed high *per se* performance and significant heterobeltiosis for grain yield per plant, days to 50% flowering, days to maturity, plant height, number of effective tillers per plant, and 1000-grain weight. Moreover, significant economic heterosis for grain yield per plant and number of effective tillers per plant. Hence, with the use of heterosis breeding and examination with multilocational trial for testing its stability in disease and pest screening to know its resistance strength against crucial pearl millet disease and pests in order to attain hybrids having high grain yield in pearl millet, these two hybrids may be commercially utilized.

Table 1: Analysis of variance for ten characters in 9 x 9 half diallel crosses in pearl millet

Sources of variation	d.f.	Mean sum of squares									
		Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of effective tillers/plant	Earhead length (cm)	Earhead girth (cm)	1000-grain weight (g)	Grain yield per plant (g)	Grain Fe (mg/kg)	Grain Zn (mg/kg)
Replication	2	0.47	0.46	24.58	0.0073	0.024	0.14	0.20	4.46	4.42	0.67
Treatment	44	40.28**	39.73**	719.08**	0.42**	29.73**	2.73**	4.70**	263.81**	380.12**	198.85**
Parents	8	64.14**	70.98**	372.81**	0.34**	33.13**	1.12**	2.21**	57.62**	330.44**	223.02**
Hybrids	35	35.92**	33.72**	605.14**	0.44**	26.17**	2.92**	4.50**	230.55**	401.15**	195.44**
Parents *Vs.* Hybrid	1	1.66	0.90	7475.41**	0.30**	127.21**	9.00**	31.41**	3077.22**	41.40**	124.66**
Error	88	4.26	3.86	35.24	0.014	1.62	0.19	0.34	13.81	1.80	2.35
Total	134	16.03	15.58	259.61	0.14	10.83	1.02	1.77	95.76	126.06	66.84

*, ** Significant at 5 and 1 percent level, respectively

Table 2: Percent heterosis over mid parent, better parent and standard check for days to 50 percent flowering and days to maturity in pearl millet

Sr. No.	Crosses	Days to 50% flowering			Days to maturity		
		MP	BP	SH	MP	BP	SH
1.	DHLBI-1103 x DHLBI-967	1.66	0.66	-1.92	1.43	-0.40	-3.88*
2.	DHLBI-1103 x DHLBI-1013	2.80	-4.07	5.77	3.53*	-2.22	2.33
3.	DHLBI-1103 x DHLBI-1708	5.72	5.37	0.64	6.42**	5.76**	-0.39
4.	DHLBI-1103 x DHLBI-18963	3.41	-4.02	7.05*	2.75	-2.96	1.55
5.	DHLBI-1103 x DHLBI-181181	11.18**	9.03**	8.33*	7.23**	3.49	3.49
6.	DHLBI-1103 x DHLBI-181138	3.03	-6.08*	8.97**	2.52	-4.00*	2.33
7.	DHLBI-1103 x DHLBI-1035	-2.12	-9.61**	2.56	2.53	-2.56	1.93
8.	DHLBI-1103 x DHLBI-1603	14.02**	4.47	19.87**	4.63**	-3.67*	5.04**
9.	DHLBI-967 x DHLBI-1013	-0.62	-6.40*	3.21	0.58	-3.33	1.16
10.	DHLBI-967 x DHLBI-1708	7.33*	5.92	3.21	6.91**	5.62**	1.94
11.	DHLBI-967 x DHLBI-18963	4.91	-1.72	9.62**	4.05*	0.00	4.65*
12.	DHLBI-967 x DHLBI-181181	-6.84*	-7.74*	-8.33*	-5.72**	-7.36**	-7.36**
13.	DHLBI-967 x DHLBI-181138	4.50	-3.87	11.54**	4.20**	-0.73	5.81**
14.	DHLBI-967 x DHLBI-1035	0.30	-6.78*	5.77	1.53	-2.93	2.71
15.	DHLBI-967 x DHLBI-1603	-0.30	-7.82**	5.77	1.33	-3.96*	3.49
16.	DHLBI-1013 x DHLBI-1708	-9.38**	-15.70**	-7.05*	-5.26**	-10.00**	-5.81**
17.	DHLBI-1013 x DHLBI-18963	-7.51**	-8.05**	2.56	-3.33*	-3.33	1.16
18.	DHLBI-1013 x DHLBI-181181	6.42*	1.16	11.54**	3.03	0.74	5.43**
19.	DHLBI-1013 x DHLBI-181138	-2.55	-4.97	10.26**	-1.28	-2.18	4.26*
20.	DHLBI-1013 x DHLBI-1035	-8.88**	-10.17**	1.92	-3.87*	-4.40*	1.16
21.	DHLBI-1013 x DHLBI-1603	1.99	0.00	14.74**	0.36	-1.08	6.59**
22.	DHLBI-1708 x DHLBI-18963	-3.11	-10.34**	0.00	-1.75	-6.67**	-2.33
23.	DHLBI-1708 x DHLBI-181181	-4.95	-7.10*	-7.69*	-2.99	-5.81**	-5.81**
24.	DHLBI-1708 x DHLBI-181138	-5.17	-13.81**	0.00	0.39	-5.45**	0.78
25.	DHLBI-1708 x DHLBI-1035	4.00	-4.52	8.33*	0.39	-5.13**	0.39
26.	DHLBI-1708 x DHLBI-1603	1.53	-7.26*	6.41	2.50	-3.96*	3.49
27.	DHLBI-18963 x DHLBI-181181	-14.29**	-18.97**	-9.62**	-12.12**	-14.07**	-10.08**
28.	DHLBI-18963 x DHLBI-181138	-3.10	-4.97	10.26**	-0.55	-1.45	5.04**
29.	DHLBI-18963 x DHLBI-1035	-2.56	-3.39	9.62**	-1.66	-2.20	3.49
30.	DHLBI-18963 x DHLBI-1603	-3.12	-4.47	9.62**	-1.82	-3.24	4.26*
31.	DHLBI-181181 x DHLBI-181138	3.57	-3.87	11.54**	-0.56	-3.64*	2.71
32.	DHLBI-181181 x DHLBI-1035	-4.82	-10.73**	1.28	-1.69	-4.40*	1.16
33.	DHLBI-181181 x DHLBI-1603	0.60	-6.15*	7.69*	-0.37	-3.96*	3.49
34.	DHLBI-181138 x DHLBI-1035	-6.70**	-7.73**	7.05*	-4.38**	-4.73**	1.55
35.	DHLBI-181138 x DHLBI-1603	-1.67	-2.21	13.46**	-0.54	-1.08	6.59**
36.	DHLBI-1035 x DHLBI-1603	-8.99**	-9.50**	3.85	-4.54**	-5.40**	1.94
	SE(D)±	1.46	1.68	1.68	1.38	1.60	1.60
	CD at 5%	2.90	3.35	3.35	2.76	3.18	3.18
	CD at 1%	3.84	4.44	4.44	3.65	4.22	4.22

*, ** Significant at 5 and 1 percent level, respectively

Table 3: Percent heterosis over mid parent, better parent and standard check for plant height and number of effective tillers per plant in pearl millet

Sr. No.	Crosses	Plant height (cm)			No. effective tillers/plant		
		MP	BP	SH	MP	BP	SH
1.	DHLBI-1103 x DHLBI-967	15.01**	13.63**	-6.91**	1.54	-4.35	8.20
2.	DHLBI-1103 x DHLBI-1013	12.75**	7.67*	-5.38*	14.55**	13.61**	13.61**
3.	DHLBI-1103 x DHLBI-1708	10.19**	6.32*	-8.57**	4.92	4.92	4.92
4.	DHLBI-1103 x DHLBI-18963	12.08**	4.83	-3.72	-1.02	-4.98	3.28
5.	DHLBI-1103 x DHLBI-181181	7.78**	4.21	-10.76**	14.29**	8.20	8.20
6.	DHLBI-1103 x DHLBI-181138	16.10**	6.26*	2.30	8.27*	0.00	18.03**
7.	DHLBI-1103 x DHLBI-1035	17.07**	12.37**	-2.30	28.98**	19.67**	19.67**
8.	DHLBI-1103 x DHLBI-1603	-8.48**	-10.27**	-28.25**	3.03	-16.39**	-16.39**
9.	DHLBI-967 x DHLBI-1013	18.92**	14.88**	0.96	11.63**	4.35	18.03**
10.	DHLBI-967 x DHLBI-1708	15.31**	12.58**	-3.19	-20.77**	-25.36**	-15.57**
11.	DHLBI-967 x DHLBI-18963	12.11**	6.05*	-2.60	-8.35*	-10.14*	1.64
12.	DHLBI-967 x DHLBI-181181	20.63**	18.01**	1.06	-17.41**	-26.09**	-16.39**
13.	DHLBI-967 x DHLBI-181138	19.00**	10.13**	6.03*	-14.89**	-16.67**	-1.64
14.	DHLBI-967 x DHLBI-1035	16.25**	12.89**	-1.85	-12.54**	-23.19**	-13.11**
15.	DHLBI-967 x DHLBI-1603	21.21**	17.46**	-3.78	4.67	-18.84**	-8.20
16.	DHLBI-1013 x DHLBI-1708	12.58**	11.36**	-2.13	12.40**	11.48*	11.48*

17.	DHLBI-1013 x DHLBI-18963	8.38**	6.05*	-2.60	-17.66**	-21.57**	-14.75**
18.	DHLBI-1013 x DHLBI-181181	17.78**	16.27**	2.19	1.31	-3.33	-4.92
19.	DHLBI-1013 x DHLBI-181138	16.80**	11.71**	7.55**	4.55	-4.17	13.11**
20.	DHLBI-1013 x DHLBI-1035	1.28	0.74	-11.47**	-8.73*	-14.67**	-16.07**
21.	DHLBI-1013 x DHLBI-1603	13.23**	6.12*	-6.74*	10.41*	-9.83*	-11.31*
22.	DHLBI-1708 x DHLBI-18963	13.99**	10.36**	1.36	39.83**	34.24**	45.90**
23.	DHLBI-1708 x DHLBI-181181	10.74**	10.52**	-4.96	38.53**	31.15**	31.15**
24.	DHLBI-1708 x DHLBI-181138	17.14**	10.89**	6.76*	35.34**	25.00**	47.54**
25.	DHLBI-1708 x DHLBI-1035	13.12**	12.51**	-2.19	43.99**	33.61**	33.61**
26.	DHLBI-1708 x DHLBI-1603	8.89**	3.09	-11.35**	41.01**	14.43**	14.43**
27.	DHLBI-18963 x DHLBI-181181	-0.50	-3.86	-11.70**	-17.22**	-24.59**	-18.03**
28.	DHLBI-18963 x DHLBI-181138	9.33**	6.81*	2.84	-3.11	-6.94	9.84*
29.	DHLBI-18963 x DHLBI-1035	10.48**	7.53**	-1.24	-18.14**	-26.85**	-20.49**
30.	DHLBI-18963 x DHLBI-1603	-1.41	-9.46**	-16.84**	13.14**	-11.01*	-3.28
31.	DHLBI-181181 x DHLBI-181138	7.86**	1.90	-1.89	18.58**	4.17	22.95**
32.	DHLBI-181181 x DHLBI-1035	2.33	1.56	-11.70**	4.97	2.75	-8.20
33.	DHLBI-181181 x DHLBI-1603	4.11	-1.24	-15.43**	-4.86	-19.27**	-27.87**
34.	DHLBI-181138 x DHLBI-1035	14.58**	9.02**	4.96	9.50*	-5.56	11.48*
35.	DHLBI-181138 x DHLBI-1603	19.83**	7.73**	3.72	-11.82**	-32.64**	-20.49**
36.	DHLBI-1035 x DHLBI-1603	6.53*	0.34	-12.77**	24.17**	7.28	-8.20
	SE(D)±	4.19	4.84	4.84	0.08	0.09	0.09
	CD at 5%	8.34	9.63	9.63	0.15	0.18	0.18
	CD at 1%	11.05	12.76	12.76	0.21	0.24	0.24

*, ** Significant at 5 and 1 percent level, respectively

Table 4: Percent heterosis over mid parent, better parent and standard check for earhead length and earhead girth in pearl millet

Sr. No.	Crosses	Earhead length (cm)			Earhead girth (cm)		
		MP	BP	SH	MP	BP	SH
1.	DHLBI-1103 x DHLBI-967	16.93**	7.64	-13.68**	9.67**	2.52	8.84*
2.	DHLBI-1103 x DHLBI-1013	-3.13	-18.26**	-19.81**	-4.52	-9.60**	-6.59
3.	DHLBI-1103 x DHLBI-1708	17.99**	7.48	-11.79**	5.81	3.41	0
4.	DHLBI-1103 x DHLBI-18963	7.68	-11.32**	-7.56	10.31**	3.68	8.80*
5.	DHLBI-1103 x DHLBI-181181	13.95**	-9.03*	2.83	6.68*	0.03	5.51
6.	DHLBI-1103 x DHLBI-181138	20.00**	0.48	0.47	14.74**	6.03	15.40**
7.	DHLBI-1103 x DHLBI-1035	26.85**	7.25	4.71	3.35	-3.09	2.21
8.	DHLBI-1103 x DHLBI-1603	-24.15**	-32.61**	-41.50**	-19.51**	-19.98**	-25.26**
9.	DHLBI-967 x DHLBI-1013	10.59*	0.49	-1.42	9.13**	7.67*	14.31**
10.	DHLBI-967 x DHLBI-1708	15.11**	13.79*	-6.61	9.41**	4.53	10.98**
11.	DHLBI-967 x DHLBI-18963	16.60**	3.15	7.53	4.11	3.51	9.89**
12.	DHLBI-967 x DHLBI-181181	19.60**	2.23	15.55**	10.11**	9.75**	16.52**
13.	DHLBI-967 x DHLBI-181138	28.28**	15.58**	15.57**	19.61**	18.15**	28.59**
14.	DHLBI-967 x DHLBI-1035	-5.05	-13.54**	-15.58**	12.17**	11.80**	18.69**
15.	DHLBI-967 x DHLBI-1603	16.38**	11.95*	-2.83	14.55**	7.67*	14.31**
16.	DHLBI-1013 x DHLBI-1708	13.09**	3.85	1.88	4.4	1.05	4.42
17.	DHLBI-1013 x DHLBI-18963	12.35**	9.04*	13.67**	-2.93	-3.68	1.09
18.	DHLBI-1013 x DHLBI-181181	8.57*	1.40	14.62**	2.13	1.09	6.63
19.	DHLBI-1013 x DHLBI-181138	6.68	5.68	5.66	7.75**	5.03	14.31**
20.	DHLBI-1013 x DHLBI-1035	2.65	2.41	0.47	5.26	4.19	9.89**
21.	DHLBI-1013 x DHLBI-1603	18.36**	11.54*	9.42*	15.07**	9.54**	13.19**
22.	DHLBI-1708 x DHLBI-18963	-3.80	-14.04**	-10.39*	4.64	0.53	5.51
23.	DHLBI-1708 x DHLBI-181181	16.04**	0.15	13.20**	1.14	-3.06	2.24
24.	DHLBI-1708 x DHLBI-181138	18.14**	7.56	7.54	15.37**	8.94**	18.56**
25.	DHLBI-1708 x DHLBI-1035	18.11**	8.70	6.13	4.37	0.03	5.51
26.	DHLBI-1708 x DHLBI-1603	18.43**	15.21**	0.00	15.64**	13.67**	9.92**
27.	DHLBI-18963 x DHLBI-181181	9.41**	5.16	18.86**	-0.78	-1.03	4.39
28.	DHLBI-18963 x DHLBI-181138	2.09	0.00	4.25	-3.36	-5.09	3.3
29.	DHLBI-18963 x DHLBI-1035	6.54	3.16	7.54	-11.22**	-11.44**	-6.59
30.	DHLBI-18963 x DHLBI-1603	20.49**	10.41*	15.10**	10.80**	4.71	9.89**
31.	DHLBI-181181 x DHLBI-181138	8.49*	2.23	15.55**	6.68*	5.03	14.31**
32.	DHLBI-181181 x DHLBI-1035	11.50**	3.91	17.45**	9.41**	9.41**	15.40**
33.	DHLBI-181181 x DHLBI-1603	-0.40	-11.96**	-0.48	3.32	-2.59	2.74
34.	DHLBI-181138 x DHLBI-1035	15.98**	14.62**	14.60**	-2.58	-4.09	4.39
35.	DHLBI-181138 x DHLBI-1603	13.14**	5.68	5.66	28.24**	19.15**	29.67**
36.	DHLBI-1035 x DHLBI-1603	10.97**	4.81	2.33	6.13*	0.06	5.54
	SE(D)±	0.90	1.04	1.04	0.31	0.35	1.04

	CD at 5%	1.79	2.06	2.06	0.61	0.71	2.06
	CD at 1%	2.37	2.73	2.73	0.81	0.94	2.73

*, ** Significant at 5 and 1 percent level, respectively

Table 5: Percent heterosis over mid parent, better parent and standard check for 1000-grain weight and grain yield per plant in pearl millet

Sr. No.	Crosses	1000-grain weight (g)			Grain yield per plant (g)		
		MP	BP	SH	MP	BP	SH
1.	DHLBI-1103 x DHLBI-967	12.83**	6.04	-12.84**	41.43**	34.01**	-0.56
2.	DHLBI-1103 x DHLBI-1013	-7.86*	-10.29*	-22.15**	56.51**	49.39**	-0.78
3.	DHLBI-1103 x DHLBI-1708	10.01**	7.78	-11.41**	44.72**	43.18**	-4.91
4.	DHLBI-1103 x DHLBI-18963	17.25**	15.50**	-2.14	40.81**	31.43**	0.70
5.	DHLBI-1103 x DHLBI-181181	13.53**	12.19**	-5.54	44.60**	41.38**	-6.10
6.	DHLBI-1103 x DHLBI-181138	13.74**	6.81	-0.02	48.89**	36.89**	8.39
7.	DHLBI-1103 x DHLBI-1035	18.42**	13.80**	1.46	75.30**	59.31**	5.81
8.	DHLBI-1103 x DHLBI-1603	20.08**	17.90**	-3.09	-4.02	-15.18	-43.67**
9.	DHLBI-967 x DHLBI-1013	24.45**	14.07**	-1.02	49.04**	35.16**	0.29
10.	DHLBI-967 x DHLBI-1708	0.71	-3.48	-23.88**	-9.79	-15.38	-37.21**
11.	DHLBI-967 x DHLBI-18963	20.30**	11.48**	-5.54	24.17**	22.22*	-6.36
12.	DHLBI-967 x DHLBI-181181	25.41**	16.55**	-1.87	26.40**	17.24	-13.00
13.	DHLBI-967 x DHLBI-181138	5.16	-6.81	-12.77**	28.56**	24.52**	-1.40
14.	DHLBI-967 x DHLBI-1035	17.04**	5.97	-5.52	-18.01	-29.00**	-47.32**
15.	DHLBI-967 x DHLBI-1603	23.24**	17.87**	-6.64	39.65**	17.78	-12.60
16.	DHLBI-1013 x DHLBI-1708	1.39	-3.22	-16.03**	31.32**	26.64*	-17.68*
17.	DHLBI-1013 x DHLBI-18963	12.56**	11.24**	-3.48	41.89**	26.84**	-2.81
18.	DHLBI-1013 x DHLBI-181181	5.26	3.70	-10.02**	45.04**	41.52**	-10.20
19.	DHLBI-1013 x DHLBI-181138	15.60**	11.38**	4.26	53.68**	35.43**	7.23
20.	DHLBI-1013 x DHLBI-1035	1.69	0.33	-10.55**	41.84**	34.70**	-18.68**
21.	DHLBI-1013 x DHLBI-1603	16.60**	11.52**	-3.23	36.40**	25.77*	-24.07**
22.	DHLBI-1708 x DHLBI-18963	15.06**	11.08**	-5.89	77.72**	64.25**	25.84**
23.	DHLBI-1708 x DHLBI-181181	5.47	2.14	-14.01**	71.61**	67.56**	10.22
24.	DHLBI-1708 x DHLBI-181138	18.53**	9.20*	2.21	84.15**	69.66**	32.76**
25.	DHLBI-1708 x DHLBI-1035	20.74**	13.78**	1.43	76.30**	61.78**	5.16
26.	DHLBI-1708 x DHLBI-1603	-5.02	-5.22	-24.93**	67.17**	49.11**	-3.07
27.	DHLBI-18963 x DHLBI-181181	-24.13**	-24.37**	-35.92**	-13.79	-21.19*	-39.62**
28.	DHLBI-18963 x DHLBI-181138	12.86**	7.51*	0.63	45.88**	43.52**	13.64*
29.	DHLBI-18963 x DHLBI-1035	-6.21	-8.54*	-18.46**	-3.90	-17.90*	-37.09**
30.	DHLBI-18963 x DHLBI-1603	14.17**	10.45*	-6.42	45.15**	20.85*	-7.41
31.	DHLBI-181181 x DHLBI-181138	11.23**	5.64	-1.12	66.25**	49.74**	18.57**
32.	DHLBI-181181 x DHLBI-1035	9.37**	6.33	-5.20	48.52**	37.80**	-12.56
33.	DHLBI-181181 x DHLBI-1603	9.72*	6.47	-10.36**	-1.59	-11.28	-43.71**
34.	DHLBI-181138 x DHLBI-1035	13.05**	10.37**	3.31	55.25**	30.85**	3.61
35.	DHLBI-181138 x DHLBI-1603	12.33**	3.69	-2.94	19.75*	-1.59	-22.07**
36.	DHLBI-1035 x DHLBI-1603	7.53*	1.53	-9.48**	42.50**	26.43**	-4.97
	SE(D)±	0.41	0.47	0.47	2.62	3.04	3.04
	CD at 5%	0.82	0.95	0.95	5.22	6.03	6.03
	CD at 1%	1.09	1.26	1.26	6.92	7.99	7.99

*, ** Significant at 5 and 1 percent level, respectively

Table 6: Percent heterosis over mid parent, better parent and standard check for grain Fe and grain Zn content per plant in pearl millet

Sr. No.	Crosses	Grain Fe (mg/kg)			Grain Zn (mg/kg)		
		MP	BP	SH	MP	BP	SH
1.	DHLBI-1103 x DHLBI-967	1.10	-3.22	-2.07	6.30	3.28	-9.84**
2.	DHLBI-1103 x DHLBI-1013	4.99**	-8.94**	25.41**	15.94**	-5.88*	24.25**
3.	DHLBI-1103 x DHLBI-1708	-3.24	-6.98**	-5.88**	-18.24**	-21.05**	-35.00**
4.	DHLBI-1103 x DHLBI-18963	6.69**	0.57	14.94**	19.25**	4.82	13.84**
5.	DHLBI-1103 x DHLBI-181181	16.62**	8.15**	28.03**	22.99**	5.06	22.11**
6.	DHLBI-1103 x DHLBI-181138	11.06**	-6.73**	38.86**	29.08**	4.41	39.15**
7.	DHLBI-1103 x DHLBI-1035	9.15**	2.84	17.67**	27.23**	12.76**	20.18**
8.	DHLBI-1103 x DHLBI-1603	-4.43**	-16.24**	12.57**	13.22**	-9.07**	23.49**
9.	DHLBI-967 x DHLBI-1013	6.06**	-11.34**	22.10**	18.52**	-1.55	29.96**
10.	DHLBI-967 x DHLBI-1708	-20.75**	-21.09**	-26.34**	10.38**	3.66	-9.51**
11.	DHLBI-967 x DHLBI-18963	-9.81**	-18.39**	-6.73**	18.90**	7.24*	16.46**
12.	DHLBI-967 x DHLBI-181181	-3.93*	-14.42**	1.32	-5.73*	-17.46**	-4.06
13.	DHLBI-967 x DHLBI-181138	-7.89**	-25.32**	11.18**	17.81**	-2.52	29.93**
14.	DHLBI-967 x DHLBI-1035	-11.62**	-20.07**	-8.54**	-20.36**	-27.56**	-22.79**
15.	DHLBI-967 x DHLBI-1603	-9.35**	-23.47**	2.85	-1.46	-19.06**	9.93**

16.	DHLBI-1013 x DHLBI-1708	-7.73**	-22.59**	6.60**	2.05	-19.34**	6.48
17.	DHLBI-1013 x DHLBI-18963	-4.27**	-12.42**	20.62**	-0.08	-8.94**	20.21**
18.	DHLBI-1013 x DHLBI-181181	3.97**	-3.32*	33.14**	0.33	-5.67*	24.52**
19.	DHLBI-1013 x DHLBI-181138	15.59**	11.25**	65.63**	18.50**	17.93**	57.18**
20.	DHLBI-1013 x DHLBI-1035	-8.44**	-16.19**	15.42**	-5.03*	-14.17**	13.30**
21.	DHLBI-1013 x DHLBI-1603	-3.53**	-4.69**	31.25**	-8.65**	-9.93**	22.32**
22.	DHLBI-1708 x DHLBI-18963	12.77**	2.45	17.08**	-7.73*	-21.29**	-14.53**
23.	DHLBI-1708 x DHLBI-181181	13.37**	1.38	20.03**	-0.86	-17.73**	-4.38
24.	DHLBI-1708 x DHLBI-181138	32.53**	7.82**	60.51**	24.01**	-2.33	30.17**
25.	DHLBI-1708 x DHLBI-1035	-0.98	-10.10**	2.87	-13.23**	-25.41**	-20.50**
26.	DHLBI-1708 x DHLBI-1603	2.32	-13.30**	16.52**	-17.11**	-35.16**	-11.94**
27.	DHLBI-18963 x DHLBI-181181	-1.65	-3.35	14.42**	-0.11	-3.39	12.29**
28.	DHLBI-18963 x DHLBI-181138	1.55	-10.25**	33.62**	-1.56	-10.67**	19.05**
29.	DHLBI-18963 x DHLBI-1035	-12.92**	-12.97**	-0.42	-2.59	-3.50	4.80
30.	DHLBI-18963 x DHLBI-1603	0.86	-6.69**	25.41**	4.60	-5.88*	27.82**
31.	DHLBI-181181 x DHLBI-181138	11.09**	-0.28	48.45**	8.76**	1.80	35.69**
32.	DHLBI-181181 x DHLBI-1035	-17.72**	-19.10**	-4.22*	1.34	-2.86	12.90**
33.	DHLBI-181181 x DHLBI-1603	-6.14**	-11.73**	18.64**	4.51*	-3.02	31.70**
34.	DHLBI-181138 x DHLBI-1035	20.14**	6.24**	58.16**	17.53**	5.76*	40.95**
35.	DHLBI-181138 x DHLBI-1603	19.34**	13.54**	69.04**	14.47**	13.40**	54.01**
36.	DHLBI-1035 x DHLBI-1603	10.17**	1.99	37.07**	9.56**	-2.23	32.78**
	SE(D)±	0.95	1.09	1.09	1.08	1.25	1.25
	CD at 5%	1.88	2.18	2.18	2.15	2.48	2.48
	CD at 1%	2.50	2.88	2.88	2.85	3.29	3.29

*, ** Significant at 5 and 1 percent level, respectively

Table 7: Best performing crosses based on mean performance and heterosis for yield and its contributing characters

Sr. No.	Hybrid	*Per se*	Heterosis over			Useful and significant heterosis over MP for component trait	Useful and significant heterosis over BP for component trait	Useful and significant heterosis over SC for MP BP SC component trait
			MP	BP	SH			
1	DHLBI-1708 x DHLBI-181138	59.90	84.15**	69.66**	32.76**	PH, ETPP, EL, EG, TW, GYP	DF, DM, PH, ETPP, EG, TW, GYP	PH, ETPP, EG, GYP
2	DHLBI-1708 x DHLBI-18963	56.78	77.72**	64.25**	25.84**	PH, ETPP, TW, GYP	DF, DM, PH, ETPP, TW, GYP	ETPP, GYP
3	DHLBI-181181 x DHLBI-181138	53.50	66.25**	49.74**	18.57**	PH, ETPP, EL,EG, TW, GYP	DM, GYP	ETPP, EL, EG, GYP
4	DHLBI-18963 x DHLBI-181138	51.27	45.88**	43.52**	13.64**	PH, TW, GYP	PH. TW, GYP	ETPP, GYP
5	DHLBI-1708 x DHLBI-181181	49.73	71.61**	67.56**	10.22	PH, ETPP, GYP	DF, DM, PH, ETPP, GYP	DF, DM, ETPP, EL

DF: Days to 50%Flowering, DM: Days to Maturity, PH: Plant Height, ETPP: Effective Tillers Per Plant, EL: Earhead Length, EG: Earhead Girth, TW: 1000-grain weight and GYP: Grain yield per plant.

References

1. Bhadalia AS, Dhedhi KK, Joshi HJ. Combining ability studies through diallel analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Int. J Agric. Sci.; c2014. p. 57-60.
2. Chaudhary A. Heterosis, combining ability and inbreeding depression analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.] (Unpublished). Sardarkrushinagar Dantiwada Agricultural University, Dantiwada, Gujarat; c2019. p. 32-78.
3. Chaudhary ZK. Study of different sources of CMS lines in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. (Unpublished). Sardarkrushinagar Dantiwada Agricultural University, Dantiwada, Gujarat; c2019. p. 42-82.
4. Chotaliya JM. Studies on heterosis combining ability and gene action in pearl millet [*Pennisetum glaucum* (L.) R. Br.] M.Sc. (Agri). Thesis, (Unpublished), Junagadh Agricultural University, Junagadh; c2005.
5. Dangaria CJ, Valu MG, Atata SD. Combining ability on resent developed parental line of pearl millet for gain and dry fodder yield. National seminar on millet research and development future policy options in India, Mandor, Jodhpur; c2004. p. 1-2.
6. Griffing B. Concept of general and specific combining ability in relation to diallel crossing system. Australian J Bio. Sci. 1956;9:484-493.
7. Joshi HJ, Mehta DR, Dhaduk HL, Pethani KV. Combining ability analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Indian J Agric. Res. 2001b;35(4):251-254.
8. Ioshi HJ, Pethani KV, Dhaduk HL, Mehta DR. Combining ability of restorers in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Agric. Sci. Digest 2001a;21(3):161-163.
9. Ladumor VL, Mungra KD, Parmar SK, Sorathiya JS, Vansjaliya HG. Grain Iron, Zinc and Yield Genetics in pearl millet [*Pennisetum glaucum* (L.) R. Br]. Int. J Curr. Microbiol. Appl. Sci. 2018b;7(9):242-250.
10. Lakshmana D, Surendra P, Gurumarty R. Combining ability studies in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Res crops. 2003;4(3):358-362.

11. Rasal PN, Patil HS. Line × tester analysis for yield and its component characters in pearl millet [*Pennisetum glaucum* (L.) R. Br]. Res Crops. 2003;4(1):85-90.
12. Reshma Krishnan MR, Patel MS, Gami RA, Bhadauriya HS, Patel YN. Genetic Analysis in pearl millet [*Pennisetum glaucum* (L) R. Br.]. Int. J Curr. Microbiol. Appl. Sci. 2017;6(11):900-907.