The Pharma Innovation Journal 2021; 10(11): 1749-1455

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 1749-1455

www.thepharmajournal.com
Received: 10-09-2021
Accepted: 27-10-2021

CD Prajapati
Department of Genetics and Plant Breeding, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

MS Patel
Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

NN Prajapati
Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

KN Prajapati
Polytechnic in Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Khedbrahma, Gujarat, India

Corresponding Author:
CD Prajapati
Department of Genetics and Plant Breeding, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Heterosis study for yield and yield attributes in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

CD Prajapati, MS Patel, NN Prajapati and KN Prajapati

DOI: https://doi.org/10.22271/tpi.2021.v10.i11y.9130

Abstract
The present study was undertaken to assess the magnitude of heterosis of 28 hybrids derived from eight parents of pearl millet through diallel mating design excluding reciprocals. Hybrids exhibited from low to high significant mid parent heterosis, heterobeltiosis, and standard heterosis in desired direction for all the traits except standard heterosis for days to flowering as well as number of effective tillers per plant. The hybrid 17548 × 15388 manifested significant economic heterosis in desirable direction for grain yield per plant with plant height, test weight and protein content. The cross 15851 × 15725 also showed high heterotic magnitude over check for grain yield per plant with traits like days to flowering, days to maturity, harvest index and test weight. The heterobeltiosis for grain yield per plant ranged from -58.60 to 350.02 per cent, while the standard heterosis for grain yield per plant ranged from -61.30 to 48.72 per cent. The highest heterobeltiosis was recorded by the hybrids *viz.*15058 × 15725 and 15058 ×15388.

Keywords: Diallel, hybrids, heterosis, heterobeltiosis, harvest index

Introduction
Globally, pearl millet [*Pennisetum glaucum* (L) R. Br.] is sixth and in India, it's third chief cereal food crop just behind rice and wheat. During 2020, pearl millet was grown in 7.41 million ha with average production of 10.3 million tonnes and 1391kg/ha productivity. (Anonymous, 2021) [1]. Rajasthan, Gujarat, Maharashtra, Haryana, Uttar Pradesh and Karnataka are the important pearl millet growing states where, it is grown both in *kharif* as well as in summer seasons. Hybrid vigor exploitation is considered to be one of the outstanding achievements in pearl millet. Pearl millet is naturally cross pollinated and easy availability of male sterile lines had made of it easy to exploit hybrid vigor on commercial level. Therefore, to recognize better heterotic response for grain yield with its attributing characters are very important. The breeding methods which utilized for this crop are widely suitable for breeding of almost all cross-pollinated crops. Conventional breeding procedures has been used for its genetic improvement. The present investigation was carried out to identify superior hybrids on the basis of mid parent, better parent and standard heterosis.

Materials and Methods
Plant materials: An experimental material comprised of 37 genotypes consisting of 28 hybrids resulting from diallel mating design excluding reciprocals involved 8 parental lines and standard check (GHB 558).

Field experiments: The experimental material, comprising of 37 entries including 8 parents, their 28 crosses and one commercial check, was raised in Randomized Block Design with three replications in *kharif* 2019 at Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Plot size was single row of 3m length with plant-to-plant spacing of 15cm. Different ten observations were recorded on days to flowering, days to maturity, plant height (cm), number of effective tillers per plant, ear head length (cm), ear head girth (cm), grain yield per plant (g), harvest index (%), test weight (g) and protein content (%). The observations were recorded from randomly selected 5 plants from each genotype in each replication.

Statistical analysis: The mean performance of parents as well as hybrids was subjected to statistical analysis. Analysis of variance was carried out to test the significance for each character as per methodology suggested by Panse and Sukhatme (1985) [15]. Relative heterosis was calculated by the formula given by Briggle (1963) [3], Better parent heterosis by Fonseca and Patterson (1968) [9] and Standard heterosis by Meredith and Bridge (1972) [14].

Results 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 eight parents were also significant for all the traits. The presence of significant differences among parents showed greater diversity in the eight 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 protein content, 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 28 hybrids, hybrids exhibited significant heterosis in desired direction for days to flowering (16, 0, 0), days maturity (25, 18, 3), plant height (16, 0, 7), number of effective tillers (12, 5, 0), ear head length (9, 1, 6), ear head girth (7, 2, 1), grain yield per plant (22, 20, 9), harvest index (10, 5, 5), test weight (9, 2, 26), and protein content (11, 4, 1). (Table 3-7)

For grain yield per plant, the relative heterosis varied from -46.52 (15851 × 17548) to 376.66 per cent (15058 × 15388). Out of 28 hybrids, 22 hybrids showed significant positive relative heterosis. The hybrid 15058 × 15388 (376.66%) exhibited desirable relative heterosis followed by 15058 × 15725 (351.75%), 15725 × 16110 (273.88%) and 17548 × 15388 (260.54%). The heterobeltiosis ranged from -58.60 (15851 × 17548) to 350.02 per cent (15058 × 15725). Out of 28 hybrids, 19 hybrids showed significant positive heterobeltiosis. The hybrid, 15058 × 15725 (350.02%) exhibited desirable heterobeltiosis followed by15058 ×15388 (284.61%) and 17548 × 15388 (190.04%). The range of standard heterosis was from -61.30 (15851 × 17548) to 48.72 per cent (17548 × 15388). Out of 28 hybrids, 8 hybrids, expressed positive significant standard heterosis. The hybrid, 17548 × 15388 (48.72%) exhibited desirable standard heterosis followed by 15851 × 15725 (47.31%) and 15851 × 15708 (35.30%) manifested positive standard heterosis over check hybrid GHB-558.

The hybrid, 15058 × 16110 for days to flowering, 15851 × 15725 and 15058 × 15851 for days to maturity, 15851 × 17548 for plant height, 15851 × 16110 for number of effective tillers per plant, 15708 × 15725 for earhead length, 15725 × 16317 for earhead girth, 15058 × 15725 for grain yield per plant and 16110 × 16317 for harvest index 15058 × 16110 for test weight and 15708 × 16110 for protein content showed significant and maximum heterosis over better parent in desirable direction.

The hybrid, 16110 × 16317 for days to flowering, 15851 × 17548 for days to maturity, 15725 × 15388 for plant height, 15851 × 15725 for earhead length, 15708 × 17548 for earhead girth, 17548 × 15388 for grain yield per plant and 15388 × 16317 for harvest index 15851 × 15708 for test weight and 17548 × 15388 for protein content showed significant and maximum heterosis over standard check GHB558 in desirable direction. Similar results were also reported by Joshi *et al.* (2001[a]) [11], Joshi *et al.* (2001[b]) [10], Sidpara (2002) [19], Rasal and Patil (2003) [18], Lakshmana *et al.* (2003) [13], Dangaria *et al.* (2004) [7], Chotaliya (2005) [6], Yahia Eldie *et al.* (2009) [8], 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.* (2018[b]) [12], Chaudhary A *et al.* (2019) [4] and Chaudhary Z. K *et al.* (2019) [5].

Considering *per se* performance of hybrids, 18 hybrids yielded higher than GHB 558 for grain yield per plant, of which two hybrids 17548 × 15388 and 15851 × 15725 yielded significantly higher than GHB 558. Seven superior hybrids in relation to *per se* value and heterosis for grain yield per plant with useful component characters showing desirable heterosis yield per plant placed in Table 2. The crosses 17548 × 15388, 15851 × 15725 and 15851 × 15708 showed higher *per se* performance for grain yield per plant. Apart from grain yield per plant, the cross 17548 × 15388 also exhibited higher *per se* performance for protein content whereas the cross 15851 × 15725 showed higher *per se* performance for days to maturity, number of effective tillers per plant, earhead length and harvest index. The cross 15851 × 15708 also gave higher *per se* performance for number of effective tillers per plant and test weight.

The cross 17548 × 15388 showed high *per se* performance and significant heterobeltiosis for grain yield per plant and test weight also showed significant standard heterosis for grain yield per plant, test weight, plant height and protein content. The cross, 15851 × 15725 showed high *per se* performance and significant heterobeltiosis for grain yield per plant, days to maturity and harvest index. Moreover, significant economic heterosis for days to flowering, days to maturity, earhead length, grain yield per plant, harvest index and test weight (Fig. 1). 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 (Mean square) for parents and hybrids for grain yield and its components characters in pearl Millet

Source of variation	Degree of Freedom	Mean sum of square									
		Days to flowering	**Days to maturity**	**Plant height**	**No. of effective tillers per plant**	**Ear head length**	**Ear head girth**	**Grain yield per plant**	**Harvest Index**	**Test weight**	**Protein content**
Replications	2	0.75	0.62	424.23	0.01	0.38	0.01	22.63	28.53	0.14	0.17
Genotypes	36	45.99**	93.24**	2792.39**	0.43**	33.00**	0.32**	784.92**	208.87**	4.76**	2.58**
Parents (P)	7	49.71**	50.66**	3292.63**	0.52**	19.16**	0.40**	479.30**	308.79**	8.05**	2.71**
Hybrids (H)	27	42.33**	64.39**	2343.24**	0.34**	29.46**	0.23**	615.78**	187.68**	5.01**	2.67**
Parent × Hybrid	1	102.15**	1257.69**	14036.11**	0.54**	255.28**	0.22**	8164.51**	288.78**	21.25**	0.01
Error	72	2.75	7.61	186.44	0.01	2.41	0.01	21.22	10.62	0.12**	0.16

* and** stands for significant at P = 0.05 and P = 0.01 levels, respectively.

Table 2: Comparative study of most promising hybrids in relation to *per se* value and heterosis for grain yield per plant with useful component characters showing desirable heterosis

Sr. No.	Hybrid	Grain yield per plant (g)	Heterosis for grain yield 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 component trait
			MP	BP	SC			
1	17548 × 15388	66.97	260.54**	190.04**	48.72**	DF, DM, PH and TW.	TW	PH, TW and PC.
2	15851 × 15725	66.33	161.12**	57.52**	47.31**	DM, PH, ETPP, EL, EG, HI and TW.	DM and HI.	DF, DM, EL, HI and TW.
3	15851 × 15708	60.93	50.17**	44.68**	35.30**	DF, DM, ETPP, HI and PC.	DM and PC.	DF, PH, HI, TW and PC.
4	15058 × 15708	57.83	142.65**	48.15**	28.42**	DF, DM, PH, ETPP and PC.	DM.	DF and HI.
5	15388 × 16317	56.28	192.93**	130.99**	24.98**	DF, DM, EL and HI	DM	HI and TW
6	15725 × 16110	55.30	273.88**	164.78**	22.81**	DF, DM, ETPP, EG, TW and PC	DM	TW
7	15058 × 15388	54.08	376.66**	284.61**	20.10*	DF, DM, ETPP and TW	DM and EL	EL and TW
* and** stands for significant at P = 0.05 and P = 0.01 levels, respectively.								

DF: Days to Flowering DM: Days to Maturity, PH: Plant Height, ETPP: Effective Tillers Per Plant, EL: Earhead Length, EG: Earhead Girth HI: Harvest Index, TW: Test Weight, PC: Protein Content

Table 3: Extent of heterosis for days to flowering and days to maturity expressed as percentage over mid parent value (MP), over better parent (BP) and over commercial check (SC)

Sr. No	Hybrids	Days to flowering			Days to maturity		
		MP	BP	SC	MP	BP	SC
1	15058 × 15851	-3.82	-1.95	3.43	-14.55**	-14.07**	-6.08*
2	15058 × 15708	-8.01**	-3.13	6.17*	-10.11**	-8.79**	0.81
3	15058 × 15725	1.81	5.63 *	15.76**	-8.27**	-6.59**	3.24
4	15058 × 17548	-4.13	-2.58	3.43	-11.03**	-7.51**	-5.27
5	15058 × 15388	-10.66**	-3.13	6.17*	-11.67**	-9.89**	-0.41
6	15058 × 16110	-6.17**	-5.00	4.11	-13.01**	-11.70**	-5.27
7	15058 × 16317	-3.18	-1.30	4.11	-8.54**	-5.12	-2.43
8	15851 × 15708	-5.14*	1.95	7.54**	-13.25**	-11.48**	-3.24
9	15851 × 15725	-0.61	5.19	10.96**	-16.09**	-14.07**	-6.08*
10	15851 × 17548	-3.56	-3.25	2.06	-13.96**	-11.07**	-8.91**
11	15851 × 15388	-7.92**	1.95	7.54**	-4.69*	-2.22	6.89*
12	15851 × 16110	-5.66*	-2.60	2.74	-10.28**	-9.43**	-2.84
13	15851 × 16317	-1.95	-1.95	3.43	-6.49**	-3.54	-0.81
14	15708 × 15725	10.03**	11.63**	31.51**	-0.71	-0.36	13.37**
15	15708 × 17548	-6.63**	0.00	6.17*	-2.62	2.77	5.27
16	15708 × 15388	1.65	4.52	26.72**	-6.19**	-5.69*	7.29**
17	15708 × 16110	-6.16**	-2.44	9.59**	-9.52**	-6.79**	0.00
18	15708 × 16317	-5.74**	1.30	6.85*	-7.29**	-2.36	0.41
19	15725 × 17548	-3.98	1.29	7.54**	-11.94**	-6.72 *	-4.46
20	15725 × 15388	2.51	6.98 **	26.03**	-0.18	0.00	14.58**
21	15725 × 16110	-5.36*	-3.05	8.91**	-12.04**	-9.06**	-2.43
22	15725 × 16317	-4.91*	0.65	6.17*	-11.73**	-6.69*	-4.05
23	17548 × 15388	-12.28**	-3.23	2.74	-10.24**	-4.74	-2.43
24	17548 × 16110	-6.58**	-3.87	2.06	-7.34**	-5.14	-2.84
25	17548 × 16317	-0.32	0.00	5.48	-6.51**	-6.32*	-4.05
26	15388 × 16110	-6.55**	0.00	12.33**	-8.2**	-4.91	2.03
27	15388 × 16317	-8.50**	1.30	6.85*	-10.78**	-5.51*	-2.84
28	16110 × 16317	-7.55**	-4.55	0.69	-8.29**	-6.30*	-3.65
S.Em.±		1.96	1.17	1.36	1.36	2.26	2.26
Range		-16.09 to -0.18	-12.28 to 10.03	-5.00 to 11.63	0.69 to 31.51	-14.07 to 2.77	-8.91 to 14.58
Significant heterosis		25	17	3	17	18	7
No. of +ve significant		0	1	3	17	0	4
No. of -ve significant		25	16	0	0	18	3
* and** stands for significant at P = 0.05 and P = 0.01 levels, respectively.							

Table 4: Extent of heterosis for plant height and no. of effective tillers per plant expressed as percentage over mid parent value (MP), over better parent (BP) and over commercial check (SC)

Sr. No	Hybrids	Plant height			No. of effective tillers per plant		
		MP	BP	SC	MP	BP	SC
1	15058 × 15851	6.34	32.94**	0.18	22.45**	20.00**	-41.87**
2	15058 × 15708	20.34**	39.07**	5.38	15.63**	-7.50*	-13.96**
3	15058 × 15725	44.58**	50.45**	5.56	-35.85**	-41.38**	-27.91**
4	15058 × 17548	3.01	8.88	-19.49**	3.57	-9.38*	-34.89**
5	15058 × 15388	41.00**	48.43**	13.50**	16.67**	-2.78	-34.89**
6	15058 × 16110	46.53**	47.76**	10.50*	13.04*	8.33	-18.61**
7	15058 × 16317	23.53**	40.13**	6.09	3.70	-6.67	-32.56**

8	15851 × 15708	3.93	11.42*	11.73*	13.85**	-7.50*	-6.98*
9	15851 × 15725	17.86**	54.53**	8.82	14.81**	6.90	-11.63**
10	15851 × 17548	-20.22**	-6.39	-22.40**	-1.75	-12.50**	-34.89**
11	15851 × 15388	12.35**	32.43**	9.88*	-8.20*	-22.22**	-20.94**
12	15851 × 16110	-7.36	16.99*	-15.08*	48.94**	40.00**	-32.56**
13	15851 × 16317	1.04	10.25	5.65	5.45	-3.33	-46.52**
14	15708 × 15725	1.63	22.86**	-14.91**	10.14**	-5.00	-32.56**
15	15708 × 17548	16.60**	26.92**	7.77	-22.22**	-30.00**	-39.54**
16	15708 × 15388	10.51*	-2.17	-18.08**	-10.53**	-15.00**	-27.91**
17	15708 × 16110	29.15**	50.68**	12.62*	-6.45	-27.50**	-34.89**
18	15708 × 16317	12.31**	14.19**	8.56	-34.29**	-42.50**	-20.94**
19	15725 × 17548	19.41**	31.62**	-4.68	-14.75**	-18.75**	-25.59**
20	15725 × 15388	-2.65	6.84	-25.67**	-4.62	-13.89**	-27.91**
21	15725 × 16110	44.18**	48.75**	3.53	9.80*	-3.45	-4.66
22	15725 × 16317	23.35**	46.28**	0.98	15.25**	13.33**	-34.89**
23	17548 × 15388	42.54**	43.10**	17.73**	-8.82*	-13.89**	-16.28**
24	17548 × 16110	-0.82	5.76	-22.05**	51.85**	28.12**	-46.52**
25	17548 × 16317	1.39	8.43	-9.26	-9.68*	-12.50**	-32.56**
26	15388 × 16110	39.10**	47.72**	9.79	-20.69**	-36.11**	-48.84**
27	15388 × 16317	4.40	12.13*	-7.94	-12.12**	-19.44**	-11.63**
28	16110 × 16317	11.13*	27.26**	-5.74	46.15**	26.67**	-30.24**
S.Em.±		9.65	11.14	11.14	0.07	0.09	0.09
Range		-20.22 to 46.53	-6.39 to 54.53	-25.67 to 17.73	-35.85 to 51.85	-42.50 to 40.00	-48.84 to -4.66
Significant heterosis		18	21	13	22	21	27
No. of +ve significant		16	21	6	12	5	0
No. of -ve significant		2	0	7	10	16	27

* and** stands for significant at P = 0.05 and P = 0.01 levels, respectively.

Table 5: Extent of heterosis for ear head length and ear head girth expressed as percentage over mid parent value (MP), over better parent (BP) and over commercial check (SC)

Sr. No	Hybrids	Ear head length			Ear head girth		
		MP	BP	SC	MP	BP	SC
1	15058 × 15851	9.77	-7.99	9.83	-14.49**	-23.25**	3.57
2	15058 × 15708	-11.35*	-22.53**	10.94	6.00	-0.35	-3.98*
3	15058 × 15725	-1.39	-3.87	17.30**	-29.15**	-30.57**	-1.11
4	15058 × 17548	6.73	-10.68*	4.80	11.53**	1.78	-7.29**
5	15058 × 15388	-10.02	-21.62**	15.00**	-5.60	-16.20	-0.04
6	15058 × 16110	-13.68*	-23.72**	13.93*	3.52	-6.90	3.31
7	15058 × 16317	6.14	-1.51	14.66*	4.49	-2.26	-12.33**
8	15851 × 15708	6.06	0.99	-0.67	4.57	-0.46	-12.88**
9	15851 × 15725	24.77**	6.80	18.67**	12.41**	2.75	-7.05**
10	15851 × 17548	-4.76	-4.93	-5.96	-2.10	-3.89	-22.74**
11	15851 × 15388	9.57*	4.70	-4.39	2.38	1.12	-6.64**
12	15851 × 16110	10.29*	3.73	-20.06**	7.46	7.22	-20.50**
13	15851 × 16317	16.63**	4.39	6.98	-4.79	-8.93*	-3.93
14	15708 × 15725	33.68**	19.46**	-21.81**	11.51**	6.84	-20.30**
15	15708 × 17548	-10.25*	-14.69**	-6.40	-14.11**	-16.77**	4.93*
16	15708 × 15388	-4.11	-4.46	-24.77**	0.48	-5.47	-16.96**
17	15708 × 16110	-18.47**	-19.52**	-6.14	-13.03**	-17.03**	3.50
18	15708 × 16317	14.96**	7.70	-4.66	9.84*	9.28	1.36
19	15725 × 17548	-0.65	-15.08**	10.24	21.61**	13.08**	-6.96**
20	15725 × 15388	-15.59**	-24.81**	-26.08**	-6.92	-15.87**	-36.24**
21	15725 × 16110	7.28	-3.02	1.28	17.71**	7.83	-6.97**
22	15725 × 16317	15.59**	9.88	13.41*	20.79**	15.18**	-5.29**
23	17548 × 15388	-29.69**	-32.94**	0.06	-33.41**	-35.42**	-1.23
24	17548 × 16110	-2.15	-8.12	-21.84**	-1.40	-2.99	-6.62**
25	17548 × 16317	15.12**	2.87	8.58	4.76	2.02	-3.61
26	15388 × 16110	-20.57**	-21.88**	-3.23	-4.08	-5.47	-4.02*
27	15388 × 16317	16.23**	8.51	-12.24**	3.19	-2.46	-16.01**
28	16110 × 16317	-4.37	-9.31	-13.23**	-8.64*	-12.43**	-11.93**
S.Em.±		1.10	1.10	1.27	0.11	0.12	0.06
Range		-29.69 to 33.68	-32.94 to 19.46	-26.08 to 18.67	-33.41 to 21.61	-35.42 to 15.18	-36.24 to 4.93
Significant heterosis		16	11	13	13	10	19
No. of +ve significant		9	1	6	7	2	1
No. of -ve significant		7	10	7	6	8	18

* and** stands for significant at P = 0.05 and P = 0.01 levels, respectively.

Table 6: Extent of heterosis for grain yield per plant and harvest index expressed as percentage over mid parent value (MP), over better parent (BP) and over commercial check (SC)

Sr. No	Hybrids	Grain yield per plant			Harvest index		
		MP	BP	SC	MP	BP	SC
1	15058 × 15851	42.94**	-13.88	-19.47*	32.65**	20.11**	-24.37**
2	15058 × 15708	142.65**	48.15**	28.42**	-10.18	-22.23**	19.85*
3	15058 × 15725	351.75**	350.02**	-13.10	-57.84**	-60.26**	-1.99
4	15058 × 17548	84.38**	26.65	-35.06**	1.77	-14.32**	-18.77**
5	15058 × 15388	376.66**	284.61**	20.10*	-16.53*	-23.98**	-3.67
6	15058 × 16110	248.23**	146.06**	14.14	-6.69	-8.20	-11.75
7	15058 × 16317	192.14**	97.81**	7.02	2.22	-5.57	6.52
8	15851 × 15708	50.17**	44.68**	35.30**	18.01**	-5.98	27.48**
9	15851 × 15725	161.12**	57.52**	47.31**	23.94**	18.75*	39.46**
10	15851 × 17548	-46.52**	-58.60**	-61.30**	-23.39**	-40.46**	-2.10
11	15851 × 15388	80.97**	20.70*	12.88	26.56**	25.75**	11.36
12	15851 × 16110	-19.25	-39.60**	-43.52**	2.61	-8.43	-28.00**
13	15851 × 16317	-1.47	-22.24*	-27.29**	14.74*	-3.19	-20.89**
14	15708 × 15725	11.01	-32.13**	-41.18**	32.81**	9.41	-17.45*
15	15708 × 17548	50.69**	19.91*	3.95	-25.8**	-28.23**	-13.58
16	15708 × 15388	-28.37*	-51.28**	-57.78**	9.13	-12.64*	-2.01
17	15708 × 16110	50.67**	15.64	0.24	-35.67**	-43.51**	-3.66
18	15708 × 16317	48.68**	20.74*	4.67	-33.38**	-37.94**	-15.99*
19	15725 × 17548	221.9**	121.57**	13.62	-21.07**	-36.66**	36.42**
20	15725 × 15388	100.88**	62.57*	-49.25**	23.12**	18.70*	-30.10**
21	15725 × 16110	273.88**	164.78**	22.81**	7.67	-0.05	12.90
22	15725 × 16317	170.05**	83.23**	-0.88	-12.75*	-23.64**	3.04
23	17548 × 15388	260.54**	190.04**	48.72**	-34.37**	-48.75**	-23.39**
24	17548 × 16110	0.30	-4.49	-51.03**	-3.03	-17.26**	9.10
25	17548 × 16317	112.07**	106.53**	11.74	16.39**	-24.48**	9.67
26	15388 × 16110	135.71**	97.19**	-8.53	26.12**	13.19	-3.61
27	15388 × 16317	192.93**	130.99**	24.98**	17.52**	-0.32	41.58**
28	16110 × 16317	136.23**	119.37**	18.69*	37.17**	28.67**	10.05
S.Em.±		3.25	3.76	3.76	2.33	2.69	2.69
Range		-46.52 to 376.66	-58.60 to 350.02	-61.30 to 48.72	-57.84 to 37.17	-60.26 to 28.67	-30.10 to 41.58
Significant heterosis		24	24	17	20	19	13
No. of +ve significant		22	19	8	10	5	5
No. of -ve significant		2	5	9	10	14	8
* and** stands for significant at P = 0.05 and P = 0.01 levels, respectively.							

Table 7: Extent of heterosis for test weight and protein content expressed as percentage over mid parent value (MP), over better parent (BP) and over commercial check (SC)

Sr. No	Hybrids	Test weight			Protein content		
		MP	BP	SC	MP	BP	SC
1	15058 × 15851	6.78**	-2.10	12.00**	-12.65**	-17.77**	-17.32**
2	15058 × 15708	1.57	-13.43**	-8.53**	16.72**	5.56	-18.16**
3	15058 × 15725	-36.66**	-44.25**	18.73**	-10.26**	-10.96**	-21.13**
4	15058 × 17548	5.26*	-6.17**	19.96**	10.4**	6.24	-19.66**
5	15058 × 15388	4.87*	-15.11**	14.46**	-9.96**	-16.50**	-19.98**
6	15058 × 16110	14.67**	5.26*	8.38**	22.44**	15.20**	-12.67**
7	15058 × 16317	-7.86**	-19.95**	9.14**	-12.59**	-15.02**	4.62
8	15851 × 15708	-23.01**	-28.97**	28.79**	3.31	-1.02	-24.24**
9	15851 × 15725	4.04*	-0.54	14.12**	-11.29**	-17.10**	-19.45**
10	15851 × 17548	6.73**	3.48	14.55**	-5.08	-7.23	-3.47
11	15851 × 15388	1.96	-1.03	16.99**	-16.75**	-26.97**	-2.87
12	15851 × 16110	-0.31	-0.45	21.97**	5.69	5.63	-1.54
13	15851 × 16317	-5.86**	-11.28**	18.28**	15.04**	5.47	3.33
14	15708 × 15725	-8.03**	-11.39**	19.38**	-5.73	-15.33**	-4.87
15	15708 × 17548	-6.38**	-11.06**	-1.75	18.91**	11.47**	2.52
16	15708 × 15388	-4.27*	-9.16**	17.63**	4.81	-11.36**	5.95
17	15708 × 16110	2.78	-5.29*	19.31**	24.36**	19.23**	-1.05
18	15708 × 16317	-6.06**	-8.16**	6.39*	18.11**	4.16	5.43
19	15725 × 17548	-16.48**	-17.69**	15.92**	12.82**	7.76*	-13.40**
20	15725 × 15388	0.10	-1.46	21.45**	3.50	-3.32	-16.23**
21	15725 × 16110	4.69**	-0.05	21.15**	11.36**	4.01	-12.42**
22	15725 × 16317	-12.21**	-13.51**	7.98**	8.50**	6.28	-2.45
23	17548 × 15388	4.90*	4.77*	15.65**	-14.60**	-23.56**	9.59**

24	17548 × 16110	7.94**	4.51	16.75**	3.54	1.13	-5.53
25	17548 × 16317	-9.62**	-12.22**	8.56**	5.01	-1.66	-15.05**
26	15388 × 16110	4.14*	0.95	8.56**	-1.67	-13.79**	-17.42**
27	15388 × 16317	-9.03**	-11.75**	7.98**	-18.61**	-22.47**	-3.05
28	16110 × 16317	-6.74**	-12.22**	23.01**	6.68*	-2.26	-0.81
S.Em.±		.024	0.28	0.28	0.28	0.33	0.33
Range		-36.66 to 14.67	-44.25 to 5.26	-8.52 to 28.78	-18.61 to 24.36	-26.97 to 19.23	-24.24 to 9.59
Significant heterosis		23	19	27	19	15	14
No. of +ve significant		9	2	26	11	4	1
No. of -ve significant		14	17	1	8	11	13
* and** stands for significant at P = 0.05 and P = 0.01 levels, respectively.							

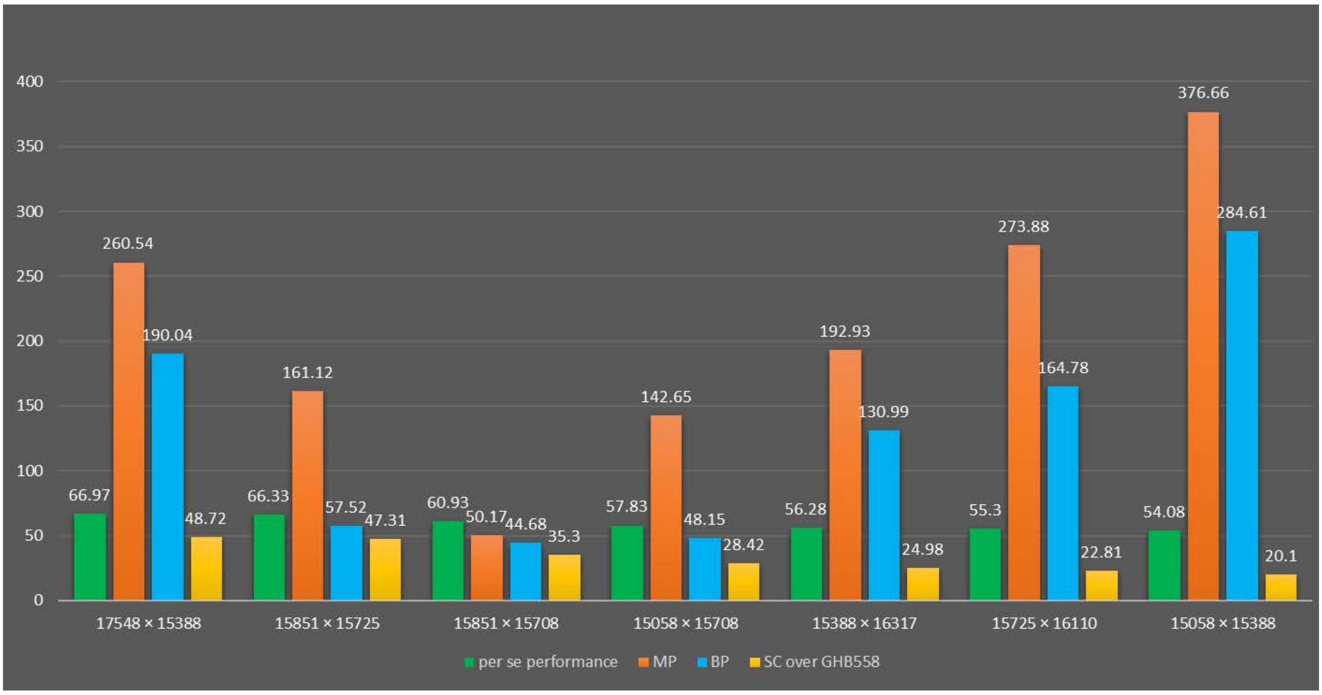

Fig 1: Diagrammatically representation of most promising hybrids in relation to *per se* value and heterosis for grain yield per plant with useful component characters showing desirable heterosis

References

1. Anonymous. Project Co-ordinator, AICRP on pearl millet review, Mandor, Jodhpur 2021,1-2.
2. Bhadalia AS, Dhedhi KK, Joshi HJ. Combining ability studies through diallel analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Int. J Agric. Sci. 2014, 57-60.
3. Briggle LW. Heterosis in Wheat - A Review. Crop Sci 1963;3:407-412.
4. Chaudhary A. Heterosis, combining ability and inbreeding depression analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.] (Unpublished). Sardarkrushinagar Dantiwada Agricultural University, Dantiwada, Gujarat 2019, 32-78.
5. Chaudhary ZK. Study of different sources of CMS lines in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. (Unpublished). Sardarkrushinagar Dantiwada Agricultural University, Dantiwada, Gujarat 2019, 42-82.
6. 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 2005.
7. 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 2004, 1-2.
8. Eldie YD, Ibrahim AES, Ali AM. Combining ability analysis for grain yield and its components in pearl millet. Journals of university of Gezira 2009;7(2):9556-1728.
9. Fonseca S, Patterson FL. Hybrid vigour in seven parent diallel cross in common winter wheat (*Triticum aestivum* L.) Crop Sci 1968;8(1):85-88.
10. 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.
11. 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.
12. 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.
13. Lakshmana D, Surendra P, Gurumarty R. Combining ability studies in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Res crops 2003;4(3):358-362.
14. Meredith WR, Bridge RR. Heterosis and gene action in cotton *Gossypium hirsutum*. Crop Sci 1972;12:304-310.
15. Panse VG, Sukhatme PV. Statistical methods for

agricultural workers. ICAR, New Delhi 1985, 97-156.
16. Patel BC, Patel MP. Combining ability studies for grain yield and its components in pearl millet [*Pennisetum glaucum* (L). R. Br.]. Electron J Plant Breed 2016;7(3):595-601.
17. Patel SM, Patel MP. Combining ability and gene action for grain yield and agronomic traits in pearl millet restorer lines. Electron J Plant Breed 2014;5(3):394-401.
18. 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.
19. Reshma Krishnan MR, Patel MS, Gami RA, Bhadauriya HS, Patel YN. Genetic Analysis in pearl millet [*Pennisetum glaucum* (L) R. Br.]. International Journal of Current Microbiology and Applied Sciences 2017;6(11):900-907.
20. Sidpara SV. M. Sc. (Agri.) Thesis. Gujarat Agricultural University, Sardarkrushinagar. Gujarat 2002.