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Study of combining ability for seed yield and its component traits in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract
Combining ability for seed yield and its component traits in bajara was studied using line x tester mating design involving five diverse male sterile lines and nine male lines. Analysis of variance revealed that, there is highly significant difference among the parents for all the traits under study. The analysis for combining ability revealed significant mean sum of squares of both general combining ability (GCA) and specific combining ability (SCA) for all the characters which indicated the presence of both additive and non-additive gene actions. Five parental lines, JMSA 20102 and ICMA 04999 among the females and J-2508, J-2503 and J-2433 among the males, exhibited good general combining ability effects for seed yield per plant and important yield components. The best three hybrids on the basis of significant positive sca effects for seed yield per plant were JSMA 20102 x J-2496 (good x good), JMSA 20102 x J-2479 (good x good combiners) and ICMA 841 x J-2500 (poor x average combiners). The top high yielding hybrids JMSA 20102 x J-2496 and JMSA 20102 x J-2479, with significant heterobeltiosis as well as standard heterosis, also depicted significant sca effects for seed yield per plant.

Keywords: Combining ability, GCA and SCA effects, gene action, yield attributes

Introduction
Pearl millet (*Pennisetum glaucum* (L.). R.Br.) is annual, tillering diploid (2n = 14) crop. It belongs to family *Poaceae* and sub family *Paniceidae* and believed to be originated in Africa. Pearl millet is one of the important staple food crops of India ranking fourth in acreage next to rice, wheat, and sorghum and world's sixth important cereal food crop. However, it is primarily grown as forage crop in USA, Australia and South Africa. It is a highly cross-pollinated crop with protogynous flowering and wind-borne pollination mechanism. Being a C_4 species, it is endowed with a very high photosynthetic efficiency and more ability for dry matter production. Pearl millet is not only a quick growing short duration crop, but also found drought as well as heat tolerant and well adapted to different soil types. Because of its propensity for high dry matter production at high temperature, it has made a mark in tropics and sub-tropics. It is a drought resistant cereal having the maximum potentiality of grain production in adverse conditions. The better nutritive value of pearl millet grains appears from its protein, fat and mineral matters contents. It is also rich in vitamin A, vitamin B, thiamin as well as riboflavin contents and imparts substantial energy to the body with easy digestibility (Pal *et al*., 1996) [10]. Apart from grain, it also supplies fair quality of dry matter (forage and stover) at harvest in large bulk; which is an important secondary product in low resource agriculture for animal feed. The improvement in this crop in India started as early as in 1920. However, the real breakthrough was made when the first and the most widely used cytoplasmic male sterile line *Tift* 23A (Burton, 1965) [3] was utilized in development of grain hybrids in India. Extensive testing of single crosses with $23A_1$, Indian breeders could able to announce the release of 'HB–1' hybrid in 1965 (Athwal, 1965) [2]. Subsequently, availability of several cytoplasmic genetic male sterility systems have facilitated production and release of number of hybrids with increased drought tolerance as well as resistance to biotic stress and increased yield with greater efficiency in growth factor use (Burton, 1983 [4]; Andrews and Anand, 1992 [1]).

Materials and Methods
Experimental material consisting of 60 entries comprised of five male sterile lines (used as testers/females JMSA 101, JMSA 20102, ICMA 841, ICMA 89111, ICMA 04999) and nine

inbred lines (used as lines/males J-2433, J-2479, J-2482, J-2496, J-2500, J-2503, J-2507, J-2508, J-2510) and their 45 hybrids developed through line x tester mating design along with standard check hybrid (GHB 732) were evaluated in a randomized block design with three replications. The 45 crosses made in line x tester mating design during *summer* 2016 at Instructional Farm, College of Agriculture, JAU, Junagadh, which were evaluated during *kharif* 2016 also at the Sagdividi Farm, Department of Seed Science and Technology, College of Agriculture, Junagadh Agricultural University, Junagadh. Five competitive plants per each entry in each replication were randomly selected before flowering and tagged for the purpose of recording the observations of different characters *viz*., grain yield per plant, days to 50% flowering, days to maturity, number of nodes on main stem, number of effective tillers per plant, plant height, earhead length, earhead girth, earhead weight, test weight, panicle index, total biomass per plant and harvest index. Analysis of variance for combining ability was computed according to the model given by Kempthorne (1957) [7] which is analogous to design II of Comstock and Robinson (1952) [5] in terms of covariance of half-sibs (H.S.) and full-sibs (F.S.).

Experimental Results and Discussion

The analysis of variance for combining ability revealed (Table 1) that general combining ability and specific combining ability variance were significant for most of the characters, which indicated that both additive and non-additive gene actions were important in the inheritance of these traits. It was observed that none of the parent was found to be good general combiner for all the traits.

JMSA 20102 the females and J-2479 and J-2503 among the males, exhibited good general combining ability effect for seed yield per plant. Among the male sterile lines, JMSA 101was found good general combiner for Days to 50% flowering, Number of nodes on main stem, Plant height, Test weight; JMSA 20102 was found good general combiner for days to grain yield per plant also found good general combiners for days to maturity, number of nodes on main stem, number of effective tillers per plant, plant height, earhead girth, total biomass per plant and harvest index.; JMSA 101 was found good general combiner for days to 50% flowering, plant height, test weight, panicle index and total biomass per plant; and J-2479 was found good general combiner for plant height, earhead weight, test weight and harvest index (Table 2). Thus, the association between *per se* performance of parents and their gca effects suggested that while selecting the parents for hybridization programme, *per se* performance of the parents should also be given due consideration. Thus, if a character is Uni-directionally controlled by a set of alleles and additive effects are important, the choice of parents on the basis of *per se* performance may be more effective. Similar findings have also been reported by Patel (2012) [11], Khadagale *et al.* (2014) [8], Patel *et al.* (2014) [14] and Mungra *et al.* (2015) [9]. However, this cannot be taken as a rule because genotypes with high *per se* performance need not always be good general combiners. This could be attributed due to the intra and/or inter-allelic interaction of genes concerned with the character modified by environmental factors (Dabholkar, 1999) [6].

Out of 45 crosses, 15 exhibited significantly positive sca effects and 17 had significantly negative sca effects for grain yield per plant. The highest yielding hybrid JMSA 20102 x J-2496. Being higher manifested and significantly positive sca effects for grain yield per plant, Likewise, the hybrid JMSA 101 x J-2508 depicted significant sca effect for grain yield per plant as well as for plant height, earhead length, earhead weight, test weight and harvest index., which involved good x good combining parents for seed yield per plant, The third high yielding cross, ICMA 841 x J-2500 involved poor x average poor combiners for seed yield per plant, also exhibited positive sca effect (Table 5).

Estimation of sca effects did not reveal any specific trend among the crosses. The crosses exhibited high sca effects did not always involve both parents as good general combiners with high gca effects, thereby suggesting importance of intra as well as inter-allelic interactions. The high sca effects of crosses in general correspond to their high heterotic effects, but these might also be accompanied by poor and /or average gca effects of their parents. The crosses having high sca effects for seed yield per plant had also registered significant sca effects in desirable direction for some of the yield component characters Out of ten top most high yielding cross combinations, three cross combinations *viz*., JMSA 20102 x J-2496, JMSA 20102 x J-2479 and ICMA 841 x J-2500 possessed good x good, good x good and poor x average general combiner parents, respectively (Table 5). the other crosses namely JMSA 101 x J-2508, JMSA 101 x J-2503, JMSA 20102 x J-2500, ICMA 89111 x J-2433 and ICMA 841 x J-2510 depicted poor x poor, poor x good, good x average, average x average and poor x poor combiner of parents. These hybrids expressed significantly positive sca effect by involving poor and average parents could be due to better complementation between favourable alleles of the parents involve.

The estimates of general combining ability suggested that one female parent JMSA 20102 and three male parents J-2479, J-2496 and J-2503 were found good general combiner for grain yield per plant. Moreover, these parents were also good combiners for other yield attributing characters. The parent JMSA 20102 found good general combiner not only for grain yield per plant but, also good combiners for days to maturity, number of nodes on main stem, number of effective tillers per plant, plant height, ear head girth, total biomass per plant, harvest index. Whereas, parents JMSA 101 was appeared to be good general combiner for other traits such as days to 50% flowering, plant height, test weight, panicle index, total biomass per plant. While, the parent J-2479 was good combiner for plant height, ear head weight, test weight, harvest index. The parents JMSA 101, JMSA 20102, J-2500 and J-2507 were found good general combiner for days to 50% flowering and days to maturity. The three superior crosses namely JMSA 20102 x J-2496, JMSA 20102 x J-2479 and JMSA 20102 x J-2500 exhibited higher per se performance, positively significant and high magnitude of heterobeltiosis as well as standard heterosis and significant sca effects for grain yield per plant. These hybrids also registered significantly higher heterosis and sca effects in desired direction for other yield attributing components. Therefore, these hybrids could be further evaluated over years and locations in diverse environments to exploit for commercial cultivation.

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

Source	Df	Grain yield per plant	Days to 50% flowering	Days to maturity	Number of nodes on main stem	Number of effective tillers per plant	Plant height	Earhead length
Replications	2	1.609	1.622	39.874	0.351	0.090	757.135**	7.219*
Hybrids	44	22.909**	12.485**	24.242**	3.457**	0.205**	569.110**	3.795*
Lines	4	60.349*	74.352**	37.641	17.472**	0.211	3807.362**	3.107
Testers	8	9.994	9.417	56.213**	1.015	0.123	204.588	2.942
Lines x testers	32	21.458	5.519	14.574	2.316**	0.224**	255.459**	4.094*
Error	88	0.808	4.448	13.420	0.396	0.058	52.289	2.192
Estimates								
σ^2 L		2.205	2.589	0.897	0.632	0.005	139.076	0.033
σ^2 T		0.612	0.331	2.852	0.041	0.004	10.153	0.050
σ^2gca		1.636	1.782	1.595	0.421	0.005	93.032	0.039
σ^2sca		6.883	0.356	0.384	0.640	0.055	67.723	0.633
σ^2gca/ σ^2sca		0.237	5.005	4.153	0.657	0.090	1.373	0.616

*, ** were significant at 5% and 1% levels of probability, respectively.

Table 1.1: Contd…

Source	Df	Earhead girth	Earhead weight	Test weight	Panicle index	Total biomass per plant	Harvest index
Replications	2	20.396**	13.039*	0.241	3858.493**	41.565*	60.024*
Hybrids	39	6.542**	34.974**	1.695**	5673.449**	357.612**	158.679**
Lines	3	31.186**	93.865*	2.234	17873.994*	220.194	122.782
Testers	9	3.088	26.923	2.515	1445.697	257.012	110.599
Lines x testers	27	4.326*	29.625**	1.423**	5205.318**	399.939**	175.186**
Error	78	2.280	2.700	0.086	450.859	10.526	12.407
Estimates							
σ^2 L		1.070	3.376	0.079	645.301	7.765	4.088
σ^2 T		0.053	1.614	0.161	66.322	16.432	6.546
σ^2gca		0.707	2.747	0.109	438.523	10.860	4.965
σ^2sca		0.681	8.975	0.445	1584.819	129.804	54.259
σ^2gca/ σ^2sca		1.038	0.306	0.244	0.276	0.083	0.091

*, ** were significant at 5% and 1% levels of probability, respectively.

Table 2: Summary of general combining ability effects of the parents for different characters in pearl millet

Parents	Grain yield per plant	Days to 50% flowering	Days to maturity	Numbers of nodes on main stem	Numbers of effective tillers per plant	Plant height	Earhead length	Earhead girth	Earhead weight	Test weight	Panicle index	Total biomass per plant	Harvest index
Lines													
JMSA 101	P	G	A	G	A	G	A	P	A	G	G	G	P
JMSA 20102	G	A	G	G	G	G	A	G	P	A	A	G	G
ICMA 841	P	A	A	G	P	P	A	G	P	A	A	P	P
ICMA 89111	A	A	A	P	P	P	A	A	G	P	P	P	A
ICMA 04999	P	P	A	P	A	P	A	P	G	P	P	A	P
Testers													
J-2433	A	A	A	G	A	A	A	A	P	A	A	P	A
J-2479	G	A	A	A	A	G	A	A	G	G	A	P	G
J-2482	P	A	A	A	A	A	A	A	A	A	A	P	A
J-2496	G	A	A	A	G	A	A	A	P	P	P	A	A
J-2500	A	A	G	A	P	A	A	A	P	P	A	G	P
J-2503	G	A	P	A	A	A	A	A	A	G	P	G	A
J-2507	A	G	G	A	A	A	A	A	G	P	A	G	A
J-2508	P	A	A	A	A	P	A	P	A	P	G	P	A
J-2510	P	A	A	P	A	P	A	A	A	G	A	A	P

G = Good combiner, A = Average combiner, P = Poor combiner

Table 3: Estimates of specific combining ability effects (sca) for grain yield and growth characters in pearl millet

Sr. No.	Hybrids	Grain yield per plant	Days to 50% flowering	Days to maturity	Number of nodes on main stem	Number of effective tillers per plant	Plant height
1	JMSA 101 x J-2433	1.25 *	-1.66	-1.38	1.01 **	-0.21	14.73 **
2	JMSA 101 x J-2479	-0.87	0.54	-0.32	0.21	-0.10	3.02
3	JMSA 101 x J-2482	0.09	0.74	0.21	-0.43	0.10	-7.96
4	JMSA 101 x J-2496	-2.81 **	-0.39	1.54	1.46 **	-0.28 *	1.31
5	JMSA 101 x J-2500	-2.77 **	-2.86 *	-3.65	-1.17 **	0.16	-5.37
6	JMSA 101 x J-2503	3.11 **	1.67	-0.12	-0.10	-0.21	10.97 *
7	JMSA 101 x J-2507	-1.48 **	-0.86	1.81	0.17	-0.04	0.78
8	JMSA 101 x J-2508	3.30 **	1.60	1.68	-0.72	0.46 **	-21.84 **
9	JMSA 101 x J-2510	0.16	1.20	0.21	-0.44	0.12	4.37
10	JMSA 20102 x J-2433	-4.05 **	0.67	2.46	-0.64	0.05	-20.77 **

11	JMSA 20102 x J-2479	3.93 **	-0.79	-1.13	-0.04	0.22	-0.14
12	JMSA 20102 x J-2482	-1.37 **	-0.92	0.40	0.50	-0.43 **	4.06
13	JMSA 20102 x J-2496	6.18 **	0.94	-2.26	-0.59	0.05	2.81
14	JMSA 20102 x J-2500	2.93 **	1.47	2.20	1.43 **	0.09	-1.54
15	JMSA 20102 x J-2503	-1.21 *	-0.99	0.06	-0.83 *	0.41 **	9.46 *
16	JMSA 20102 x J-2507	-0.71	-0.52	-3.00	0.65	-0.04	-1.38
17	JMSA 20102 x J-2508	-4.59 **	0.60	-1.46	-0.57	-0.27	5.38
18	JMSA 20102 x J-2510	-1.07 *	-0.46	2.73	0.10	-0.08	2.13
19	ICMA 841 x J-2433	-1.47 **	1.67	-5.23 *	0.15	-0.04	-5.47
20	ICMA 841 x J-2479	-2.07 **	-0.46	2.49	-0.11	-0.07	-8.04
21	ICMA 841 x J-2482	0.92	0.74	0.69	-1.29 **	0.60 **	10.57 *
22	ICMA 841 x J-2496	-2.65 **	0.94	2.03	-0.25	-0.31 *	2.98

*, ** were significant at 5% and 1% levels of probability, respectively.

Table 3: Contd…

Sr. No.	Hybrids	Grain yield per plant	Days to 50% flowering	Days to maturity	Number of nodes on main stem	Number of effective tillers per plant	Plant height
23	ICMA 841 x J-2500	3.59 **	-1.52	-2.83	1.57 **	0.06	8.82 *
24	ICMA 841 x J-2503	-0.18	0.34	-0.97	-0.36	0.12	-12.83 **
25	ICMA 841 x J-2507	0.47	0.14	3.29	0.11	-0.07	-1.41
26	ICMA 841 x J-2508	-0.63	-1.39	0.16	1.09 **	-0.10	6.29
27	ICMA 841 x J-2510	2.02 **	-0.45	0.36	-0.89 *	-0.18	-0.89
28	ICMA 89111 x J-2433	2.89 **	0.89	2.02	0.01	0.25	12.95 **
29	ICMA 89111 x J-2479	-2.63 **	-0.23	-0.91	-0.19	-0.03	-3.22
30	ICMA 89111 x J-2482	0.06	0.96	-1.04	1.22 **	-0.09	-3.47
31	ICMA 89111 x J-2496	-1.34 *	-0.17	0.62	-0.80 *	-0.21	-8.59 *
32	ICMA 89111 x J-2500	-2.39 **	0.03	2.75	-0.77 *	-0.10	-1.15
33	ICMA 89111 x J-2503	1.25 *	-0.43	0.62	1.22 **	-0.11	-0.07
34	ICMA 89111 x J-2507	-0.01	-0.63	-0.77	-1.23 **	0.09	-6.79
35	ICMA 89111 x J-2508	1.10 *	-1.58	-0.24	-0.12	0.07	5.97
36	ICMA 89111 x J-2510	1.06 *	0.94	-3.04	0.68	0.12	4.39
37	ICMA 04999 x J-2433	1.64 **	-1.51	2.13	-0.53	-0.04	-1.43
38	ICMA 04999 x J-2479	0.27	-1.31	-0.13	0.13	-0.00	8.39 *
39	ICMA 04999 x J-2482	0.63	2.88 *	-0.26	0.01	-0.19	-3.19
40	ICMA 04999 x J-2496	-1.35 *	-0.58	-1.93	0.18	0.75 **	1.48
41	ICMA 04999 x J-2500	-2.96 **	1.88	1.53	-1.05 **	-0.20	-0.74
42	ICMA 04999 x J-2503	1.73 **	-0.98	0.40	0.08	-0.21	-7.52
43	ICMA 04999 x J-2507	0.82	0.28	-1.33	0.29	0.06	8.82 *
44	ICMA 04999 x J-2508	-2.18 **	-1.58	-0.13	0.33	-0.16	4.19
45	ICMA 04999 x J-2510	1.64 **	0.94	-0.26	0.54	0.02	-9.99 *
S. E. ±		0.51	1.21	2.11	0.36	0.13	4.17
Total significant positive		15	1	0	7	4	8
Total significant negative		17	1	1	8	3	4

*, ** were significant at 5% and 1% levels of probability, respectively.

Table 4: Estimates of specific combining ability effects (sca) for yield attributes and other characters in pearl millet

Sr. No.	Hybrids	Earhead length	Earhead girth	Earhead weight	Test weight	Panicle index	Total biomass per plant	Harvest index
1	JMSA 101 x J-2433	2.38 **	-0.60	0.00	-0.22	-17.25	-15.03 **	16.33 **
2	JMSA 101 x J-2479	-1.58	-0.93	2.76 **	0.61 **	32.46 **	-0.51	-3.23
3	JMSA 101 x J-2482	-0.45	0.24	-3.70 **	-0.95 **	-38.74 **	4.49 *	-5.19 *
4	JMSA 101 x J-2496	-1.89 *	-0.82	-4.42 **	-0.02	-13.27	-6.04 **	-4.49 *
5	JMSA 101 x J-2500	0.14	0.63	1.38	0.17	60.67 **	3.87 *	-7.23 **
6	JMSA 101 x J-2503	-0.26	1.25	3.07 **	0.45 **	-13.69	-8.37 **	10.68 **
7	JMSA 101 x J-2507	-0.17	0.77	2.74 **	-0.15	61.68 **	4.53 *	-6.38 **
8	JMSA 101 x J-2508	1.40	-2.26 *	2.28 *	0.34 *	-25.60 *	1.87	5.61 **
9	JMSA 101 x J-2510	0.44	1.71	-4.12 **	-0.23	-46.24 **	15.20 **	-6.09 **
10	JMSA 20102 x J-2433	-1.32	0.01	-0.51	0.48 **	35.85 **	-2.40	-9.24 **
11	JMSA 20102 x J-2479	-0.16	-0.39	0.90	-0.73 **	-29.01 *	4.50 *	5.17 *
12	JMSA 20102 x J-2482	0.90	-0.88	1.54	-0.48 **	19.15	-15.13 **	6.62 **
13	JMSA 20102 x J-2496	-0.01	-0.05	3.59 **	0.29	-18.78	4.84*	8.39 **
14	JMSA 20102 x J-2500	1.16	-0.68	-2.76 **	0.07	-57.77 **	13.20 **	-0.83
15	JMSA 20102 x J-2503	1.95 *	0.68	-5.30 **	-0.07	-36.39 **	10.94 **	-7.59 **
16	JMSA 20102 x J-2507	0.78	-0.80	-1.71	-0.34 *	-14.79	-13.38 **	9.23 **
17	JMSA 20102 x J-2508	-2.11 *	1.39	0.87	0.28	72.17 **	-5.14 **	-7.47 **
18	JMSA 20102 x J-2510	-1.20	0.74	3.39 **	0.51 **	29.57 *	2.57	-4.26 *
19	ICMA 841 x J-2433	-1.34	0.32	1.62	1.23 **	52.34 **	1.88	-6.57 **

20	ICMA 841 x J-2479	1.68	-0.13	-1.08	-0.47 **	17.02	-10.25 **	3.66
21	ICMA 841 x J-2482	-0.24	-0.68	3.28 **	0.54 **	26.52 *	23.40 **	-9.95 **
22	ICMA 841 x J-2496	0.04	0.76	-2.58 **	-0.69 **	6.73	-18.02 **	4.81 *

*, ** were significant at 5% and 1% levels of probability, respectively.

Table 4: Contd…

Sr. No.	Hybrids	Earhead length	Earhead girth	Earhead weight	Test weight	Panicle index	Total biomass per plant	Harvest index
23	ICMA 841 x J-2500	-0.78	1.19	-0.85	-0.51 **	-67.08 **	10.30 **	2.30
24	ICMA 841 x J-2503	-0.59	-0.73	5.45 **	-0.56 **	54.01 **	2.93	-2.66
25	ICMA 841 x J-2507	-0.63	-0.35	-2.29 *	-0.08	-32.07 *	-1.50	0.05
26	ICMA 841 x J-2508	1.60	-0.18	-3.96 **	-1.00 **	-29.62 *	1.16	-2.74
27	ICMA 841 x J-2510	0.24	-0.20	0.42	1.55 **	-27.86 *	-9.90 **	11.11 **
28	ICMA 89111 x J-2433	-0.17	0.51	1.95 *	-0.57 **	-20.85	14.61 **	-1.93
29	ICMA 89111 x J-2479	0.05	0.54	-3.72 **	-0.16	2.97	5.82 **	-9.20 **
30	ICMA 89111 x J-2482	0.12	2.44 **	0.36	0.60 **	8.16	3.32	-3.73
31	ICMA 89111 x J-2496	-0.11	-0.73	-1.58	0.77 **	-3.18	-2.96	-1.07
32	ICMA 89111 x J-2500	-0.21	-1.26	1.59	-0.26	52.54 **	-12.27 **	1.35
33	ICMA 89111 x J-2503	0.04	-0.21	-0.11	0.14	-20.38	-5.52 **	6.93 **
34	ICMA 89111 x J-2507	0.13	1.36	2.40 *	0.34 *	22.54	-1.81	0.23
35	ICMA 89111 x J-2508	-0.35	-1.29	-2.13 *	-0.03	-37.33 **	-1.42	5.26 *
36	ICMA 89111 x J-2510	0.48	-1.36	1.24	-0.85 **	-4.47	0.25	2.18
37	ICMA 04999 x J-2433	0.44	-0.24	-3.05 **	-0.91 **	-50.09 **	0.94	1.43
38	ICMA 04999 x J-2479	0.00	0.91	1.13	0.75 **	-23.44	0.44	3.60
39	ICMA 04999 x J-2482	-0.32	-1.12	-1.47	0.28	-15.09	-16.07 **	12.26**
40	ICMA 04999 x J-2496	1.96 *	0.85	4.99 **	-0.34 *	28.50 *	22.19 **	-7.64 **
41	ICMA 04999 x J-2500	-0.32	0.11	0.64	0.53 **	11.64	-15.10 **	4.42 *
42	ICMA 04999 x J-2503	-1.14	-0.99	-3.10 **	0.03	16.46	0.02	-7.35**
43	ICMA 04999 x J-2507	-0.11	-0.98	-1.13	0.22	-37.36 **	12.17 **	-3.13
44	ICMA 04999 x J-2508	-0.54	2.34 **	2.95 **	0.40 *	20.39	3.52	-0.65
45	ICMA 04999 x J-2510	0.03	-0.87	-0.94	-0.97 **	49.00 **	-8.12 **	-2.94
S. E. ±		0.85	0.87	0.94	0.16	12.25	1.87	2.03
Total significant positive		3	2	11	13	12	14	13
Total significant negative		2	1	12	14	13	14	14

*, ** were significant at 5% and 1% levels of probability, respectively

Table 5: The best specific combinations for grain yield per plant along with GCA effect of their parent and desirable sca effects for other traits

Hybrids	Grain yield per plant (g)	SCA effect	GCA effect		Heterosis (%) over GHB732	Significant and desirable sca effects for other traits
			Female	Male		
JMSA 20102 x J-2496	19.56	6.18**	2.54**	0.58 *	126.6*	4,6,7
JMSA 20102 x J-2479	18.13	3.93**	2.54**	1.40 **	110.04**	6,7
ICMA 841 x J-2500	12.40	3.59**	-1.24**	-0.19	43.67**	1,2,6
JMSA 101 x J-2508	12.13	3.30**	-0.55**	-0.86**	40.54**	2,3,4,5,7
JMSA 101 x J-2503	13.60	3.11**	-0.55**	0.78 **	57.57**	3,4,5,7
JMSA 20102 x J-2500	15.23	2.93**	2.54**	-0.19	79.92**	1,6
ICMA 89111 x J-2433	12.70	2.89	0.01	-0.45	47.14**	2,4,6
ICMA 841 x J-2510	10.37	2.02	-1.24**	-0.66 **	20.04**	5,7

Where,
*, ** were significant at 5% and 1% levels of probability, respectively.

1 = Numbers of nodes on main stem
2 = Plant height (cm)
3 = Earhead length (cm)
4 = Earhead weight (g)
5 = Test weight (g)
6 = Total biomass per plant (g)
7 = Harvest index (%)

References

1. Andrews DJ, Anand KK. Pearl millet for food, feed and forage. Advances in Agronomy 1992;48:89-139.
2. Athwal DS. Hybrid bajra-1 marks a new era. Indian Farming 1965;15:6-7.
3. Burton GW. Pearl millet tift 23A released. Crops and Soil 1965;17:19.
4. Burton GW. Breeding pearl millet. Plant Breed. Rev 1983;1:162-182.
5. Comstock RE, Robinson HF. Genetic parameters, their estimation and significance. Proc. 6th International Grassland Congress 1952;1:284-291.
6. Dabholkar AR. Elements of Biometrical Genetics. Revised ad Enlarged Edition. Concept Publishing Company, New Delhi.
7. Kempthorne O. An Introduction to Genetic Statistics. John Willey and Sons. Ind., New York 1957, p. 468-470.
8. Khandagale SG, Sharma V, Lone RP, Khandagale VG, Kumara S. Combining ability analysis and gene action in pearl millet [*Pennisetum glaucum* (L.) R. Br.] Electronic Journal of Plant Breeding, 2014;5(3):445-450.
9. Mungra KS, Dobariya KL, Sapovadiya MH, Vavadiya PA. Combining ability and gene action for grain yield and its component traits in pearl millet (*Pennisetum*

glaucum (L.) R. Br.). Electronic Journal of Plant Breeding 2015;6(1):66-63.
10. Pal M, Daka J, Rai RK. Fundamentals of Cereal Crop Production. Tata Mc Grow Hill Publishing Company Limited, New Delhi 1996.
11. Patel SM. Genetic analysis of grain yield and its component characters in pearl millet (*Pennisetum glaucum* (L.) R. Br.), Unpublished M. Sc. (Agri.) thesis submitted to Anand Agricultural University, Anand 2012.
12. Patel SM, Patel MP, Patel BC, Patel JA. Combining ability and gene action for grain yield and agronomic traits in pearl millet restorer lines. Electronic Journal of Plant Breeding 2014;5(3):394-401.