International Journal of Plant & Soil Science

18(5): 1-6, 2017; Article no.IJPSS.36433
ISSN: 2320-7035

Studies on Heterosis for Grain Yield and Its Contributing Characters in Hybrids of Pearl Millet [*Pennisetum glaucum* (L.) R.Br.]

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Authors' contributions

This work was carried out in collaboration between all authors. Author KB monitored the trial and wrote the first draft of the manuscript. Author DS design the study and monitored the work. Author KMK performed the data interpretation and monitored the work. Author MHVB performed the statistical analysis and manage the analysis of data. All the authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2017/36433
Editor(s):
(1) Enrique Luis Cointry Peix, Department of Plant Breeding, Rosario National University, Argentina.
Reviewers:
(1) Manasi Dash, Orissa University of Agriculture and Technology, India.
(2) Panchangam Sameera Sastry, Southern Methodist University, USA.
Complete Peer review History: http://www.sciencedomain.org/review-history/20993

Original Research Article

Received 28th August 2017
Accepted 12th September 2017
Published 15th September 2017

ABSTRACT

Heterosis for grain yield and its component traits were studied in bajra through line x tester mating design using five lines and eight testers along with two checks, PHB-3 and GHB-558. Heterosis was observed in both directions for most of the characters. Maximum range of standard heterosis was obtained for 1000 grain weight, fodder yield per plot, number of productive tillers per plant, plant height, panicle length, grain yield per plant and panicle diameter. The heterobeltiosis for grain yield per plant ranged from 10.89 to 56.18 per cent, while the standard heterosis ranged from -12.06 to 17.32 per cent. The cross combinations ICMA99666 x PLM1454R, ICMA97111 x PLM15047R and ICMA97444 x PLM15627R had higher grain yield *per se* ranging from 48.07

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(ICMA97444 x PLM15627R) to 48.77 (ICMA99666 x PLM1454R) and recorded significant positive standard heterosis of 17.32, 15.86, 15.80 and 15.62 respectively for gain yield per plant.

Keywords: Grain yield; heterosis; Pennisetum glaucum; line x tester.

1. INTRODUCTION

Pearl millet is an important coarse grain crop and provides nutritionally superior and staple diet for the vast majority of poor people. The crop is able to thrive under adverse conditions and also form an important fodder crop for livestock population in arid and semi arid regions of India. Pearl millet is the sixth most important and widely grown potential cereal crop in the world and is the fourth in India, after rice, wheat and maize. In India, it is mainly cultivated in the states of Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Telangana, Uttar Pradesh and Tamil Nadu on a total area of 7.8 million hectare with the production of 9.25 million tones and the national average productivity is 1270 kg/ha [1].

Pearl millet grain is comparatively high in protein (14-20%) with 70% carbohydrates and has a good amino acid balance. It is high in lysine, methionine and cytosine levels. It is equally superior to other fine cereals. It is rich in dietary fiber, minerals such iron, zinc and magnesium etc. Its regular consumption helps in risk reduction of many of the life style diseases like diabetes, heart diseases, hypertension, obesity etc.

Pearl millet is a highly cross-pollinated protogynous crop. The availability of cytoplasmic genetic male sterility in this crop has made it feasible to exploit heterosis commercially and hybrid seed production on large scale. The exploitation of heterosis on commercial scale in pearl millet is regarded as one of the major breakthroughs in the improvement of its productivity. 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.

2. MATERIALS AND METHODS

Five inbred lines were crossed with eight inbred testers in a line x tester mating design in *summer*, 2014 to generate 40 crosses. All the 40 crosses and two standard checks PHB-3 and GHB-558 and parents were evaluated during *kharif*, 2015 at Regional Agricultural Research Station (R.A.R.S), Palem, Mahabubnagar (District), Telangana State. Each genotype was grown in three rows of five meters length with 45 x 15 cm^2 spacing in a randomized block design with three replications. The trial was conducted in a sandy loam soils. All the recommended agronomic practices were followed to raise a normal crop. Data were recorded on five randomly selected plants in each treatment for nine characters viz., plant height, productive tillers per plant, panicle length, panicle diameter, 1000 grain weight, grain yield per plant and fodder yield and on plot basis for 50 percent flowering and days to maturity . The data collected were subjected to analysis of variance as suggested by [2]. The magnitude of standard heterosis was estimated over standard checks PHB-3 and GHB-558 by the method proposed by [3].

3. RESULTS AND DISCUSSION

The analysis of variance for the experimental design showed significant differences among the genotypes, parents and hybrids for all the characters (Table 1). This indicated the presence of phenotypic variability in the material selected for the present investigation for grain yield and important yield attributes. The estimates of variance due to parents *vs* hybrids were significant for all the traits except flowering and productive tillers per plant content, which indicated the presence of high level of mean heterosis due to selection of female and male lines with diverse genetic origin.

The measure of heterosis over mid parental value has relatively limited scope and is of more academic interest than of practical utility. Thus, the heterosis measured in terms of superiority over the better parent and over the standard check hybrid is more valuable. Maximum range of standard heterosis was obtained for fodder yield per plot, number of productive tillers per plant, 1000 grain weight, plant height, panicle length, grain yield per plant and panicle diameter (Table 2).

Table 1. Analysis of variance for combining ability for grain yield and its component characters in pearl millet

Source	d.f	Days to 50% flowering	Days to maturity	Plant height (cm)	Productive tillers per plant	Panicle length (cm)	Panicle diameter (cm)	1000 grain weight (g)	Grain yield per plant (g)	Fodder yield (kg/ plot)
Replications	**2**	2.33*	2.78	3.95	0.13	0.05	0.08	4.28*	6.71	1.84*
Genotypes	52	4.21**	6.06**	1942.65**	0.56**	23.11**	0.19**	5.80**	103.46**	3.69**
Parents	12	3.92**	5.24**	199.104**	0.48**	6.12**	0.17**	2.98**	22.93	0.05
Parents vs. crosses	1	2.04	0.16	90760.37**	0.07	674.81**	4.27**	74.48**	3272.35**	96.56**
Crosses	39	4.36**	6.46**	201.75**	0.60**	11.63**	0.09**	4.91**	35.33**	2.43**
Lines	4	7.2	6.85	790.18**	0.95	4.17	0.16	6.32	52.85	5.07*
Teters	7	4.5	6.19	124.67	0.29	8.85	0.03	3.72	11.69	3.42
Lines x testers	28	3.92**	6.47**	136.96**	0.63**	13.39**	0.10**	5.01**	38.74**	1.81**
σ2 gca		0.202	0.2741	23.1919	0.0274	0.2961	0.0028	0.1938	0.9283	0.1948
σ2 sca		1.0481	1.766	43.9266	0.1819	4.2168	0.0201	1.2562	8.1889	0.4551
σ2 gca / σ2 sca		0.1927	0.1552	0.5279	0.1506	0.0702	0.1393	0.1542	0.1133	0.428
Error	104	0.71	1.13	4.36	0.05	0.78	0.04	1.3	18	0.54

** and ** significant at 5 and 1 per cent level respectively*

Table 2. Heterosis and *per se* performance of top Bajra hybrids

Characters	Per se performance of the best crosses	Heterobeltiotic combinations (%)	Standard Heterotic combinations (%)
Days to 50% flowering	ICMA 96222 x PLM 191R (48) ICMA 99666 x PLM 15047R (48)	ICMA 96222 x PLM 191R (-5.26**) ICMA 99666 x PLM 15047R (-4.64**)	ICMA 96222 x PLM 191R (-1.36) ICMA 99666 x PLM 15047R (-1.36)
Days to maturity	ICMA 96222 x PLM 191R (76) ICMA 99666 x PLM 15047R (76)	ICMA 96222 x PLM 191R (-4.60**) ICMA 99666 x PLM 15047R (-4.60**)	ICMA 96222 x PLM 191R (-4.60**) ICMA 99666 x PLM 15047R (-4.60**)
Plant height (cm)	ICMA 96222 x PLM 15627R(161.22) ICMA 97444 x PLM 15627R (164.55)	ICMA 96222 x PLM 1698R (61.57**) ICMA 97444 x PLM 15627R (76.94**) ICMA 96222 x PLM 15627R (67.35**)	ICMA 96222 x PLM 1698R (23.05**) ICMA 97444 x PLM 15627R (17.50**) ICMA 96222 x PLM 15627R (15.12**)
Productive tillers per plant	ICMA 99666 x PLM 1611R (3.00) ICMA 07444 x PLM 1698R (3.00) ICMA 99666 x PLM 1454R (3.33) ICMA 97111 x PLM 15047R (3.00)	ICMA 97111 x PLM 15047R (28.57**) ICMA 99666 x PLM 1454R (25.13**) ICMA 99666 x PLM 1611R (18.41**) ICMA 07444 x PLM1 698R (50.00**)	ICMA 97111 x PLM 15047R (28.57**) ICMA 99666 x PLM 1454R (43.00**) ICMA 99666 x PLM 1611R (28.57**) ICMA 07444 x PLM1 698R (28.57**)
Panicle length (cm)	ICMA 99666 x PLM 1454R (26.23) ICMA 07444 x PLM 1698R (26.04) ICMA 97111 x PLM 15047R (26.88)	ICMA 97111 x PLM 15047R (55.12**) ICMA 99666 x PLM 1454R (31.17**) ICMA 07444 x PLM1 698R (44.67**) ICMA 99666 x PLM 1611R (25.92**)	ICMA 97111 x PLM 15047R (21.49**) ICMA 99666 x PLM 1454R (18.54**) ICMA 07444 x PLM1 698R (17.69**)
Panicle diameter (cm)	ICMA 97111 x PLM 15047R (2.63) ICMA 96222 x PLM 15623R (2.53)	ICMA 97111 x PLM 15047R (35.21**) ICMA 96222 x PLM 15623R (26.49**)	Nil
1000 grain weight (g)	ICMA 99666 x PLM 1454R (14.29) ICMA 99666 x PLM 1611R (14.28) ICMA 97111 x PLM 15047R (14.74)	ICMA 97111 x PLM 15047R (40.19**) ICMA 99666 x PLM 1454R (16.58**) ICMA 97444 x PLM1 698R (45.54**)	ICMA 97111 x PLM 15047R (24.07**) ICMA 99666 x PLM 1454R (20.28**) ICMA 97444 x PLM1 698R (20.28**)
Grain yield per plant (g)	ICMA 97444 x PLM 15627R (48.07) ICMA 99666 x PLM 1454R (48.77) ICMA 99666 x PLM 1611R (47.08) ICMA 97111 x PLM 15047R (48.17)	ICMA 97111 x PLM 15047R (56.18**) ICMA 97444 x PLM 15627R (48.32**) ICMA 99666 x PLM 1454R (43.39**)	ICMA 97111 x PLM 15047R (15.86*) ICMA 97444 x PLM 15627R (15.62*) ICMA 99666 x PLM 1454R (17.32**)
Fodder yield (kg/ plot)	ICMA 97444 x PLM 15627R (5.74) ICMA 97444 x PLM 15047R (6.46) ICMA 97111 x PLM 15627R (6.44) ICMA 97111 x PLM 15047R (4.49) ICMA 99666 x PLM 1454R (4.34)	ICMA 97444 x PLM 15047R(132.22**) ICMA 97444 x PLM 15627R (114.98**) ICMA 97111 x PLM 15047R (61.44**) ICMA 99666 x PLM 1454R (64.23**)	ICMA 97444 x PLM 15627R (95.46**) ICMA 97111 x PLM 15047R (53.01**) ICMA 99666 x PLM 1454R (48.01**)

Grain yield per plant in pearl millet is the character of economic importance for which 34 hybrids over better parent and 04 hybrids over standard check exhibited significant and positive heterosis. Several hybrids exhibited significant and desirable direction of heterobeltiosis and standard heterosis for various characters such as plant height (40 & 29 hybrids); productive tillers (04 & 04 hybrids); panicle length (34 & 18 hybrids); test weight (12 & 05 hybrids), grain yield (34 & 04 hybrids) and fodder yield (32 & 26 hybrids).

In general, high magnitude of standard heterosis was obtained for fodder yield per plot, number of productive tillers per plant, 1000 grain weight, plant height, panicle length, grain yield per plant and panicle diameter.

The cross, ICMA 96222 x PLM 191R for days to flowering and days to maturity, ICMA 97444 x PLM 15627R for plant height, ICMA 07444 x PLM 1698R for productive tillers, ICMA 97111 x PLM 15047R for panicle length and, panicle diameter ICMA 97111 x PLM 15047R for 1000 grain weight and grain yield per plant and ICMA 97111 x PLM 15627R for fodder yield per plot, showed significant and maximum heterosis over better parent.

The hybrids, ICMA 96222 x PLM 191R for days to flowering and days to maturity, ICMA 96222 x PLM 1698R for plant height, ICMA 99666 x PLM 1454R for productive tillers, ICMA 97111 x PLM 15047R for panicle length, ICMA 97111 x PLM 15047R for 1000 grain weight, ICMA 99666 x PLM 1454R for grain yield per plant and ICMA 97111 x PLM 15627R for fodder yield per plot, showed significant and maximum heterosis over standard check.

The cross, ICMA99666 x PLM1454R showed significant standard heterosis for grain yield which was accompanied by significant standard heterosis in 1000 grain weight, plant height, productive tillers per plant and fodder yield per plot. The significant standard heterosis in cross, ICMA97111 x PLM15047R, was due to significant standard heterosis in 1000 grain weight, productive tillers per plant and fodder yield per plot. In cross, ICMA07444 x PLM1698R, the significant standard heterosis for grain yield was accompained by significant standard heterosis in 1000 grain weight, productive tillers per plant and panicle length. The standard heterosis in cross, ICMA97444 x PLM15627R, was due to significant standard heterosis in 1000 grain weight, fodder yield per plot, plant height and panicle length.

This revealed that the heterosis for grain yield per plant was associated with the heterosis expressed by its component traits. Such a situation of combinational heterosis in pearl millet has also been reported by [4-8]. The crosses showing combinational heterosis favour the idea of heterosis breeding for their efficient utilization in future breeding programme. Considerable amount of high heterosis in certain crosses and low in other crosses revealed that nature of gene action varied with the genetic makeup of the parents involved in crosses. As such, nature and magnitude of heterosis helps in identifying superior cross combinations to obtain better transgressive segregants. In view of the variation observed for hybrid vigour, it would be worthwhile to find out suitable combinations, where maximum heterosis can be exploited.

To develop a commercial hybrid, *per se* performance and the extent of heterosis are chiefly considered by [9].

4. CONCLUSION

In the present study also, the hybrids were evaluated on the basis of the above said two parameters. Among the 40 hybrids, ICMA99666 x PLM1454R, ICMA97111 x PLM15047R and ICMA97444 x PLM15627R had significant per *se* performance and standard heterosis for grain yield and its contributing characters (Table 2). Therefore, these hybrids are of considerable practical importance which were proved to be superior over popular commercial hybrid, GHB-558.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Directorate of Economics and Statistics (DES), Department of Agriculture and cooperation (DAC), Ministry of Agriculture, Government of India. DES $ DAC. 2016-17.
2. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi; 1985.

3. Virmani SS, Aquino RO, Khush GS. Heterosis breeding in Rice (*Oryza sativa* L.). Theoretical and Applied Genetics. 1982;63:373-380.
4. Ansodariya VV. Genetic studies on yield and its components in pearl millet [*Pennisetum glaucum* (L.) R.BR.]. M.Sc. (Agri.) Thesis (Unpublished) Submitted to Junagadh Agricultural University, Junagadh; 2004.
5. Bhadalia AS, Dhedhi KK, Joshi HJ, Sorathiya JS. Combining ability studies through diallele analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. International Journal of Agricultural Sciences. 2014;10(1):57-60.
6. Chaudhary VP, Dhedhi KK, Joshi HJ, Mehta DR. Combining ability studies in line x tester crosses of pearl millet [*Pennisetum glaucum* (L.) R. Br.]. Research on Crops. 2012;13(3):1094-1097.
7. Chotaliya JM, Dangaria CJ, Dhedhi KK. Exploitation of heterosis and selection of superior in breds in pearl millet. Int. J. Agric. Sci. 2009;5(2):531-535.
8. Dhuppe MV, Chavan AA, Phad DS, Chandrankar GD. Combining ability studies in pearl millet. Journal of Maharashtra Agricultural Universities. 2006;31:146-148.
9. Murali Krishna K, Kulkarni O, Sai Kumar R. Nature of gene action and hybrid vigour for yield and its component traits in maize (*Zea mays* L.). Agribios Research. Theoretical and Applied Genetics. 2012;2: 149-154.

Peer-review history:
The peer review history for this paper can be accessed here:
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