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Heterosis analysis for grain yield components in pearl millet [*Pennisetum glaucum* (L.)R. Br.)]

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Abstract
An experiment comprised of 4 male sterile line and 10 inbred tester of pearl millet and their 40 hybrids was carried out at Post Graduate Institute, Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri during Kharif, 2019 for studying the extent of hybrid vigour in F1 for yield and its components. For the days to 50 per cent flowering, and days to maturity highest significant negative relative heterosis, heterobeltiosis was observed in cross DHLB-27A X S-19/17 and DHLB-27A X S-19/22. The cross combination DHLB-21A X S-19/24 and DHLB-24 X S-19/25 showed higher magnitude of positive standard heterosis and heterobeltiosis for the trait number of tillers/plant, earhead length. The hybrid DHLB-24A X S-19/24 recorded highest and significant positive relative heterosis for earhead girth and DHLB-21A X S-19/25, DHLB-23A X S-19/20 for fodder yield/plant and1000 grain weight. The hybrid DHLB-24A X S-19/27 expressed very high percentage heterosis for grain yield also exhibited significant heterosis in desirable direction for other nine characters. So study on vigorous testing for stability of these good hybrids should be taken for further commercial exploitation.

Keywords: Heterosis, heterobeltiosis, standard heterosis, *Pennisetum glaucum*, male sterile line.

Introduction
Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a monocot species belongs to family poaceae and sub family penicedae, having relatively small diploid genome (2n = 2x = 14). It is considered to be originated in Africa from where it was imported to India.

India is major perl millet producing country with 43.3 percent of the world's area and 42 percent of the world's production. It is mainly cultivated in states of Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Utter Pradesh and Tamil nadu. Total area of 6.93 million ha with an average production of 8.61 million tones and productivity of 1243 kg/ha (Anonymous, 2020).

Pearl millet is highly heterozygous because of its cross pollinated nature. The floral biology of pearl millet consent many breeding techniques to be used ranging from various type of population improvement to strict pedigree selection.

The phenomenon of heterosis has proved to be outstanding genetic tool enhancing the yield of cross pollinated species in general and pearl millet in particular. With the ease of use CGMS system in pearl millet, exploitation of hybrid vigor on a commercial scale has become realistic and economical. In India, a factual breakthrough in pearl millet production has come with development and release of hybrids for commercial cultivation. Heterosis breeding programme, it is essential to study and evaluate available useful promising diverse potential lines in their hybrid combination through the magnitude and direction of heterotic behavior is of paramount importance.

In Maharashtra, pearl millet is grown as a summer as well *Kharif* crop, in low fertility soil of Maharashtra as rainfed crop and also in high fertility regions of Maharashtra under assured irrigation. By stimulating environmental conditions existing indifferent pearl millet growing regions of Maharashtra and evaluating different hybrids, combinations in these environments, it is possible to draw plausible conclusions regarding the performance of hybrids, which will be suitable under varied environmental conditions. An extensive survey of pearl millet literature showed 35 average better parent heterosis for grain yield. Therefore, this investigation was conducted to study the extent of hybrid vigor in F_1 for grain yield and its components.

The improvement in pearl millet needs attention for the characters like early flowering, grain yield per plant, grain yield per ha, ear head length and girth, protein content, number of tillers/plant. Keeping these things in view, the present study has been planned with the following objectives, to estimate the heterosis for yield and its components.

Material and Methods

Present study involving four male sterile lines and ten restorers were select for the study. The materials were obtained from Bajra Research Scheme, College of Agriculture Dhule during 2019. The forty crosses were made in line x tester mating design by hand pollination during *summer* 2019. Resultant forty F_1 along with their parents and standard check Phule aadishakti and Phule Mahashakti were raised in Randomized Block Design (RBD) with three replication at Post Graduate Institute Farm Mahatma Phule Krishi Vidyapeeth, Rahuri location during *Kharif*, 2019. Each F_1 was accommodated in two row with a row spacing of 50 cm and plant to plant spacing 15 cm. uniform and recommended cultural practices were followed to raise agronomically good managed crop. The observations were recorded ten randomly selected competitive plants from each replications for nine traits *viz.*, Days to 50% flowering, Days to maturity, Plant height (cm), number of tillers/ plant, Earhead length (cm), Earhead girth (cm), Grain yield/ plant, Fodder yield/ plant and 1000 grain weight (g). The expression of heterosis in 40 hybrids involving four lines and ten tester was measure heterosis and heterobeltiosis in relation mid parents and better parents in comparison with Aadishakti.

Results and Discussion

Analysis of variance revealed that mean sum of square for treatments were highly significant for all the characters. (Table 1). It indicated the presence of genetic variability. The variances for females Vs Males were significant for days to 50 % flowering, days to maturity, plant height, Ear head length, Ear head girth, 1000 grain weight, except number of effective tillers, grain yield and fodder yield. The variance for male and females were significant for all the characters.

The mean sum of squares for hybrids and parent vs hybrids were significant for all the studied characters. The range of mid parent heterosis, heterobeltiosis and standard heterosis, as well as, number of hybrids showing desirable direction in presented Table 2. For days to 50 percent flowering 38 hybrids for relative heterosis, 20 for heterobeltiosis and 11 hybrids for standard heterosis recorded significant negative heterosis. Highest significant and negative heterosis, heterobeltiosis was recorded by DHLB-27A X S-19/25 (-15.32%), DHLB-27A X S-19/17 (-13.46%) and standard heterosis for DHLB-24A X S-19/17 (-11.76%). For days to maturity 23 hybrids for relative heterosis, 8 hybrids for heterobeltiosis and 11 hybrids was recorded for standard heterosis. The cross combination DHLB-21A X S-16/25 (-7.95%) was recorded highly negative significant for the relative heterosis and DHLB-27A X S-19/22 (-6.82%) for heterobeltiosis, for maturity. Earliness flowering and maturity negative heterosis of hybrids was considered desirable have also been reported by Patil *et al.,* (1994) [10], Chavan *et al.,* (1994) [2], Pachade (2006) [8], Pawar *et al.,* (2015) [11], Gavali *et al.,* (2017) [3] and Krishnan *et al.,* (2019) [7]. Negative heterosis is desirable for plant height, out of forty cross combination none of hybrid was recorded negative significant relative heterosis and heterobeltiosis, for the plant height while the hybrid DHLB-23A X S-19/27 (-19.34%) recorded higher negative standard heterosis over standard check Phule Aadishakti. Similar results for plant height was recorded Patel *et al.,* (2016) [9]. For the number of tillers per plant the hybrid DHLB-21A X S-19/24 (48.76%), showed higher magnitude of positive relative heterosis and heterobeltiosis (42.86%) and highly significant positive standard heterosis was observed in hybrid DHLB-27A X S-19/18 (30.00%). Out of forty cross combinations 30 hybrids showed positive relative heterosis, 20 hybrids for heterobeltiosis and 9 hybrids for standard heterosis. Similar results were reported by Jethva *et al.,* (2012) [5], Thakare *et al.,* (2014) [12]. Highest significant positive relative heterosis and heterobeltiosis was observed in the cross DHLB-23A X S-19/23 (21.19 %), DHLB-24A X S-19/25 (19.70 %) for the trait earhead length. Out of 40 hybrids 26 hybrids showed positive significant relative heterosis, 17 heterobeltiosis and 16 standard heterosis.

The hybrid DHLB-24A X S-19/24 (23.30 %) and (21.49 %) was recorded highly significant positive relative heterosis and heterobeltiosis for earhead girth. Similar results were reported by Thakare *et al.* (2014) [12] and Gavali *et al.,* (2017) [3]. Out of 40 cross combinations 24 hybrids showed for positive relative heterosis, 8 heterobeltiosis 10 standard heterosis. The maximum and minimum range obtain for heterobeltiosis DHLB-24A X S-19/24 (21.49 %) and DHLB-27A X S-19/22(0.08 %) for the trait. For the fodder weight. Highest significant positive relative heterosis and heterobeltiosis was observed DHLB-21A X S-19/25 (125.07 and 115.45%) and standard heterosis, DHLB-27A X S-19/18 was recorded 35.00 %). Similar finding were observed by Vagadiya *et al.,* (2010) [13], Jethva *et al.,* (2012) [5] and Gavali *et al.,* (2017) [3]. For the 1000 grain weight among the forty cross combinations, 34 exhibited a significant positive relative heterosis, 24 significant positive heterobeltiosis and 35 are recorded positive significant standard heterosis. Highest significant positive relative heterosis and heterobeltiosis was observed in the cross combinations DHLB-23A X S-19/20 (37.30 % and 36.38%) and standard heterosis was observed in the cross DHLB-27A X S-19/18 (54.80 %). Similar finding were also reported by Pawar *et al.,* (2015) [11] and Gavali *et al.,* (2017) [3]. Highest significant positive relative heterosis and heterobeltiosis was observed in the hybrid DHLB-21AX S-19/23 (110.17%) and DHLB-24A X S-19/27 (102.52%) for the grain yield /per plant. Out of forty cross combinations 39 and 32 are observed for relative heterosis, heterobeltiosis and 17 crosses observed for standard heterosis. The results on similar line were also observed by Kulkarni *et al.,* (1993) [6] and Vagadiya *et al.,* (2010) [13].

Table 1: Analysis variance for different characters in L x T mating in pearl millet

Sources	d.f	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of effectivetillers/plant	Earhead length (cm)	Earhead girth(cm)	1000 grain weight (g)	Grain yield/plant(g)	Fodder yield/plant (g)
Replications	1	1.12	1.33	45.38	0.01	0.01	0.01	0.01	0.18	228.58
Treatments	53	28.40**	30.71**	621.67**	0.19**	10.35**	1.83**	8.40**	310.72**	998.16**
Parents	13	32.82**	39.96**	332.06**	0.18**	8.39**	1.56**	2.75**	67.62**	265.62**
Females	3	5.46**	9.83*	418.58**	0.25**	13.48**	2.15**	3.06**	131.04**	308.55**
Males	9	29.87**	47.31**	322.60**	0.17**	6.65**	1.42**	2.75**	53.81**	278.86**
Females Vs Male	27	141.43**	64.13**	157.64**	0.01	8.84**	1.12**	1.85**	1.58	17.65
Parents Vs Crosses	1	698.58**	364.62**	17005.78**	1.50**	63.72**	3.86**	112.04**	7834.67**	21496.46**
Crosses	39	9.74**	19.07**	298.10**	0.16**	9.63**	1.86**	7.62**	198.84**	716.74**
Error	53	1.12	3.14	20.25	0.01	0.32	0.06	0.13	10.96	59.18

*, ** denote significant at 5 and 1 % level respectively.

Table 2: Range of heterosis and number of crosses showing significant heterosis in desirable direction in pearl millet

Sr. No.	Name of the characters	Best hybrid for heterosis	Heterosis (%) over mid parents	Best hybrids for heterobeltiosis	No. of hybrids showing desirable significant Heterosis (%) over standard check	Heterosis (%) over better parents	No. of hybrids showing desirable significant Heterosis (%) over standard check	
	No. of crosses	Range	No. of Crosses	Aadishakti			No. of crosses	Aadishakti
1	Days to 50% flowering	DHLB-27AXS-19/25 DHLB-24AXS-19/22	-15.32 -2.80	38	DHLB-27AXS-19/17 DHLB-21AXS-19/24	-13.46 1.01	20	16
2	Days to maturity	DHLB-21AXS-19/25 DHLB-27AXS-19/18	-7.95 0.55	23	DHLB-27AXS-19/22 DHLB-27AXS-19/23	-6.82 1.14	8	10
3	Plant height (cm)	DHLB-21AXS-19/17 DHLB-27AXS-19/21	36.43 0.66	38	DHLB-24AXS-19/17 DHLB-21AXS-19/21	30.40 5.61	35	1
4	No. of tillers/plant	DHLB-21AXS-19/24 DHLB-23AXS-19/21	48.76 -2.51	30	DHLB-21AXS-19/24 DHLB-27AXS-19/25	42.86 -1.75	20	9
5	Earhead length (cm)	DHLB-23AXS-19/23 DHLB-23AXS-19/27	21.19 -0.92	26	DHLB-24AXS-19/25 DHLB-21AXS-19/16	19.70 -0.51	17	16
6	Earhead girth (cm)	DHLB-24AXS-19/24 DHLB-27AXS-19/22	23.30 0.02	24	DHLB-24AXS-19/24 DHLB-21AXS-19/25	21.49 0.08	8	10
7	Fodder weight (g)	DHLB-21AXS-19/25 DHLB-27AXS-19/27	125.07 0.05	32	DHLB-21AXS-19/25 DHLB-27AXS-19/21	115.45 -1.74	29	9
8	1000 grain weight (g)	DHLB-23AXS-19/20 DHLB-23AXS-19/21	37.30 0.22	34	DHLB-23AXS-19/20 DHLB-23AXS-19/24	36.38 -0.57	24	35
9	Grain yield/plot	DHLB-21AXS-19/23 DHLB-27AXS-19/17	110.17 15.15	39	DHLB-24AXS-19/27 DHLB-27AXS-19/17	102.52 -11.80	32	17

Table 3: Three best performing cross combinations, heterobeltiosis and heterosis for various traits in Pearl millet

Characters	Best performing hybrids	Relative heterosis (%)	Best performing hybrids	Heterobeltiosis (%)	Best performing hybrids standard heterosis over checks	
						Phule aadishakti
Days to 50% flowering	DHLB-27AXS-19/25	-15.32**	DHLB-27AXS-19/17	-13.46**	DHLB-24AXS-19/17	-11.76**
Days to maturity	DHLB-21AXS-19/25	-7.95**	DHLB-27AXS-19/22	-6.82**	DHLB-24AXS-19/17	-7.06**
Plant height (cm)	DHLB-21AXS-19/17	36.43**	DHLB-24AXS-19/17	30.40**	DHLB-23AXS-19/27	-19.34**
No. of tillers/plant	DHLB-21AXS-19/24	48.76**	DHLB-21AXS-19/24	42.86**	DHLB-27AXS-19/18	30.00**
Earheads length (cm)	DHLB-23AXS-19/23	21.19**	DHLB-24AXS-19/25	19.70**	DHLB-27AXS-19/18	20.57**
Ear head girth (cm)	DHLB-24AXS-19/24	23.30**	DHLB-24AXS-19/24	21.49**	DHLB-23AXS-19/23	7.23**
Fodder weight (g)	DHLB-21AXS-19/25	125.07**	DHLB-21AXS-19/25	115.45**	DHLB-27AXS-19/18	35.00**
1000 grain weight (g)	DHLB-23AXS-19/20	37.30**	DHLB-23AXS-19/20	36.38**	DHLB-27AXS-19/18	54.80**
Grain yield/plot	DHLB-21AXS-19/23	110.17**	DHLB-24AXS-19/27	102.52**	DHLB-27AXS-19/18	50.80**

Conclusion

The hybrid namely DHLB-27A X S-19/17, DHLB-27A X S-19/22, DHLB-21A X S-19/24, DHLB-24A X S-19/25, DHLB-24A X S-19/24, DHLB-21A X S-19/25, and DHLB-23A X S-19/20 expressed high standard heterotic value for Days to 50% flowering, Days to maturity, number of tillers/plant, earhead length (cm), Earhead girth (cm), fodder weight (g) and 1000 grain weight respectively.

The hybrid DHLB-24A X S-19/27 expressed very high percentage heterosis for grain yield also exhibited significant heterosis in desirable direction for other nine characters. So study on vigorous testing for stability of these good hybrids should be taken for further commercial exploitation. Exhibited significant heterosis in desirable direction for other nine characters.

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