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RESEARCH PAPER

Identification of heterotic crosses involving cytoplasmic-genic male sterile lines in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract : Forty eight hybrid combinations were obtained by crossing four male sterile lines (cytoplasm A_1) with twelve newly developed inbred of a diverse origin. The performance of the hybrids was studied to estimate heterobeltiosis and standard heterosis for grain yield per plant and other related morphonutritional characters. Many of the hybrids exhibited significantly negative heterobeltiosis as well as standard heterosis for days to 50 per cent flowering and maturity indicating possibilities for exploiting heterosis for earliness. The best hybrids were DHLB-15A x K-13/973 and DHLB-16A x K-13/1017, which showed standard heterosis and heterobeltiosis for these traits. Only a few hybrids recorded significant heterobeltiosis and standard heterosis in a desirable direction for plant height and number of productive tillers per plant. Many crosses exhibited heterobeltiosis and standard heterosis for grain yield, ear head length, fodder yield per plant and 1000 grain weight. The crosses DHLB-17A x K-13/1005 and DHLB-18A x K-13/1005 exhibited the highest significant standard heterosis and the cross DHLB-18A x K-13/1007 exhibited highest heterobeltiosis for grain yield per plant. None of the cross showed significant heterobeltiosis as well as standard heterosis in desirable direction for Zn content in grain. The highest standard heterosis and heterobeltiosis for Fe content in grain were observed in the crosses DHLB-18A x K-13/1017 and DHLB-16A x K-13/1008, respectively. The cross DHLB-16A x K-13/1011 showed highest standard heterosis and heterobeltiosis for number of grains per cm^2. DHLB-15A x K-13/1009 and DHLB-16A x K-13/1009 exhibited highest and significant standard heterosis for ear head length and 1000 grain weight, respectively.

Key Words : Pearl millet, Cytoplasmic-genic male sterility, Heterobeltiosis, Standard heterosis

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INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a highly cross-pollinated crop with protogynous flowering and wind borne pollination mechanism, which fulfills one of the essential biological requirements for hybrid development. India is a largest producer of pearl millet

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both in terms of area (8.7 million ha) and production (9.25 million ton), with an average productivity is 1270 kg/ha (Anonymous, 2015). The exploitation of heterosis is, therefore, possible with the availability of a suitable pollen parent to improve the productivity of this crop. Exploring possibilities for the utilization of male sterility is highly desirable in this regard. The discovery of cytoplasmic genetic male sterile systems in pearl millet (*Tift* 23 A and *Tift* 18A) by Burton (1958), opened new field for genetic improvement in pearl millet. The male sterile lines have been extensively used in India for development of desirable hybrids. The development of male sterile lines was a significant step towards the practical exploitation of heterosis, which is reported to be available in great magnitude in pearl millet (Athwal, 1965: Murty *et al.,* 1967; Harinarayana, 1987; Ugale *et al.,* 1989; Rai *et al.,* 2006; Vaghasiya *et al.,* 2009 and Kanatti *et al.,* 2014). In a second step, it is essential to identify useful pollen parents producing heterotic crosses with these CGMS lines for developing standard hybrids. Now-a-day's heterosis breeding has been recognized as the most suitable breeding tool for boosting up yield. It requires evaluation of inbreeds in terms of their genetic value and the selection of suitable parents for breeding programme. Therefore, the present investigation attempted to identify heterotic crosses involving four CGMS lines and twelve pollen (testers) parents.

MATERIAL AND METHODS

The experiment material consisted of four male sterile lines (cytoplasm A_1) *viz.,* DHLB -15A, DHLB-16A, DHLB-17A and DHLB-18A obtained from Bajra Improvement Project, College of Agriculture, Dhule, M. P. K. V. Rahuri (Maharashtra), India and twelve inbreeds of diverse origin, *viz.,*K-13/973, K-13/991, K-13/995, K-13/996, K-13/999, K-13/1005, K-13/1007, K-13/1008, K-13/1009, K-13/1011, K-13/1016 and K-13/1017, as well as Shanti used as standard hybrid check. The male sterile lines were crossed with the pollen parents mentioned above by hand pollination in line X tester fashion to obtain F_1 during summer 2014. The resulting hybrids along with the parents were grown in a Randomized Block Design with two replications at the Botany Section Farm, College of Agriculture, Dhule during *Kharif* 2014. The best performing recommended variety of the region in terms of grain yield, Shanti, was used as standard checks to estimate standard heterosis. Normal recommended agronomic practices were followed to raise the crop. Each genotype was represented by two rows of 4 m length with spacing 50 cm between rows and 15 cm between plants. Observations on days to 50 per cent flowering, days to maturity on plot basis on each genotype from each replication, whereas characters plant height(cm), ear head length, ear head girth,(cm), number of productive tillers per plant, number of grains per cm^2, 1000-grain weight (g), fodder yield per plant (g), grain yield per plant (g), grain Fe content (mg/kg) and grain Zn content (mg/kg) on plant basis *i. e.* on five randomly selected plants in each genotype in each replication were recorded and their averages values were computed. Heterosis over better parent (heterobeltiosis) and standard heterosis was estimated as per usual procedure and its significance was tested as per Wynne *et al.* (1970).

RESULTS AND DISCUSSION

The range of heterobeltiosis, standard heterosis and the best heterotic crosses for different morpho-nutritional traits are presented in Table 1. A wide range of the *per se* performances of the crosses was observed for all the characters. A greater magnitude of heterobeltiosis (30%) was observed in many crosses for grain yield per plant, fodder yield per plant, number of productive tillers per plant, 1000 grain weight and ear head length. A large number of crosses exhibited standard heterosis in a desirable direction for different morpho-nutritional traits under study. The cross DHLB-16A x K-13/1017 exhibited highest negative heterobeltiosis for days to 50 per cent flowering and days to maturity. While, cross DHLB-15A x K-13/973 showed highest negative standard heterosis for days to 50 per cent flowering and days to maturity in desirable direction. Appearance of significant and negative (both heterobeltiosis and standard heterosis) for days to 50 per cent flowering and days to maturity indicated the possibility of exploiting heterosis for earliness. Pachade *et al*. (2006) and Vagadiya *et al*. (2010) have also reported significant negative heterobeltiosis for earliness characters. For plant height and number of productive tillers per plant, only a few hybrids recorded significant heterobeltiosis and standard heterosis in a desirable direction. These observations are in contrast to the results of earlier studies indicating positive heterosis for plant height (Patil *et al*., 1994; Sheoran *et al*., 2000 and Thakare *et al.,* 2014). The cross DHLB-17A x K-13/1007 exhibited the highest negative heterobeltiosis for plant height, while the standard heterosis was highest significant negative in cross DHLB-15A x K-13/1009, suggesting exploiting heterosis for dwarfness. Twenty two and thirty three different cross combinations showed a significant positive heterobeltiosis and standard heterosis, respectively for ear head length. In the present study among 48 crosses, 47 cross combinations exhibited significant positive heterobeltiosis for grain yield per plant and fodder yield per plant. Standard heterosis was also observed for grain yield per plant and fodder yield per plant in twenty two and thirty two crosses, respectively. A similar trend also recorded by Vagadiya *et al*. (2010). The cross DHLB-

Table 1: Range of *per se* performance, heterosis and most heterotic crosses for grain yield and morpho-nutritional attributes in pearl millet

Characters	C.D. (P=0.05)	Range of			Best hybrid based on	
		per se performance	Heterobeltiosis (%)	Standard heterosis (%)	Heterobeltiosis	Standard heterosis
Days to 50 % flowering	1.79	47-52	-8.65-5.10	-4.17-9.38	DHLB-16A x K-13/1017	DHLB-15A x K-13/973
Days to maturity	2.04	79-86	-6.43-4.27	-5.42-3.61	DHLB-16A x K-13/1017	DHLB-15A x K-13/973
Plant height (cm)	12.29	135.80-210.00	-3.29-29.93	-16.17-15.55	DHLB-17A x K-13/1007	DHLB-15A x K-13/1009
Number of productive tillers per plant	0.57	1.84-3.20	-12.20-64.13	-18.26-39.13	DHLB-15A x K-13/999	DHLB-18A x K-13/1005
Ear head length (cm)	2.24	18.00-31.00	-24.63-34.00	-10.22-37.78	DHLB-16A x K-13/995	DHLB-15A x K-13/1009
Ear head girth (cm)	0.51	9.40-12.40	-5.63-20.69	-9.09-12.27	DHLB-18A x K-13/995	DHLB-17A x K-13/1009
Grain yield / plant (g)	9.07	19.70-75.50	24.31-166.08	-28.86-77.86	DHLB-18A x K-13/1007	DHLB-17A x K-13/1005
Fodder yield / plant (g)	14.40	30.95-130.65	16.41-167.16	-26.21-83.63	DHLB-16A x K-13/1008	DHLB-18A x K-13/1005
1000 grain weight (g)	1.47	8.95-15.20	-22.09-37.02	-14.62-43.40	DHLB-17A x K-13/995	DHLB-16A x K-13/1009
No. of grains / cm^2	3.83	16.17-27.34	-33.07-12.10	-23.00-30.19	DHLB-16A x K-13/1011	DHLB-16A x K-13/1011
Fe content (mg/kg)	5.53	40.00-72.00	-38.46-13.21	-36.51-14.29	DHLB-16A x K-13/1008	DHLB-18A x K-13/1017
Zn content (mg/kg)	5.11	37.00-67.00	-36.51-7.84	-27.27-9.09	DHLB-17A x K-13/1007	DHLB-18A x K-13/999

Table 2 : Standard heterotic crosses for grain yield and their *per se* performance for morpho-nutritional attributes

Crosses	Heterobeltiosis (%)	Standard heterosis (%)	Mean values for the characters											
			Days to 50 % flowering	Days to maturity	Plant height (cm)	Productive tillers / plant	Ear head length (cm)	Ear head girth (cm)	Grain yield / plant (g)	Fodder yield / plant (g)	1000 grain weight (g)	No. of grains / cm^2	Fe content (mg/kg)	Zn content (mg/kg)
DHLB-17A x K-13/1005	114.79	77.86	52.00	85.50	172.40	2.84	26.20	12.15	75.50	120.00	11.60	16.78	43.00	48.00
DHLB-18A x K-13/1005	99.86	65.49	52.00	86.00	182.70	3.20	26.50	11.05	70.25	130.65	11.40	16.17	63.00	48.00
DHLB-18A x K-13/991	142.78	56.42	51.00	85.50	167.30	2.90	23.80	10.70	66.40	112.00	12.05	23.49	54.00	52.00
DHLB-15A x K-13/1017	109.85	53.83	48.00	81.00	186.30	2.94	27.00	10.70	61.80	114.65	12.15	19.47	55.00	52.00
DHLB-17A x K-13/991	131.08	48.88	52.50	84.00	185.30	2.88	24.50	11.35	63.20	108.50	11.80	19.50	55.00	43.00
DHLB-18A x K-13/999	91.41	41.81	51.50	84,50	201.30	2.72	27.80	11.15	60.20	106.90	11.80	21.13	57.00	60.00
DHLB-16A x K-13/1017	95.25	41.34	47.50	81.00	183.00	2.94	24.20	11.15	57.50	103.00	10.50	23.48	68.00	46.00
DHLB-18A x K-13/1007	166.08	41.34	51.00	83.50	180.90	2.73	24.20	10.90	60.00	102.50	11.90	22.45	60.00	54.00
DHLB-16A x K-13/991	52.99	39.46	50.50	81.50	166.20	2.85	27.20	10.90	56.70	98.55	11.70	23.30	50.00	42.00
DHLB-17A x K-13/1007	162.53	39.46	50.00	83.00	176.20	2.85	25.00	11.70	59.20	100.60	11.70	19.33	51.00	55.00

16A x K-13/995 exhibited the highest heterobeltiosis for ear head length, while the standard heterosis was highest in cross DHLB-15A x K-13/1009. For ear head girth, heterobeltiosis and standard heterosis were highest in the cross DHLB-18A x K-13/995 and DHLB-17A x K-13/1009, respectively. These results are in agreement with the findings of Ramamoorthi and Govindarasu (2000) and Jethva *et al*. (2012). For 1000 grain weight the greatest magnitude of heterobeltiosis and standard heterosis was exhibited by the crosses DHLB-17A x K-13/995 and DHLB-16A x K-13/1009, respectively. The crosses DHLB-16A x K-13/1008 and DHLB-18A x K-13/1005 showed significant positive heterobeltiosis and standard heterosis for fodder yield per plant. The heterobeltiosis was highest in desirable direction for grain yield per plant in the cross DHLB-18A x K-13/1007 followed by DHLB-17A x K-13/1007 and DHLB-18A x K-13/991. Whereas, the standard heterosis was higher in crosses DHLB-17A x K-13/1005 and DHLB-18A x K-13/1005 for grain yield per plant. The cross DHLB-16A x K-13/1011 exhibited both the highest heterobeltiosis and standard heterosis for number of grains per cm^2. None of the cross showed significant heterobeltiosis as well as standard heterosis in desirable direction for Zn content in grain. Whereas, only one cross DHLB-16A x K-13/1008 exhibited significant heterobeltiosis for Fe content in grain and two crosses (DHLB-18A x K-13/1017, DHLB-18A x K-13/973) showed significant standard heterosis for the trait suggesting there would be little opportunity to exploit heterosis in micronutrient. Previously, Velu *et al*. (2011) and Govindraj *et al*. (2013) was reported negative heterosis for grain Fe and Zn content in pearl millet.

The ten standard heterotic crosses for grain yield per plant and their performance in other characters are shown in Table 2. The crosses DHLB-17A x K-13/1005 and DHLB-18A x K-13/1005 which recorded higher *per se* performance showed significant standard heterosis in respect of grain yield per plant, also exhibited significant heterobeltiosis in a desirable direction for two to more other traits. The highly heterotic crosses did not necessarily display high *per se* performance, therefore, for isolating potential hybrid so as to exploit hybrid vigour, it is necessary to consider *per se* performance of hybrid in addition to magnitude of heterosis for grain yield and morpho-nutritional characters. Three out of the best heterotic crosses for grain yield per plant involved the pollen parent (inbred) K-13/1005 and CGMS line DHLB-18A. Hence, these parents seems to be most potential and deserve due consideration in further hybrid development programme in pearl millet.

It is also interesting to note that considering the magnitude of heterosis alone in the absence of per *se* performance of F_1 hybrid will be little use in genetic improvement programme, since many times poor parents express higher degree of per cent heterosis than the high yielding parents. This could be seen from the heterosis for the trait grain yield per plant in cross DHLB-15A x K-13/1017 which exhibited significant positive heterobeltiosis and standard heterosis also exhibited significant heterosis in desirable direction for other seven characters under study. Thus, it is concluded that while selecting potential crosses for its further use in breeding programmes, *per se* performance of parents and hybrids for various attributes must be taken into consideration in addition to percentage heterosis. Further, selection of crosses should not rest only on the *per se* performance of parents and heterosis for grain yield but the performance of parents and their hybrids for various attributes should also be considered.

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