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Exploitation of heterosis and selection of superior inbreds in pearl millet

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ABSTRACT

Ten diverse inbreds were crossed in a diallel fashion, excluding reciprocals, to study the magnitude of heterosis and to identify new restorers in pearl millet. The degree of heterosis varied from cross to cross for all the characters studied. The high magnitude of heterobeltiosis was found for grain yield per plant, fodder yield per plant, plant height, number of effective tillers per plant, ear head weight, 1000 grain weight and harvest index, while moderate heterosis over better parent was exhibited for ear head girth, ear head length and number of nodes. Days to 50 per cent flowering and days to maturity displayed the least heterotic values. The maximum positive heterosis for grain yield per plant was observed to be 194.65 and 153.22 per cent over mid and better parent, respectively. The cause of heterosis in grain yield might be due to heterosis in its yield attributing traits, mainly, 1000 grain weight, fodder yield per plant, plant height, number of effective tillers per plant, ear head weight, ear head length, and harvest index. The crosses *viz*., J-2480 x D-23, J-2467 x J-2474 and J-2467 x D-23 depicted high heterosis, *per se* performance, coupled with high SCA and involved both or atleast one good combiner parents. Such crosses have potential to throw desirable transegresants in the segregating material for the development of high yielding inbred lines in pearl millet.

Key words : Pearl millet, Heterosis, Inbreds, Grain yield

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the fourth most important crop among the cereals cultivated in India and is grown mainly in Rajasthan, U.P., Maharashtra, Gujarat and Haryana which account for 95 % of the area under this crop. Pearl millet has an embodiment of unique features like allogamy, protogamy, male sterility, huge genetic variability and remarkable geographic diversity. These characteristics offer great possibilities of crop improvement through hybridization. Development of Tift 23A male sterile source by Burton (1965) opened new vistas for the exploitation of heterosis on commercial scale in pearl millet. In heterosis breeding programme, it is essential to study and evaluate available useful promising diverse parental lines in their hybrid combinations for yield and yield components. Selection of parents and crosses for development of new restorer parents is most critical. Hence, the present investigation was undertaken to determine the extent of heterosis and to identify new restorer lines in pearl millet.

MATERIALS AND METHODS

Ten genetically diverse restorers *viz*., J-2454, J-108, J-2448, J-2340, J-2475, J-2464, J-2480, D-23, H-77/833-2 and J-2474 were crossed in all possible combinations (excluding reciprocals) at the Main Millet Research Station, Junagadh Agricultural University, Jamnagar during summer 2004 to generate a diallel set. Forty five crosses and their ten parents were sown in a randomized block design with three replications during *kharif*-2004. Each entry was grown in a single row of 4.0 m length each with inter and intra row spacing of 60 cm x 15 cm. The recommended agronomic practices were adopted for raising the good crop. Observations were recorded on five randomly selected competitive plants for each entry, in each replication for grain yield and eleven component traits (Table 1). Days to 50 per cent flowering and days to maturity were noted on the basis of whole plot. The heterosis as percentage deviation from mid parental (relative heterosis) and better parental value (heterobeltiosis) for each character was worked out.

RESULTS AND DISCUSSION

The nature and magnitude of heterosis help in identifying superior cross combinations for their exploitation to obtain better transgressive segregants. In the commercial exploitation of hybrid vigour, excess of F_1 over better parent, is of significance. Hence, in the present investigation, the extent of heterosis over better parent for grain yield and eleven attributing traits is discussed as under.

A perusal of Table 1 revealed that the degree and direction of heterosis varied considerably for grain yield and its components. Overall, the degree of heterobeltiosis was high for grain yield per plant, fodder yield per plant, plant height, number of effective tillers per plant, ear head weight, 1000 grain weight and harvest index. Whereas, ear head girth, ear head length and number of nodes on main stem exhibited moderate heterosis over better parent. Days to 50 per cent flowering and days to maturity displayed the least heterotic values. Pearl millet being grown in erratic conditions of rainfall, the earliness in

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Table 1 : Three best *per se* performing parents and three top ranking heterotic crosses alongwith range of heterosis and number of crosses showing significant heterosis in desired direction for various characters in pearl millet

Characters	Best *per se* performing parents	Range of heterosis (%)		Heterosis over mid parent (MP)			Heterosis over better parent (BP)		
		MP	BP	Best crosses	Heterosis	N*	Best crosses	Heterosis	N*
Days to 50	J-2480	-13.20	-12.94	J-2475 x D-23	-13.20		J-2475 x D-23	-12.94	
per cent	D-23	to	to	J-2467 x D-23	-13.20	28	J-2467 x D-23	-12.94	18
flowering	J-2467	8.07	15.23	J-2454 x J-108	-12.73		J-108 x J-2475	-12.43	
Days to	J-2448	-5.63	-6.52	J-2475 x D-23	-5.63		J-2475xH-77/833-2	-6.52	
maturity	J-2480	to	to	J-2467 x D-23	-5.11	18	J-2454 x J-108	-6.16	30
	J-108	6.51	6.00	J-2475 x J-2480	-5.07		J-2340 x J-2475	-5.80	
Plant	D-23	-13.84	-18.54	J-2467 x J-2480	42.73		J-2448 x J-2480	32.05	
height (cm)	J-2480	to	to	J-2467 x J-2474	41.46	23	J-2467 x J-2474	23.53	12
	J-2475	42.73	32.05	J-2467xH-77/833-2	28.48		J-2448 x J-2474	22.03	
No. of	J-2340	-31.42	-27.76	J-2448 x D-23	76.72		J-2480 x D-23	54.17	
effective	J-2475	to	to	J-2480 x D-23	60.19	9	J-2448 x D-23	52.60	2
tillers/plant	H-77/833-2	76.72	54.17	J-2448 x J-2480	54.54		J-2448 x J-2480	40.35	
No. of	J-2340	-9.67	-14.94	J-2480 x D-23	19.71		J-2454 x J-2467	20.72	
nodes on	J-2480	to	to	J-2454 x J-2467	19.30	8	J-2480 x D-23	17.87	3
main stem	D-23	19.71	20.72	J-2454 x J-108	17.84		D-23 x J-2474	13.79	
Ear head	J-2480	-12.49	-22.80	H-77/833-2xJ-2474	53.71		H-77/833-2xJ-2474	36.69	
length	D-23	to	to	J-2448xH-77/833-2	31.54	6	J-2448xH-77/833-2	22.04	2
(cm)	J-2475	53.71	36.69	J-2480xH-77/833-2	26.28		J-2475 x J-2467	17.72	
Ear head	J-2448	-14.10	-18.75	J-2475xH-77/833-2	28.40		J-2475 x D-23	20.51	
girth (cm)	J-2467	to	to	H-77/833-2xJ-2474	24.26	9	H-77/833-2xJ-2474	16.96	1
	J-108	28.40	20.51	J-2475 x D-23	23.47		J-2475 x J-2480	13.82	
Ear head	J-2480	-55.85	-61.00	J-2467 x D-23	73.56		J-2475 x J-2467	63.91	
weight (g)	J-2454	to	to	J-2448 x J-2474	73.37	6	J-2467 x D-23	57.20	4
	H-77/833-2	73.56	63.91	J-2475 x J-2467	68.77		J-2448 x D-23	47.03	
1000 grain	J-108	-26.58	-30.38	J-2467 x J-2480	44.09		J-2480xH-77/833-2	35.56	
weight (g)	J-2474	to	to	J-2475 x D-23	43.27	16	J-2467 x J-2480	32.90	10
	J-2454	44.09	35.56	J-2448 x J-2340	39.97		J-2475 x D-23	31.55	
Harvest	H-77/833-2	-47.86	-55.16	J-2340 x J-2480	84.83		J-2340 x J-2480	84.65	
index (%)	J-2454	to	to	J-2340 x J-2474	80.56	9	J-2340 x J-2474	65.13	4
	J-2467	84.83	84.65	J-2475 x J-2474	70.49		H-77/833-2xJ-2474	56.49	
Fodder	J-2475	-68.33	-71.38	J-2467 x D-23	248.89		J-108 x D-23	222.73	
yield per	J-2480	to	to	J-108 x D-23	248.04	21	J-108 x J-2467	195.74	14
plant (g)	J-2474	248.89	222.73	J-108 x J-2467	239.02		J-2467 x D-23	185.45	
Grain yield	H-77/833-2	-52.16	-42.96	J-2467 x J-2474	194.65		J-2480 x D-23	153.22	
per plant	J-2474	to	to	J-2467 x D-23	169.68	22	J-2467 x J-2474	149.73	21
(g)	J-2454	194.65	153.22	J-2480 x D-23	162.22		J-2467 x D-23	142.20	

*N =Number of crosses showing significant desirable heterosis.

flowering and maturity are desirable in pearl millet for escaping the drought conditions. Hence, negative heterosis is useful for days to 50 per cent flowering and days to maturity. Heterobeltiosis for days to 50 per cent flowering and days to maturity ranged from -12.94 to 15.23 per cent and -6.52 to 6.00 per cent, respectively. Among 45 crosses studied, 18 and 30 showed significant heterosis over better parent in desired direction for days to 50 per cent flowering and days to maturity, respectively, suggesting the existence of dominant genes for earliness. The present findings corroborate the findings of Bhanderi *et al.* (2007), Manga and Dubey (2004) and Gandhi *et al.*(1999) have also reported heterosis in desired direction for earliness.

Plant height is regarded as a favourable character due to important role of stem as a source in supplementing assimilates during grain development and as a stove yield (Joshi *et al.*, 2003). The extent of heterosis over better parent ranged -18.54 to 32.05 per cent. Twelve crosses registered significant and positive heterobeltiosis. Significant and positive heterosis in plant height has also been reported by Bhanderi *et al.* (2007), Sidpara (2002), Sheoran *et al.* (2000) and Gandhi *et al.* (1999). An appreciable amount of heterosis has been observed for number of effective tillers per plant, which is the major yield contributing character. The range of heterobeltiosis lied between -27.76 to 54.17 per cent for this trait. Twenty eight crosses recorded positive value, of which, only two crosses depicted significant and positive heterosis over better parent. Positive heterosis for number of effective tillers per plant in pearl millet were also observed by Davda *et al.* (2008), Bhanderi *et al.* (2007), Manga and Dubey (2004), Singh *et al.* (2004), Sidpara (2002) and Singh and Sagar (2001).

A large number of nodes are considered as a positive character, because the plant height is a desirable character in pearl millet. The extent of heterobeltiosis ranged from -14.94 to 20.72 per cent for number of nodes. Out of 45 crosses studied, only three crosses depicted significant and positive heterosis over better parent for this trait. Similar, results has been reported by Sidpara (2002) in pearl millet. In case of ear head length, the magnitude of heterobeltiosis ranged from -22.80 to 36.69 per cent. Out of 45 crosses studied, only two manifested significant positive heterosis over better parent. Significant and positive heterosis for this trait has also been recorded by Bhanderi *et al.* (2007), Manga and Dubey (2004), Singh *et al.* (2004), Sidpara (2002), Sheoran *et al.* (2000) and Gandhi *et al.*(1999).

The range of heterobeltiosis varied from -18.75 to 20.51 per cent for ear head girth. Sixteen crosses showed positive values of which only one cross registered significant heterobeltiosis, focusing the preponderance of partial dominance. The results are in close correspondence with the findings of Bhanderi *et al.* (2007), Manga and Dubey (2004), Singh *et al.* (2004) and Sidpara (2002). High magnitude of heterosis has been observed for ear head weight, which is the major yield contributing character. The range of better parental heterosis was -61.00 to 63.91 per cent for this trait. The cross combination J-2475 x J-2467 (63.91 %) recorded the highest positive heterobeltiosis followed by J-2467 x D-23 (57.20 %) and J-2448 x D-23 (47.03%) for ear head weight. Significant and positive heterosis for ear head weight in pearl millet has been also reported by Davda *et al.* (2008), Bhanderi *et al.* (2007), Manga and Dubey (2004), Sidpara (2002) and Singh and Sagar (2001).

Test weight being an important yield attributing character, use of high test weighted parental line in breeding programme may be most desirable. The range of better parental heterosis varied from -30.38 to 35.56 per cent. Out of 33 significant crosses, ten registered positive heterobeltiosis for this trait. Heterosis for test weight in pearl millet was also reported by Manga and Dubey (2004), Singh *et al.*(2004) and Sheoran *et al.* (2000). With regards to harvest index, the range of better parental heterosis was -55.16 to 84.65 per cent. Out of 20 significant crosses, four crosses displayed positive heterosis in increasing the compactness over better parent. The hybrid J-2340 x J-2480 (84.65 %) recorded the highest heterobeltiosis for harvest index followed by J-2340 x J-2474 (65.13 %) and H-77/833-2 x J-2474 (56.49 %). Joshi *et al.* (2005, 2006) reported the predominant role of harvest index with respect to grain yield in pearl millet under rainfed condition as observed in the present study. Further, Bhanderi *et al.* (2007) and Manga and Dubey (2004) have also reported positive heterosis for harvest index.

Paramount of heterosis has been observed in fodder yield, which is an important component of pearl millet being a dual-purpose crop. J-108 x D-23 (222.73 %) recorded maximum better parental heterosis for higher dry fodder yield followed by J-108 x J-2467 (195.74 %) and J-2467 x D-23 (185.45 %). Out of 29 significant crosses, 14 manifested positive heterobeltiosis, suggesting the greater role of fodder yield in the expression of grain yield. This outcome is in accordance with that of Bidinger *et al.* (2002) who reported association between grain yield and bio-mass. Davda *et al.* (2008), Bhanderi *et al.* (2007) and Manga and Dubey (2004) observed heterosis for this trait which confirmed the present findings.

Yield is an attribute of economic importance, for which considerable magnitude of heterosis was registered in a number of crosses. The extent of relative heterosis ranged from -52.16 (J-2448 x J-2474) to 194.65 per cent (J-2467 x J-2474), while heterobeltiosis varied between -42.96 (J-2448 x J-2474) to 153.22 per cent (J-2480 x D-23). Twenty three hybrids displayed significant relative heterosis, of which, 22 exhibited positive values in grain yield. A maximum of 21 crosses manifested significant heterobeltiosis, of which, all the crosses registered positive heterosis for higher yield over their respective better parent. Interestingly, the magnitude of heterosis in positive direction was too high.

Ten top ranking hybrids were identified for grain yield, based on magnitude of heterosis over better parent from evaluation of 45 crosses (Table 2). The hybrid J-2480 x D-23 had the highest heterobeltiosis, also possessed

Table 2 : Ten top heterobeltiotic crosses alongwith their *per se* performance, GCA and SCA effects for grain yield per plant and significant desirable heterosis over better parent for other traits in pearl millet

Sr. No.	Crosses	Grain yield/ plant(g)	Heterosis (%) over		SCA	GCA effects of parents		Significant heterosis over better parent in other traits in desired direction
			MP	BP		P_1	P_2	
1.	J-2480 x D-23	81.20	162.22**	153.22**	25.99**	High	High	ET, NS, TW, FY, HI
2.	J-2467 x J-2474	91.73	194.65**	149.73**	44.57**	High	Average	DF, DM, TW, FY, HI
3.	J-2467 x D-23	77.67	169.68**	142.20**	20.73**	High	High	DF, DM, PH, EL, FY, TW
4.	J-2467 x J-2480	71.73	158.97**	140.18**	15.98**	High	High	PH, ET, NS, EL, EW, FY, TW, HI
5.	J-2340 x J-2480	65.33	130.18**	118.75**	21.43**	High	High	DF, DM, PH, TW, HI
6.	J-2448 x J-2480	64.27	127.90**	115.18**	19.07**	High	High	DM, PH, ET, EW, TW, FY
7.	J-2454 x J-108	77.40	146.24**	111.48**	38.13**	Low	Low	DF, DM, PH, ET, NS, EW, TW, FY, HI
8.	J-2475 x D-23	66.67	112.99**	107.90**	23.08**	Low	High	DF, DM, EG, TW, FY
9.	J-2480 x H-77/833-2	68.33	112.17**	82.71**	17.78**	High	Low	DF, DM, PH, EL, TW, FY
10.	J-2467 x H-77/833-2	66.87	112.10**	78.79**	14.59**	High	Low	DF, DM, PH, ET, TW, FY

* and ** indicates significance of values at P=0.05 and 0.01, respectively. DF = Days to 50 per cent flowering, DM = Days to maturity, PH = Plant height, ET = Number of effective tillers per plant, NS = Number of nodes on main stem, EL = Ear head length, EW = Ear head weight, EG =Ear head girth, TW = 1000 grain weight, FY = Dry fodder yield per plant, HI = Harvest index.

second rank in *per se* performance and third rank in SCA effects and involved both the parents with high GCA effects for grain yield. These suggested that the predominant role of additive and additive x additive gene effects were responsible for governing the inheritance of grain yield and its attributes. This hybrid had also exhibited first rank in number of effective tillers per plant and second in number of nodes for heterobeltiosis, focusing greater role of these traits towards grain yield. Similarly, another high heterobeltiotic cross *viz*., J-2467 x J-2474 ranking first both in *per se* performance and SCA effects and involvement of one parent with high GCA effect for grain yield, indicated the predominantly non-additive gene effects with significant additive effects in the expressing grain yield and its components. They have also possessed the second rank in heterosis over batter parent for plant height. While, hybrid J-2467 x D-23 involving high x high combiners displayed third rank in both heterobeltiosis and *per se* performance, also occupied sixth position in SCA effects for grain yield, suggesting importance of additive and additive x additive gene effects in controlling the most of the traits. This cross also occupied second rank in ear head weight and third rank in 1000 grain weight for heterobeltiosis, pinpointed that the greater contribution of these characters towards the grain yield. All the ten high heterobeltiotic crosses for grain yield (Table 2), exhibited significantly heterobeltiosis in desired direction for 1000 grain weight, while nine for fodder yield per plant, eight for days to maturity, seven crosses each for plant height and days to 50 per cent flowering, five crosses each for number of effective tillers per plant and harvest index, three each for ear head weight, ear head length and number of nodes, and one cross for ear head girth. The results indicated that the heterosis in grain yield was reflected through heterosis in 1000 grain weight, fodder yield per plant, plant height, number of effective tillers per plant, ear head weight, ear head length, and harvest index. Present findings are consistent with results of Davda *et al.* (2008), Bhanderi *et al.* (2007), Manga and Dubey (2004), Singh *et al.* (2004), Sidpara (2002), Singh and Sagar (2001), Sheoran *et al.* (2000) and Gandhi *et al.*(1999).

Thus, all the three top ranking heterotic crosses *viz*., J-2480 x D-23, J-2467 x J-2474 and J-2467 x D-23 exhibited significantly positive relative heterosis, heterobeltiosis and SCA effects coupled with high *per se* performance for grain yield. These crosses also registered significantly high heterosis for many yield attributing traits in desired direction. Therefore, they have potential to generate better transgressive segreants from segregating generations for development of high yielding restorer lines in pearl millet.

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