Heterosis studies for grain yield and its components in Pearl millet

K.J. VAGADIYA[1], K.K. DHEDHI*, H.J. JOSHI, H.B.VEKARIYA[1] AND A.S. BHADELIA[1]
Pearl millet Research Station, Junagadh Agricultural University, JAMNAGAR (GUJARAT) INDIA

ABSTRACT

The present study was carried out to estimate the nature and magnitude of heterosis for grain yield and its attributing traits through line x tester fashion involving four CMS lines and 12 restorers in pearl millet. The magnitude of heterosis varied from cross to cross for all the characters studied. The high level of heterosis was observed for grain yield per plant and ear head length, while moderate heterosis was found for length of protogyny, plant height and harvest index. The number of effective tillers per plant and ear head girth exhibited the least heterosis. Maximum positive heterosis for grain yield per plant over better parent and standard check (GHB-719) was observed to be 105.71 and 11.30 per cent, respectively. The cause of heterosis in grain yield might be due to its component traits, mainly, ear head length, plant height and harvest index. Three most promising hybrids *viz.,* JMSA-20072 x J-2290, JMSA-20073 x H-77/833-2 and ICMA-98444 x J-2498 having high heterosis, *per se* performance, coupled with high SCA effects and involved both or at least one good combiner parents for grain yield.

Key words : Heterosis, *Pennisetum glaucum*, Line x Tester, Grain yield

INTRODUCTION

The exploitation of heterosis in pearl millet was considered easy with its protogynous flowering and high out-crossing rates (Chavan *et al.,* 1955). The availability and knowledge of cytoplasmic-nuclear male sterility (CMS), the development of CMS lines, and their maintainers and restorers, made it possible to produce the seed of commercial single-cross F_1 grain hybrids in India (Athwal, 1966). The magnitude of heterosis provides a basis for genetical diversity and a guide for the choice of desirable parents for developing superior F_1 hybrids to exploit hybrid vigour and for building gene pools to be employed in breeding programme. Keeping this in view, the present investigation was carried out to know magnitude of heterosis for grain yield and its components in pearl millet.

MATERIALS AND METHODS

Four cytoplasmic-genetic male sterile lines (ICMA-95444, ICMA-98444, JMSA-20072, JMSA-20073) and 12 diverse restorer lines (J-2290, J-2340, J-2405, J-2433, J-2454, J-2467, J-2474, J-2479, J-2483, J-2495, J-2498, H-77/833-2) were crossed following line x tester mating design during summer-2009. A set of 65 genotypes comprising of 48 F_1s along with fertile counter parts of four male sterile lines, 12 pollinators and one standard check (GHB-719) were sown on 13th July during *Kharif*-2009 in a randomized block design replicated thrice at Pearl millet Research Station, Junagadh Agricultural University, Jamnagar (Gujarat), India. Each genotype was grown in a single row of 5.0 m length each with inter and intra row spacing of 60 x 15 cm. The recommended cultural practices and plant protection measures whenever necessary were adopted for raising the good crop. Observations were recorded on ten randomly selected competitive plants for each entry, in each replication for seven characters (Table 1). Length of protogyny was calculated by deducting days to stigmatic stage from days to anthesis. The recorded data were subjected to analysis of variance technique for each of the characters reported by Panse and Sukhatme (1978). The heterosis as percentage deviation from the better parent (heterobeltiosis) and the standard check, GHB-719 (standard heterosis) for each character were worked out as per the standard procedure given by Fonseca and Patterson (1968) and Meredith and Bridge (1972), respectively.

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the characters (Table 1), indicating the existence of considerable amount of genetic variability in the experimental materials. Genotypic variances were further partitioned into variance due to parents, hybrids and parents Vs hybrids. Significant differences due to parents and hybrids for all the characters except length of protogyny for hybrids. Mean squares due to parents Vs hybrids were significant for all the characters except for length of protogyny and number of effective tillers per plant. The results of heterosis indicated that the degree and direction of heterosis varied enormously for all the characters studied. Overall, the

*** Author for correspondence.**
[1]Department of Agricultural Botany, College of Agriculture, Junagadh Agricultural University, JUNAGADH (GUJARAT) INDIA

Table 1: Analysis of variance for the experimental design for different characters in pearl millet

Source of variation	d.f.	Length of protogyny	Plant height (cm)	Number of effective tillers/plant	Ear head girth (cm)	Ear head length (cm)	Harvest index (%)	Grain yield/plant (g)
Replications	2	3.34**	25.87	1.54*	2.26**	7.08**	12.04*	22.95**
Genotypes	63	0.63*	1021.17**	2.83**	1.14**	29.53**	94.69**	182.89**
(a) Parents (P)	15	0.95**	1890.46**	3.55**	1.49**	29.17**	49.70**	119.94**
(b) Hybrids (H)	47	0.54	650.98**	2.65**	1.03**	24.98**	88.51**	122.15**
(c) P Vs H	1	0.17	5380.83**	0.59	1.40**	248.91**	88.51**	3982.13**
Error	126	0.42	35.61	0.34	0.19	1.44	3.320	1.63

* and ** indicate significance of values at P=0.05 and 0.10, respectively

magnitudes of heterotic effects were high for grain yield per plant and ear head length. Whereas, length of protogyny, plant height and harvest index depicted moderate heterosis. The number of effective tillers per plant and ear head girth exhibited the least heterosis.

Length of protogyny:

A short length of protogyny is desirable, because success of the commercial hybrid depends on good seed setting as one of the essential indices. Hence, this trait is important in imparting the synchrony between male and female parts, which is a must for successful fertilization, seed setting and ultimately grain yield realization. Therefore, negative heterosis in length of protogyny is desirable. The extent of heterosis over better parent was -36.36 to 42.86 per cent. Out of 48 crosses, only three exhibited significant negative heterobeltiosis. Heterosis over standard check (GHB-719) ranged from -12.50 to 37.50 per cent. None of the crosses exhibited significant and negative heterosis over standard check. The results confirmed the findings of Vaghasiya *et al*. (2009).

Plant height :

Plant height is regarded as a favourable character due to important role of stem as a source in supplementing assimilates during grain development (Joshi *et al.,* 2003). The data showed that out of 48 crosses, 22 and 7 recorded significant positive heterosis over better parent and standard check, respectively, suggesting the existence of dominance gene. The value of heterosis over better parent ranged from -26.76 to 50.92 per cent. The range of standard heterosis for plant height was -37.40 to 17.22 per cent. Significant and positive heterosis in plant height has also been reported by Sheoran *et al.* (2000), Bhanderi *et al.* (2007), Chotaliya *et al.* (2009) and Vaghasiya *et al*. (2009).

Number of effective tillers per plant :

The extent of heterosis over better parent was -60.58 to 22.97 per cent, and over standard check was -52.94 to 7.06 per cent. Among all crosses studied, only one displayed significant and positive heterosis over better parent. Whereas, none of the crosses exhibited significant and positive heterosis over standard check. It is interesting to note that all the three best standard heterotic crosses *viz*., ICMA-98444 x J-2340, ICMA-95444 x J-2340 and JMSA-20072 x J-2340 possessed common male parent J-2340, indicating the greater contribution of J-2340 towards the number of effective tillers per plant. Singh and Sagar (2001), Davda *et al*. (2008) and Vaghasiya *et al*. (2009) have reported positive heterosis for number of effective tillers per plant.

Ear head girth :

Ear head girth is the major component of the ear head dimension, which is directly reflecting the grain yield. The range of heterobeltiosis and standard heterosis varied from -20.89 to 15.88 per cent and -14.69 to 16.17 per cent, respectively. Among 48 crosses, five hybrids showed significant positive heterosis over better parent as well as standard check for this trait. Heterosis for ear head girth in pearl millet as observed in the present study was also reported by Sheoran *et al.* (2000), Singh *et al.* (2004), Bhanderi *et al*. (2007), Chotaliya *et al.* (2009) and Vaghasiya *et al*. (2009).

Ear head length:

Paramount of heterosis has been observed in ear head length, which is an important component of pearl millet. The heterobeltiosis and standard heterosis ranged from -27.72 to 54.50 per cent and -24.40 to 37.48 per cent, respectively. The cross combination JMSA-20073 x J-2479 (37.48%) recorded the highest positive standard heterosis followed by ICMA-98444 x J-2498 (34.41%) and ICMA-95444 x J-2483 (24.92%) for this trait. Out of 48 crosses, 24 and 10 exhibited significant positive heterosis over better parent and standard check, respectively. Positive and significant heterosis for this trait has also been noticed by Bhanderi *et al*. (2007), Davda *et al*. (2008) and Vaghasiya *et al*. (2009).

Harvest index:

The most of the cross combinations manifested positive heterobeltiosis and standard heterosis. Of which, 25 and 7 crosses rendered positive significant heterosis over better parent and standard check, respectively. The hybrid ICMA-95444 x J-2405 showed the highest significant positive heterobeltiosis (49.44%) followed by JMSA-20072 x J-2483 (38.02 %) and ICMA-95444 x J-2433 (32.05 %). The cross combination JMSA-20072 x J-2467 exhibited the maximum economical heterosis (27.45 %), whereas, JMSA-20073 x J-2405 recorded the minimum standard heterosis (-27.04 %) for harvest index. High magnitude of heterosis and large number of hybrids exhibiting positive significant heterosis revealed the presence of dominant alleles for this trait. The heterosis for harvest index has also been reported by Bhanderi *et al*. (2007), Davda *et al*. (2008) and Chotaliya *et al*. (2009).

Grain yield per plant:

Grain yield is the character of economic importance for which considerable degree of heterosis was registered in a number of crosses. Majority of hybrids exhibited positive heterosis over better parental values. In all, 36 and 4 hybrids manifested significant positive heterobeltiosis and standard heterosis, respectively. The magnitude of

Table 2: Three best *per se* performing parents and three top ranking heterotic crosses along with range of heterosis and number of crosses showing significant heterosis in desired direction for various characters in pearl millet

Sr. No.	Character	Best *per se* performing parents	Range of heterosis (%)		Heterosis over better parent (BP)			Heterosis over standard check (SC) (GHB-719)		
			BP	SC	Best crosses	Heterosis	N*	Best crosses	Heterosis	N*
1.	Length of	J-2454	-36.36	-12.50	ICMA-95444 x J-2433	-36.36*	3	ICMA-95444 x J-2483	-12.50	0
	protogyny	J-2340	to	to	JMSA-20073 x J-2290	-36.36*		JMSA-20073 x J-2290	-12.50	
		J-2498	42.86	37.50	JMSA-20073 x J-2498	-36.36*		JMSA-20073 x J-2498	-12.50	
2.	Plant	J-2405	-26.76	-37.40	ICMA-98444 x J-2454	50.92**	22	ICMA-98444 x J-2405	17.22**	7
	height	J-2483	to	to	JMSA-20072 x J-2454	39.35**		ICMA-98444 x J-2498	12.68**	
	(cm)	J-2498	50.92	17.22	ICMA-95444 x J-2340	31.60**		ICMA-98444 x J-2433	11.64**	
3.	No. of	JMSA-	-60.58	-52.94	ICMA-98444 x J-2340	22.97*	1	ICMA-98444 x J-2340	7.06	0
	effective	20073	to	to						
	Tillers/	JMSA-	22.97	7.06	ICMA-95444 x J-2340	18.30		ICMA-95444 x J-2340	6.47	
	plant	20072								
		ICMA-			ICMA-98444 x J-2290	13.70		JMSA-20072 x J-2340	0.59	
		95444								
4.	Ear head	JMSA-	-20.89	-14.69	JMSA-20073 x J-2467	15.88**	5	ICMA-98444 x J-2433	16.17**	5
	girth	20072	to	to						
	(cm)	J-2290	15.88	16.17	ICMA-98444 x J-2433	14.10**		JMSA-20072 x J-2405	13.61**	
		J-2340			ICMA-95444 x J-2483	11.88**		JMSA-20072 x J-2340	13.45**	
5.	Ear head	J-2498	-27.72	-24.40	JMSA-20073 x J-2454	54.50**	24	JMSA-20073 x J-2479	37.48**	10
	length	J-2405	to	to	ICMA-95444 x J-2340	51.46**		ICMA-98444 x J-2498	34.41**	
	(cm)	J-2433	54.50	37.48	JMSA-20073 x J-2479	46.81**		ICMA-95444 x J-2483	24.92**	
6.	Harvest	J-2467	-17.51	-27.04	ICMA-95444 x J-2405	49.44**	25	JMSA-20072 x J-2467	27.45**	7
	index	J-2495	to	to	JMSA-20072 x J-2483	38.02**		ICMA-95444 x J-2405	21.34**	
	(%)	JMSA-	49.44	27.45	ICMA-95444 x J-2433	32.05**		JMSA-20072 x J-2483	21.09**	
		20073								
7.	Grain	J-2433	-25.90	-42.64	ICMA-98444 x J-2498	105.7**	36	JMSA-20072 x J-2290	11.30**	4
	yield	JMSA-	to	to	JMSA-20072x J-2454	105.2**		JMSA-20073xH-77/833-2	9.08**	
	per plant	20073	105.70	11.30						
	(g)	J-2405			JMSA-20072xH-77/833-2	101.5**		ICMA-98444 x J-2498	8.99**	

*N =Number of crosses showing significant desirable heterosis

Table 3: Best heterotic crosses along with their *per se* performance, GCA and SCA effects for grain yield per plant and significant desirable heterobeltiosis for other traits in pearl millet

Sr. No.	Crosses	Grain yield/ plant (g)	Heterosis (%) over		SCA	GCA		Traits showing significant heterobeltiosis in desirable direction
			BP	SC		Female	Male	
1.	JMSA-20072 x J-2290	46.63	60.80**	11.30**	3.74**	Poor	Good	HI, GY.
2.	JMSA-20073 x H-77/833-2	46.00	32.87**	9.08**	5.54**	Good	Good	PH, EL, GY, HI.
3.	ICMA-98444 x J-2498	45.67	105.71**	8.99**	7.66**	Poor	Good	PH, EL, GY, HI.
4.	JMSA-20073 x J-2474	44.50	31.79**	6.21*	8.39**	Good	Poor	PH, EL, GY, HI.
5.	ICMA-98444 x J-2290	44.30	52.76**	5.73*	2.69**	Poor	Good	PH, EL, GY, HI.

* and ** indicate significance of values at P=0.05 and 0.10, respectively
PH=Plant height, EL=Ear head length, HI= Harvest index, GY=Grain yield/plant.

heterosis ranged from -25.90 to 105.70 per cent over better parent, while it varied between -42.64 to 11.30 per cent over standard check. Interestingly, the magnitude in positive direction was too high particularly in heterobeltiosis. Perusal of Table 2 also revealed the number of crosses displaying heterobeltiosis in various yield-attributing characters were small, whereas, the number of crosses showing heterobeltiosis in grain yield were large (36).This result indicated that the favourable combination of yield contributing characters resulted in a higher proportion of cross combinations showing significant positive heterobeltiosis.

Five most promising hybrids were identified for grain yield, based on magnitude of heterosis over standard check (GHB-719) from evaluation of 48 crosses (Table 3). The highest *per se* performing hybrid JMSA-20072 x J-2290 had first rank in standard heterosis, coupled with high heterobeltiosis and SCA effect and involving poor x good general combining parents. Similarly, ICMA-98444 x J-2498 involving poor x good combiners and ranking first in heterobeltiosis, occupied third rank in *per se* performance and fourth rank in SCA effects for grain yield. This cross also ranked second in standard heterosis for plant height and ear head length, suggesting the greater role of these traits towards the grain yield. While hybrid JMSA-20073 x H-77/833-2 involving good x good combiner parents displayed second rank in *per se* performance, occupied ninth rank in SCA with high heterobeltiosis for grain yield. All the five most superior standard heterotic hybrids for grain yield exhibited significant heterobeltiosis in desired direction for grain yield and harvest index, while four crosses each for plant height and ear head length. The results indicated that the high heterotic effects of grain yield per plant were mainly due to plant height, ear head length and harvest index. Present findings are akin with earlier results of Sheoran *et al.* (2000), Singh and Sagar (2001), Bhanderi *et al.* (2007), Davda *et al*. (2008), Chotaliya *et al.* (2009) and Vaghasiya *et al.* (2009) who reported higher magnitude of heterosis for grain yield in pearl millet.

Therefore, in the present study, three top ranking *per se* performance hybrids for grain yield *viz*., JMSA-20072 x J-2290, JMSA-20073 x H-77/833-2 and ICMA-98444 x J-2498 exhibited high heterotic status along with high SCA and also recorded high heterobeltiosis for various important yield components. Thus, it was suggested to evaluate these three hybrids under multiplication trials along with the standard hybrid for their direct released as high yielding hybrids in pearl millet.

REFERENCES

Athwal, D.S. (1966). Current plant breeding research with special reference to *Pennisetum. Indian J. Genet.,* **26**A : 73-85.

Bhanderi, S.H., Dangaria, C.J. and Dhedhi, K.K. (2007). Heterosis studies in newly developed restorers of pearl millet. *Internat. J. Bioscience Reporter*, **5**(2)**:** 563-569.

Chavan, V.M., Patil, J.A. and Chowdhary, B.B. (1955). Hybrid bajra in Bombay State. *Poona Agril. College Magazine*, **46**: 148-150.

Chotaliya, J.M., Dangaria, C.J. and Dhedhi, K.K. (2009). Exploitation of heterosis and selection of superior inbreds in pearl millet. *Internat. J. agric. Sci*., **5**(2)**:** 531-535.

Davda, B.K., Dhedhi, K.K., Dangaria, C.J. and Joshi, A.K. (2008). Heterosis for grain yield and its components in pearl millet**.** *Internat. J. agric. Sci*., **4**(1): 371-376.

Fonseca, S. and Patterson, F.L. (1968). Hybrid vigour in a seven parental diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Sci*., **8** : 85-88.

Joshi, A.K., Pandya, J.N., Buhecha, K.V., Dave, H.R., Pethani, K.V. and Dangaria, C.J. (2003). Grain yield in pearl millet in relation to source size and proximity to sink. *Photosynthetica*, **41**(1):157-159.

Meredith, W.R. and Beidge, R.R. (1972). Heterosis and gene action in cotton *Gossypium hirsutum., Crop Sci.,* **12**: 304-310.

Panse, V.G. and Sukhatme, P.V. (1967). *Statistical methods for Agricultural Workers,* ICAR, New Delhi.

Sheoran, R.K., Govila, O.P. and Singh, Balzor (2000). Genetic architecture of yield and yield contributing traits in pearl millet. *Ann. agric. Res*., **21**(3)**:** 443-445.

Singh, A.K., Srikant, Y. and Mathur, O.N. (2004). Performance of some newly developed male sterile lines and restorers in pearl millet. *Agric. Sci. Digest.,* **24**(4): 304-306.

Singh, R. and Sagar, P. (2001). Genetic analysis of grain yield and its components in pearl millet. *Madras agric. J.,* **88** (7,9) : 512-514.

Vaghasiya,V.D., Dangaria, C.J. and Dhedhi, K.K. (2009). Heterosis studies in B x R crosses for selection of superior females for A-line development in pearl millet. *Agric. Sci. Digest,* **29**(2): 84-88.

Received : April, 2010; Accepted : June, 2010