Electronic Journal of Plant Breeding, 3(3): 848-852 (Sep 2012)
ISSN 0975-928X

Research Article

Heterosis for grain yield and its related characters in pearl millet

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(Received: 09 July 2012; Accepted: 08 Aug 2012)

Abstract:

The heterosis study for grain yield and its attributes was carried out in pearl millet (*Pennisetum glaucum* (L.) R.Br.) through Line x tester mating design in three different seasons. The pooled analysis of variance showed highly significant mean squares differences among the environments (three different seasons) for all the characters. The variance due to hybrids, lines, testers and line x tester interactions were also significant for all the characters studied indicating presence of considerable variability among the material studied and existence of over all heterosis for all the characters. The degree of heterobeltiosis and standard heterosis varied for all the hybrids and for all the characters studied. In general, it is inferred that the magnitude of heterosis effect was high for grain yield per plant, fodder yield per plant, 1000-seed weight, ear head weight, harvest index and number of effective tillers per plant; moderate for ear head length and threshing index and low for ear head girth. The hybrids ICMA 95222 x J 2372 and JMSA 101 x J 2296 exhibited the highest, significant and positive heterotic effect and mean performance for grain yield per plant and some of s its important component traits. This could be exploited commercially for heterosis breeding in pearl millet.

Keywords: Heterosis, Seed yield, Line x Tester, Pearl millet

Pearl millet is a highly cross-pollinated (allogamous) crop. The availability of cytoplasm genetic male sterile lines in this crop made feasible to exploit heterosis commercially and hybrid seed production on large scale. 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.

Material and Methods

The experiment was conducted at Sugarcane Research Station, Junagadh Agricultural University, Kodinar during *Kharif*, Semi-*rabi* and summer - 2005-06. The experimental material consisting 66 entries including 15 parents (5 females as lines and 10 males as testers) and resultant 50 crosses along with one check hybrid MH 169 was raised in Randomised Block Design with three replications in three different seasons. Each entry was grown in single plot row of 4m length with 20cm spacing between plants, the rows were spaced 60cm apart. Recommended agronomic practices and plant protection measures were adopted to raise healthy crop. The observations on number of effective tillers per plant, ear head length, ear head girth, ear head weight, 1000-seed weight, harvest index, threshing index, fodder yield per plant, grain yield per plant and protein content were recorded for five randomly selected plants in each entry and in each replication. The data were statistically analysed and heterosis over better parent (H_1) and standard heterosis (H_2) were calculated as per standard procedure.

Results and Discussion

The pooled analysis of variance showed highly significant mean square differences among the environments (three different seasons) for all the characters. The variance due to hybrids, lines, testers and line x tester interactions were also significant for all the characters studied indicating the presence of considerable amount of variability among the material studied and existence of over all heterosis for all the characters.

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. The range of heterosis, number of significant and desirable heterotic crosses along with five top ranking heterotic crosses over better parent and standard

hybrid for grain yield per plant and its related characters are present in table 1. Grain yield per plant in pearl millet is the character of economic importance for which 31 hybrids over better parent and 12 hybrid over standard hybrid exhibited significant and positive heterosis. Several hybrids exhibited significant and desirable direction of heterobeltiosis and standard heterosis for various characters such as number of effective tillers per plant (7 & 12 hybrids); ear head length (13 & 9 hbrids); ear head girth (11 &24 hybrids); ear head weight (29 & 21 hbrids); 1000-seed weight (30 & 39 hbrids), harvest index (23 & 5 hbrids); threshing index (19 &1 hbrids) and fodder yield per plant. (31 &23 hybrids) respectively Similarly seven and thirty four crosses exhibited significant and positive heterobeltiosis and standard heterosis, respectively for protein content.

In general, it is inferred that magnitude of heterotic effects were high for grain yield per plant, fodder yield per plant, 1000-seed weight, ear head weight, harvest index number of tillers per plant and protein content and moderate for ear head length and threshing index and low for ear head girth.

The hybrid, ICMA 94555 x J 2454 for number of effective tillers per plant and harvest index; ICMA 95444 x J 108 for ear head length and 1000-seed weight; JMSA 101 x J 2296 for threshing index; 81A x J 2296 for fodder yield per plant and 81A x J 108 for protein content and ICMA 95444 x J 2340 for ear head girth, ear head weight and grain yield per plant showed significant and maximum heterosis over better parent.

Maximum heterosis over standard hybrid was observed in ICMA 95444 x J 2290 for number of effective tillers per plant; JMSA 101 x J 2240 for ear head length; ICMA 94555 x J 2372 for ear head girth; ICMA 95222 x J 2454 for 1000-seed weight; ICMA 95444 x J 2440 for threshing index; ICMA 95444 x J 2372 for fodder yield per plant; ICMA 95222 x J 2372 for ear head weight; harvest index and grain yield per plant and JMSA 101 x J 2290 for protein content. A comparison of five high heterotic crosses with best performing five crosses (Table 1) further revealed that for all the characters, the performance of crosses was not associated with heterotic response, i.e. the best perform and heterotic crosses were different. This indicated that selection of crosses for grain yield and its related traits on the basis of either *per se* performance or heterotic response would be equally important, but the former is more desirable. Similar results of heterosis for characters related to grain yield in pearl millet were also reported by Singh and Sagar (2001), Singh *et al.* (2004), Manga and Dubey (2004) and Dhuppe *et al.* (2005).

The degree and magnitude of heterosis over better parent and standard hybrid varied from cross to cross for all the characters over the pooled basis. This indicated that all the characters distinctly differed for mean heterosis and its range in desirable direction. Considerable amount of high heterosis in certain crosses and low in other crosses revealed that nature of gene action varied with the genetic make up 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.

A comparative study of top ten crosses for grain yield *per se* (Table 2) indicated that none of the cross combinations depicated desired heterobeltiosis and standard heterosis for all the characters studied. The cross combination ICMA 95222 x J 2372 exhibited significant and desired heterosis over better parent and standard hybrid for grain yield per plant also showed significant and desirable heterobeltiosis and standard heterosis for ear head weight, harvest index and fodder yield per plant. The hybrid ICMA 95444 x J 2296 expressed desirable heterobeltiosis for 1000-seed weight and protein content, and desirable standard heterosis for ear head length. These two superior hybrids may be exploited commercially for getting benefits of heterosis for grain yield and its component traits in pearl millet.

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Table 1.. Magnitude of heterobeltiosis (H_1) and standard heterosis (H_2) over environments for various characters in pearl millet

Characters	Range		Best five crosses with heterotic effect					
	H_1	H_2	H_1	Effect	Mean	H_2	Effect	Mean
Number of tillers per plant	-32.36 to 59.02	-29.38 to 30.63	ICMA 94555 x J 2454	59.02	3.89	ICMA 95444 x J 2290	30.63	4.60
	7@	30@	ICMA 94555 x J 104	26.97	3.36	JMSA 101 x J 2290	30.31	4.60
			81A x J 104	26.67	3.67	JMSA 101 x J 2440	28.44	4.60
			ICMA 95444 x J 2440	21.80	3.56	ICMA 94555 x J 998	28.13	4.60
			81A x J 998	21.15	3.47	ICMA 95444 x J 2440	26.25	4.50
Ear head length (cm)	-27.10 to 47.40	-19.83 to 36.48	ICMA 95444 x J 108	47.40	25.61	JMSA 101 x J 2240	41.75	30.2
	13@	9@	ICMA 95444 x J 2340	34.10	29.06	ICMA 94555 x J 2340	36.48	29.1
			ICMA 95444 x J 2454	28.93	21.81	ICMA 95444 x J 2296	28.24	27.3
			ICMA 94555 x J 2372	15.19	19.61	ICMA 94555 x J 2454	27.71	27.2
			ICMA 95222 x J 2454	12.66	18.04	ICMA 95444 x J 104	26.51	26.9
Ear head girth (cm)	-16.58 to 28.79	-11.12 to 36.36	ICMA 95444 x J 2340	28.79	7.39	ICMA 94555 x J 2372	36.36	10.61
	11@	24@	ICMA 95444 x J 108	26.83	7.71	81A x J 2454	36.34	10.61
			81A x J 108	15.81	6.68	ICMA 94555 x J 2372	31.50	10.23
			ICMA 94555 x J 2372	13.87	10.29	ICMA 95444 x J 2372	28.32	9.98
			ICMA 95444 x J 104	10.92	7.67	ICMA 95222 x J 2296	21.89	9.48
Ear head weight (g)	-19.69 to 151.36	-34.21 to 65.16	ICMA 95444 x J 2340	151.36	80.89	ICMA 95222 x J 2372	65.16	118.0
	29@	21@	ICMA 95444 x J 108	105.82	91.33	ICMA 94555 x J 998	58.32	113.0
			ICMA 94555 x J 2454	103.84	86.78	ICMA 95444 x J 2296	45.41	104.0
			ICMA 94555 x J 108	98.34	91.33	ICMA 95444 x J 2372	33.75	96.0
			81A x J 2296	95.91	43.44	JMSA 101 x J 2372	31.88	94.0
1000 – seed weight (g)	-33.88 to 64.05	-28.91 to 40.12	ICMA 95444 x J 108	64.05	10.84	ICMA 95222 x J 2454	40.12	12.46
	30@	33@	ICMA 95444 x J 2454	52.19	9.05	ICMA 95222 x J 2405	34.80	11.99
			JMSA 101 x J 2454	37.86	8.34	ICMA 95222 x J 2296	33.60	11.88
			ICMA 95444 x J 2372	33.91	10.54	ICMA 94555 x J 2372	30.84	11.63
			81A x J 108	32.28	7.31	JMSA 101 x J 2296	24.40	11.06

Contd.,…

Table 1 Contd,…

Harvest index	-20.02 to 61.72	-31.97 to 19.94	ICMA 94555 x J 2454	61.72	41.88	ICMA 95222 x J 2372	19.04	60.20
	24@	5@	81A x J 2296	41.47	31.67	ICMA 95444 x J 2296	9.93	55.60
			ICMA 95222 x J 2454	32.98	44.50	ICMA 95222 x J 2296	6.24	53.73
			JMSA 101 x J 2440	30.01	35.64	ICMA 94555 x J 998	6.03	53.63
			ICMA 94555 x J 108	29.51	43.69	ICMA 95222 x J 2405	1.76	51.46
Threshing index	-24.75 to 16.74	-27.46 to 4.08	JMSA 101 x J 2296	16.74	65.64	ICMA 95444 x J 2440	0.65	77.22
	19@	1@	81A x J 2296	14.27	57.28	---	---	---
			ICMA 94555 x J 108	13.30	70.73	---	---	---
			81A x J 108	12.70	63.64	---	---	---
			JMSA 101 x J 2454	9.79	67.57	---	---	---
Fodder yield per plant (g)	-20.21 to 74.35	-35.25 to 48.52	81A x J 2296	74.35	60.78	ICMA 95444 x J 2372	48.52	139.0
	31@	23@	ICMA 95222 x J 2340	71.95	79.78	JMSA 101 x J 2296	33.93	125.0
			ICMA 94555 x J 2340	56.93	78.22	JMSA 101 x J 2372	28.47	120.0
			81A x J 104	52.07	75.11	ICMA 95222 x J 2372	27.28	119.0
			JMSA 101 x 2454	51.30	68.00	ICMA 95444 x J 2440	26.57	119.0
Grain yield per plant (g)	-20.63 to 152.40	-48.28 to 61.26	ICMA 95444 x J 2340	152.40	50.89	ICMA 95222 x J 2372	61.26	88.33
	31@	12@	81A x J 2296	145.45	24.56	ICMA 94555 x J 998	38.74	76.00
			ICMA 95444 x J 108	134.20	54.00	ICMA 95444 x J 2296	38.13	75.67
			ICMA 94555 x J 108	126.41	53.78	ICMA 95444 x J 2372	30.63	71.56
			ICMA 94555 x J 2454	-	55.11	JMSA 101 x J 2372	22.11	66.89
Protein content (%)	-34.40 to 32.85	-19.04 to 45.70	81A x J 108	32.85	7.21	JMSA 101 x J 2290	49.66	12.54
	7@	34@	ICMA 95444 x J 108	27.39	8.39	ICMA 95222 x J 2440	45.70	12.21
			ICMA 95444 x J 2405	26.99	11.96	ICMA 95444 x J 2405	42.71	11.96
			ICMA 95444 x J 2296	26.40	8.94	81A x J 2290	36.31	11.42
			81A x J 2405	23.49	9.31	ICMA 94555 x J 2290	33.39	11.18

@ Number of crosses with significant and desirable heterosis.

Table 2 Comparative study of ten most heterobeltiotic (H_1) crosses along with standard heterosis (H_2) and *per se* performance for grain yield and its characters over environments in pearl millet

Crosses	Mean grain yield/ plant (g)	Ear head length (cm)		Ear head girth (cm)		Number of tillers per plant		Ear head weight (g)		1000-seed weight (g)	
		H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
ICMA 95222 x J 2372	88.33	-1.89	-7.05*	0.20	36.36**	-18.47**	21.25*	19.46**	65.16**	-3.49*	9.85**
ICMA 94555 x J 998	76.00	-2.66	-8.87*	-5.36*	5.01	-13.14	28.13**	26.05**	58.32**	-6.43**	11.33**
ICMA 95444 x J 2296	75.67	1.39	28.24**	2.82	8.00*	-22.03**	18.44*	14.32	45.41**	28.87**	6.00**
ICMA 95444 x J 2372	71.56	-4.02	21.66**	8.11*	28.32**	-25.80**	-2.50	-12.98**	33.75**	33.91**	18.52**
JMSA 101 x J 2372	66.89	-9.90**	3.24	0.98	18.53**	-14.84*	-10.63	10.16*	31.88**	-7.05**	-12.46**
ICMA 95444 x J 2440	66.00	-10.69**	-3.29	-5.72*	-2.47	21.80*	26.25**	-6.28	19.13**	19.80**	18.08**
ICMA 95222 x J 2296	65.84	8.73*	5.38	-3.65	21.89**	-14.39*	-5.62	-0.88	18.35**	15.87**	33.60**
ICMA 95222 x J 2405	60.11	-0.92	-8.14*	-7.67*	8.82**	-15.59*	16.56*	-1.43	15.71**	6.34**	34.80**
JMSA 101 x J 2296	59.89	-18.34**	-0.10	3.43	8.50*	-22.14**	7.50	8.43	27.99**	15.19**	24.40**
ICMA 95222 x J 998	59.78	1.46	-3.08	-6.02*	4.70	-19.42**	-7.50	42.89**	22.24**	12.59**	1.97

Table 2. Contd.,

Crosses	Harvest index (%)		Threshing index (%)		Fodder yield per plant (g)		Grain yield per plant (g)		Protein content (%)	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
ICMA 95222 x J 2372	11.05**	19.04**	7.75**	-3.38*	7.22*	27.28**	26.98**	61.26**	-34.30**	13.46**
ICMA 94555 x J 998	10.62*	6.03*	1.90	-11.20**	23.27**	10.79**	42.56**	38.74**	7.92**	-19.04**
ICMA 95444 x J 2296	-11.72**	9.93**	-8.57**	-4.89**	8.41	16.25**	29.41**	38.13**	26.40**	6.74*
ICMA 95444 x J 2372	-10.95**	-11.06**	-5.95**	-2.34	-20.21**	48.52**	-19.06**	30.63**	-35.71**	21.56**
JMSA 101 x J 2372	-16.19**	-9.16*	-13.51**	-7.32**	-7.32*	28.47**	6.42	22.11**	-15.85**	15.53**
ICMA 95444 x J 2440	-0.43	-5.45	4.60*	0.65	7.92*	26.57**	2.80	20.49**	7.61*	-2.53
ICMA 95222 x J 2296	5.05	6.24*	0.94	-8.84**	-0.18	11.15**	3.66	19.47**	-14.94**	17.04**
ICMA 95222 x J 2405	-17.35**	1.76	-10.54**	-3.11	2.54	8.07*	-12.44**	9.74*	-30.73**	19.94**
JMSA 101 x J 2296	19.94**	-24.30**	16.74**	-14.44**	11.58*	33.93**	30.82**	9.33*	-4.83	-11.62**
ICMA 95222 x J 998	8.04	-9.86**	-1.37	-10.53**	32.23**	11.51**	39.79**	9.13*	-16.36**	-3.67

*, ** Significant at 5 and 1 per cent levels of probability, respectively