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Heterosis for Grain Yield and Its Components in Pearl Millet (*Pennisetum glaucum* L.)

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ABSTRACT: Twelve pearl millet hybrids were evaluated along with two checks (RHRBH 9808 and AHB 1666) at three locations in a Randomized Block Design, with three replications for identification of superior hybrids based on standard heterosis. The magnitude of standard heterosis varied from cross to cross for all the characters studied. High standard heterosis was observed for number of effective tillers per plant, grain yield per plant, ear head girth and number of grains per cm^2; while moderate to low heterosis over standard checks was found for plant height (cm), 1000-grain weight (g), ear head length (cm), total number of tillers per plant, fodder yield per plant (g), days to maturity and days to 50% flowering. The highest positive standard heterosis for grain yield per plant was 70.81%. Heterosis for grain yield might have resulted from heterosis for its component traits, mainly, number effective tiller per plant, ear head girth and number of grains per cm^2. The crosses *viz.*, MS 99111 A × AIB 214, MS 88004 A × R 451-1, MS 94111 A × IC 1153, MS 88004 A × PPC 7 and MS 88004 A × AIB 214 were promising on the basis of mean performance and standard heterosis.

Key words: *Pennisetum glaucum,* grain yield, standard heterosis

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is India's fourth important cereal food crop after rice, wheat and maize. It is an annual tillering diploid (2n=14) species belonging to the family Poaceae and subfamily Panicoideae, and believed to be originated in Africa, where, the greatest diversity of morphological types exists. It is the most drought tolerant warm season cereal crop predominantly grown as a staple food grain and source of feed and fodder. The nutritive values of the pearl millet grains are fairly high with 69.4% carbohydrate, 12.1% protein, 4.3 to 5.0% fat, 2 to 7% mineral matter and 2.4% sugar (Nambiar *et al.*, 2011). It is also a rich source of vitamins - thiamine and riboflavin, and imparts substantial energy to body (Malleshi and Desikachar, 1985). It also produces large amount of good quality dry fodder for animals. Pearl millet is a highly cross-pollinated crop with protogynous flowering and wind borne pollination mechanism, which fulfils one of the essential biological requirements for hybrid development. Commercial exploitation of heterosis in pearl millet has been a success. The present investigation was carried out to identify superior hybrids on the basis of standard heterosis and mean values averaged over three environments.

Materials and Methods

The experimental material for the present investigation consisted of 12 experimental hybrids of pearl millet identified as promising in earlier studies at Department of Agricultural Botany, College of Agriculture, Latur, during *kharif* 2011 along with two checks *viz.,* RHRBH 9808 and AHB 1666. The details of hybrids studied in the present investigation are given in Table 1.

Checks: 02

1.	RHRBH 9808	MPKV, Rahuri
2.	AHB 1666	MKV, Parbhani

Table 1 : List of hybrids and checks tested

S. No.	Hybrids	
1	MS 88004 A	× R 451-1
2	MS 88004 A	× IC 301 R
3	MS 94555 A	× IC 301 R
4	MS 88004 A	× PPC 7
5	MS 88004 A	× AIB 214
6	MS 841 A	× IC 1179
7	MS 99111 A	× AIB 3354-2
8	MS 88004 A	× IC 1179
9	MS 94111 A	× IC 1153
10	MS 99111 A	× AIB 214
11	MS 88004 A	× IC 223-1
12	MS 94111 A	× IC 1179

The test entries were sown under rainfed condition at three locations *viz.,* Experimental Farm, Department of Agricultural Botany, College of Agriculture, Latur (E_1); Oilseed Research Sub-station, Ambajogai (E_2) and National Agricultural Research Project, Aurangabad (E_3) during *kharif* 2012 in a randomized block design with three replications. The plot size was 3.0 × 1.0 m^2. The rows were spaced at 50 cm apart with intra-row spacing of 15 cm. A fertilizer dose of 60 kg N + 30 kg P_2O_5 + 30 kg K_2O per ha was applied at the time of sowing. Recommended package of practices for pearl millet cultivation were followed. Data were recorded on randomly selected five competitive plants from each genotype per replication for the eleven characters. The standard heterosis was estimated for grain yield and yield components considering mean values averaged over three locations as per the procedure of Fonseca and Patterson (1968) separately over standard checks.

Results and Discussion

The analysis of variance (ANOVA) for yield and yield components in each environment revealed that the mean squares due to genotypes were highly significant for all characters indicating the existence of sufficient variability among the genotypes for all the traits in all environments (Table 2).

Early flowering is desirable for early maturity, and therefore negative heterosis is considered for days to 50% flowering. All the hybrids exhibited negative heterosis over both standard checks RHRBH 9808 and AHB 1666. Standard heterosis ranged from -0.21% (MS 88004 A × AIB 214) to -9.74% (MS 841 A × IC 1179) over standard check RHRBH 9808, and -2.12% (MS 88004 A × AIB 214) to -11.47% (MS 841 A × IC 1179) over AHB 1666 (Table 3). The hybrid MS 841 A × IC 1179 (-9.74%), MS 88004 A × R 451-1 (-8.44%) and MS 88004 A × IC 301 R (-8.44%), which manifested negative heterosis over best check RHRBH 9808 were categorized as early flowering hybrids. The negative heterosis for days to flowering in pearl millet was also observed by Yadav (2006).

For days to maturity, all the hybrids except MS 94111 A × IC 1153 and MS 94111 A × IC 1179 showed negative standard heterosis over the check, RHRBH 9808. The negative heterosis ranged from -1.14% (MS 94555 A × IC 301R) to - 5.69% (MS 88004 A × IC 301 R) over standard check RHRBH 9808 and -1.00% (MS 94111 A × IC 1179) to -7.33% (MS 88004 A × IC 301 R) over standard check AHB 1666 (Table 3). The hybrid MS 88004 A × IC 301 R showed highest and significant negative standard heterosis over the checks RHRBH 9808 and AHB 1666 and were categorized as early maturing hybrids. Similar results of heterosis for early maturity in pearl millet were observed by Vetriventhan *et al.* (2008).

For plant height, standard heterosis ranged from 6.39% (MS 94555 A × IC 301 R) to 38.47% (MS 99111 A × AIB 214) over the check, RHRBH 9808 and it ranged from -0.44% (MS 88004 A × PPC 7) to 24.35% (MS 99111 A × AIB 214) over the check, AHB 1666. All hybrids showed positive heterosis over the check RHRBH 9808. The hybrids MS 88004 A × IC 301 R, MS 94555 A × IC 301 R, MS 88004 A × PPC 7, MS 99111 A × AIB 3354-2, MS 88004 A × IC 1179 and MS 88004 A × IC 223-1 showed negative standard heterosis over the check AHB 1666. The hybrids MS 841 A × IC 1179 (17.15%), MS 99111 A × AIB 214 (24.35%) and MS 94111 A × IC 1153 (8.65%) showed positive and significant standard heterosis over standard check AHB 1666 (Table 3). These results were in conformation to the findings of Patil *et al.* (2008) and Patel *et al.* (2008a).

Positive heterosis for total number of tillers per plant is desirable. All the hybrids except MS 841 A × IC 1179 and MS 88004 A × IC 1179 expressed positive standard heterosis over both the checks RHRBH 9808 and AHB 1666. The hybrids MS 88004 A × IC 301 R, MS 94555 A × IC 301 R and MS 88004 A × AIB 214 exhibited highest and significant positive standard heterosis over the checks RHRBH 9808 and AHB 1666. Heterosis for

Table 2 : Analysis of variance (ANOVA) for yield and yield components over three environments in Bajra

Source of variation	DF	Days to 50 % flowering	Days to maturity	Plant height (cm)	Total number of tillers per plant	Number of effective tillers per plant	1000 grain weight (g)	Number of grains per cm²	Ear head girth (cm)	Ear head length (cm)	Fodder yield per plant (g)	Grain yield per plant (g)
Mean sum of squares												
Latur location (E_1)												
Genotype	13	10.34**	14.71**	636.48**	1.06**	1.41**	5.29**	9.05**	6.82**	17.11**	291.03**	313.66**
Error	26	1.054	0.772	1.877	0.276	0.146	0.179	0.467	0.024	1.861	1.173	5.279
Ambajogai location (E_2)												
Genotype	13	14.74**	17.52**	938.45**	1.02**	1.68**	9.12**	17.30**	4.66**	10.63**	284.90**	267.97**
Error	26	0.626	0.448	3.241	0.331	0.141	0.313	0.397	0.048	0.334	13.286	3.939
Aurangabad location (E_3)												
Genotype	13	8.85**	11.77**	730.46**	0.64**	0.50*	9.24**	16.29**	5.74**	25.65**	288.78**	247.85**
Error	26	1.763	0.871	5.163	0.122	0.208	0.356	0.507	0.122	0.935	0.621	4.215

* and ** Significant at 5% and 1% level, respectively

Table 3 : Three top ranking heterotic crosses along with mean performance and range of standard heterosis for various characters in Pearl millet

Characters	Range of standard heterosis (%)		Best crosses	Mean	Heterosis (%) over standard checks	
	RHRBH 9808	AHB 1666			RHRBH 9808	AHB 1666
Days to 50% flowering	-0.21 to -9.74	-2.12 to -11.47	MS 841 A × IC 1179	46.33	-9.74**	-11.47**
			MS 88004 A × R 451-1	47.00	-8.44**	-10.19**
			MS 88004 A × IC 301 R	47.00	-8.44**	-10.19**
Days to maturity	-1.14 to -5.69	-1.00 to -7.33	MS 88004 A × IC 301 R	82.88	-5.69**	-7.33**
			MS 88004 A × R 451-1	83.11	-5.43**	-7.08**
			MS 88004 A × PPC-7	85.22	-3.03**	-4.72**
Plant height (cm)	6.39 to 38.47	-0.44 to 24.35	MS 99111 A × AIB 214	204.48	38.47**	24.35**
			MS 841 A × IC 1179	192.64	30.45**	17.15**
			MS 94111 A × IC 1153	178.67	20.99**	8.65**
Total number of tillers per plant	-6.40 to 32.56	-6.40 to 32.56	MS 88004 A × IC 301 R	4.56	32.56**	32.56**
			MS 94555 A × IC 301 R	4.44	29.07**	29.07**
			MS 88004 A × AIB 214	4.44	29.07**	29.07**
Number of effective tillers per plant	0.00 to 73.05	7.05 to 85.26	MS 88004 A × R 451-1	2.89	73.05**	85.26**
			MS 88004 A × IC 301 R	2.89	73.05**	85.26**
			MS 94555 A × IC 301 R	2.78	66.47**	78.21**
1000-grain weight (g)	-4.01 to 36.69	-3.41 to 37.54	MS 88004 A × R 451-1	15.35	36.69**	37.54**
			MS 99111 A × AIB 214	14.97	33.30**	34.14**
			MS 88004 A × AIB 214	14.56	29.65**	30.47**
Number of grains per cm^2	3.73 to 42.20	6.07 to 45.40	MS 99111 A × AIB 214	21.33	42.20**	45.40**
			MS 94111 A × IC 1153	19.67	31.13**	34.08**
			MS 88004 A × PPC-7	19.67	31.07**	34.01**
Ear head girth (cm)	1.25 to 48.43	1.77 to 49.18	MS 99111 A × AIB 214	11.83	48.43**	49.18**
			MS 88004 A × R 451-1	11.09	39.15**	39.85**
			MS 841 A × IC 1179	11.03	38.39**	39.09**
Ear head length (cm)	-1.48 to 33.33	0.50 to 19.71	MS 88004 A × AIB 214	21.68	33.33**	19.71**
			MS 841 A × IC 1179	21.08	29.64**	16.40**
			MS 99111 A × AIB 214	20.82	28.04**	14.96**
Fodder yield per plant (g)	3.81 to 29.95	0.08 to 25.27	MS 99111 A × AIB 214	139.33	29.95**	25.27**
			MS 88004 A × R 451-1	135.44	26.32**	21.78**
			MS 94111 A × IC 1153	132.33	23.42**	18.98**
Grain yield per plant (g)	6.81 to 70.81	5.87 to 69.31	MS 99111 A × AIB 214	63.73	70.81**	69.31**
			MS 88004 A × R 451-1	60.51	62.18**	60.76**
			MS 94111 A × IC 1153	60.46	62.05**	60.63**

* and ** Significant at 5% and 1% level, respectively

total number of tillers per plant was also reported by earlier workers Vetriventhan *et al.* (2008) and Patel *et al.* (2008a).

For number of effective tillers per plant, four hybrids *viz.,* MS 88004 A × R 451-1, MS 88004 A × IC 301 R, MS 94555 A × IC 301 R and MS 88004 A × PPC 7 showed significant and positive standard heterosis over the standard check RHRBH 9808, while the hybrids MS 88004 A × R 451-1, MS 88004 A × IC 301 R , MS 94555 A × IC 301 R, MS 88004 A × PPC 7, MS 88004 A × AIB 214, MS 99111 A × AIB 3354-2 and MS 94111 A × IC 1153 showed significant and positive standard heterosis over the check AHB 1666. Heterosis for effective tillers per plant was also reported by earlier workers (Aher and Ugale, 1995 and Patel *et al.,* 2008a).

For 1000-grain weight (g), standard heterosis ranged from -4.01% (MS 88004 A × IC 223-1) to 36.69% (MS 88004 A × R 451-1) and -3.41% (MS 88004 A × IC 223-1) to 37.54% (MS 88004 A × R 451-1) over checks RHRBH 9808 and AHB 1666, respectively (Table 3). All hybrids except MS 88004 A × IC 223-1 and MS 94111 A × IC 1179 showed significant and positive standard heterosis over the checks, RHRBH 9808 and AHB 1666. Heterotic response for 1000-grain weight (g) has also been reported by Patil *et al*. (2008).

The five hybrids *viz.,* MS 88004 A × R 451-1, MS 94555 A × IC 301 R, MS 88004 A × PPC 7, MS 94111 A × IC 1153 and MS 99111 A × AIB 214 exhibited significant and positive standard heterosis over the checks.

RHRBH 9808 and AHB 1666, while the hybrids MS 88004 A × IC 301R, MS 88004 A × AIB 214, MS 841 A × IC 1179, MS 99111 A × AIB 3354-2, MS 88004 A × IC 1179, MS 88004 A × IC 223-1 and MS 94111 A × IC 1179 showed positive but non-significant standard heterosis over the checks RHRBH 9808 and AHB 1666 for number of grains per cm^2. These results are in accordance with report of Chavan and Nerkar (1994), and Aher and Ugale (1995).

For ear head girth (cm), standard heterosis ranged from 1.25% and 1.77% (MS 94111 A × IC 1179) to 48.43% and 49.18% (MS 99111 A × AIB 214) over the checks RHRBH 9808 and AHB 1666, respectively (Table 3). The hybrid MS 99111 A × AIB 214 showed highest significant and positive standard heterosis followed by MS 88004 A × R-451-1, MS 841 A × IC 1179, MS 88004 A × IC 301 R, MS 88004 A × AIB 214 and MS 88004 A × PPC 7 over the checks, RHRBH 9808 and AHB 1666. All hybrids except MS 99111 A × AIB 3354-2, MS 88004 A × IC 1179, MS 88004 A × IC 223-1 and MS 94111 A × IC 1179 recorded positive and significant standard heterosis over both the checks. Heterosis for ear head girth was also reported by Chavan and Nerkar (1994) and Patel *et al. (*2008 b).

The standard heterosis for ear head length ranged from -1.48% (MS 94111 A × IC 1153) to 33.33% (MS 88004 A × AIB 214) over the check RHRBH 9808 and from 0.50% (MS 94555 A × IC 301R) to 19.71% (MS 88004 A × AIB 214) over check AHB 1666 (Table 3). The hybrid MS 94111 A × IC 1153 exhibited highest and significant negative standard heterosis over the check AHB 1666 and the hybrid MS 88004 A × AIB 214 showed highest and significant positive standard heterosis over the checks RHRBH 9808 and AHB 1666. Heterosis for ear head length (cm) was also reported by Yadav (2006) and Vetriventhan *et al.* (2008).

For fodder yield per plant (g), standard heterosis over the checks RHRBH 9808 and AHB 1666 ranged from 3.81% and 0.08% (MS 88004 A × IC 1179) to 29.95% and 25.27% (MS 99111 A × AIB 214), respectively. All the hybrids showed significant and positive standard heterosis over the check RHRBH 9808 and AHB 1666 except hybrid MS 88004 A × IC 1179 which showed only positive standard heterosis over check AHB 1666. The heterosis over standard check was observed highest in cross MS 99111 A × AIB 214 (25.27%) followed by MS 88004 A × R 451-1 (21.78%) and MS 94111 A × IC 1153 (18.98%) (Table 3). Heterosis for fodder yield per plant was also reported by Kulkarni *et al.* (1993) and Patel *et al*. (2008 a).

For grain yield per plant, standard heterosis ranged from 6.81% and 5.87% (MS 88004 A × IC 1179) to 70.81% and 69.31% (MS 99111 A × AIB 214) over the checks RHRBH 9808 and AHB 1666, respectively (Table 3). All the hybrids except MS 88004 A × IC 1179 and MS 88004 A × IC 223-1 expressed significant and positive standard heterosis over the checks RHRBH 9808 and AHB 1666. The highest heterosis was recorded in cross MS 99111 A × AIB 214 (69.31%) followed by MS 88004 A × R 451-1 (60.76%), MS 94111 A × IC 1153 (60.63%), MS 88004 A × PPC-7 (58.29%) and MS 88004 A × AIB 214 (52.82%) over the standard check AHB 1666. Heterosis for Grain yield per plant was also reported by Patil *et al.* (2008), Vetriventhan *et al.* (2008).

Therefore, the degree of Standard heterosis varied considerably for grain yield and its components. Yield is a 'super character', built up by a number of subcomponents. Yield is a character of economic importance, for which considerable magnitude of heterosis was registered in five crosses *viz.,* MS 99111 A × AIB 214, MS 88004 A × R 451-1, MS 94111 A × IC-1153, MS 88004 A × PPC-7 and MS 88004 A × AIB 214 which exhibited significant standard heterosis for grain yield per plant in the desirable direction. These crosses have immense practical value and could be exploited on commercial basis and may be tested on large area in multi-location testing trials.

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