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Ieterosis for Grain Yield and its Components in Pearl Millet*

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A total of 30 hybrids, direct and reciprocal, involving six inbred lines of the pearl millet were studied to analyse the expression of hybrid vigour for yield and its components. Heterosis was expressed for the characters studied and a high magnitude was noted in plant height and panicle length. The combination, MS. 7625 x MS. 7373 with its reciprocal, proved to be superior for all the characters except tillering.

An evaluation of six inbred lines of pearl millet in advanced generation of inbreeding for their genetic potentiality for heterosis in hybrid, combinations was carried out. (Tewari, 1970; Singh and Singh, 1972 and Phul *et al.*, 1973). The desirability of identifying choice parents out of a large number of inbreds maintained at the Millets Breeding Station, Coimbatore, necessitated the study.

MATERIAL AND METHODS

The origin and distinguishing features of the six inbreds studied are presented in Table I. A total of 30 hybrid combinations (direct and reciprocals) were studied in a randomised block design replicated four times. A spacing of 45 cm. between rows and 15 cm between plants was adopted. Data on plant height, number of productive tillers, peduncle length, panicle length, 1000 grain weight, primary panicle grain weight and grain yield per plant were recorded in five randomly chosen plants in each replication. The analysis of variance for the traits in these combinations was worked out. The hybrid vigour was estimated as superiority over the mid-parental value and that over the better parent.

TABLE I. Origin and distinguishing features of the inbreds

Inbreds	Origin	Plant height	Tillering habit	Days to 50% bloom
M.S. 7625	Africa	Tall	Poor	45
M.S. 7373	Africa	Tall	Poor	45
P.T. 1682	Africa	Medium Tall	Poor	35
P.T. 666/2	South India	Tall	Medium	40
J. 934	Western India	Short	Medium	35-40
J. 104	Western India	Medium Tall	High	32

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RESULTS AND DISCUSSION

The results of analysis of variance for the traits are presented in Table II. The variance due to the entries observed for the traits under study was significant. The mean values of the traits for the parents and the hybrids and general mean values for the parents and the hybrids are furnished in Table III. Heterosis estimated for seven traits as percentage of increase over the better parental value as well as over the mid-parental value is presented in Table IV.

For plant height most of the hybrids were superior to their mid-parental values showing a clear dominance bias towards tallness. Earlier workers (Lal and Singh 1968; Tewari 1970; Lal and Singh 1973 and Phul *et al.* 1973) have observed such a phenomenon. Seven combinations out of 30 have shown superiority over the better parental values. Heterosis ranged from 10.50 to 44.61 % as measured from their respective better parental values. In general, there was no relationship between the expression of the parents and thier corresponding hybrids. However, the combination 2 x 1, the hybrid between the tallest parents was the tallest of all hybrids. In respect of hybrid vigour, the parents 1 (MS 7625), 2 (MS 7373) and 6 (J.104) appeared to be promising.

The overall potentiality for the production of mean number of tillers by the hybrids (5.12) exceeded the better tillering parent 5. The hybrid (2 x 6) was significantly superior to its respective better parent. Some of the hybrids were superior to the mid-parental values indicating a dominance bias towards high tillering. Singh and Singh (1972) and Tewari (1972) have observed positive heterosis for number of tillers.

For the length of peduncle, seven out of/30 hybrids significantly exceeded the better parental values. Mahadevappa (1968) has attributed such positive heterosis to both epistasis and overdominance. There seems to be a general dominance bias for longer peduncle as seen in 17 combinations which have significantly exceeded the mid-parental values, except in the combination 1 x 6.

The mean for the panicle length of the hybrids was 26.72% more than that of the parents. The combination 2 x 1 produced the longest panicle (25.25 cm) followed by its reciprocal (24.85cm). As many as 17 combinations exceeded the mid-parental values. The range of increase over the midparents was 4.56 to 61.00% while that over the better parents ranged from 3.14 to 53.82%. The hybrids exceeded the mid-parental values indicating a general dominance bias towards longer panicles. The parents 1, 2 and 5 were involved in the most heterotic hybrids.

The general mean for 1000 grain weight of the hybrids was 9.32% more than that of the parents. In the estimation of hybrid vigour for 1000 grain weight, most of heterotic combinations involved were with the parent 3. Nine combinations have exceeded the respective better parent values in 1000 grain weight with increases ranging from 13.73 to 116.05% over the respective better parent values. The combinations 1 x 3 and 2 x 3 appeared to be promising in this respect.

The mean grain weight from the primary panicle for the hybrids was 38.07% higher than that of the parents. Seven combinations exhibited heterosis exceeding the better parental values with increases ranging from 59.64 to 143.05%. The maximum weight was recorded by the combination 1 x 2 with an increase of 70.22% followed by its reciprocal with an increase of 65.17% over the mean value for the hybrids.

Among the parents, the parent 2 recorded the maximum grain yield followed by the parent 1 with increased yields of 73.63 and 40.69% respectively over the mean values for the parents. Their hybrids 1 x 2 and 2 x 1 have recorded increased yields of 38.23 and 67.75% which is the maximum for the hybrids. The combination 2 x 1 was followed by those of 1 x 6 and 6 x 1 with the increased yields, although the parent 6 was comparatively a poor yielder. The mean grain yield of the combinations exceeded that of the parents by 35.64%. A total of eleven combinations have out-yielded the average performance of the hybrids. Out of fhe five parents involved in these combinations, the parents 1 and 2 had shown the maximum heterotic effects. Each of the parents, 4, 5 and 6 with either 1 or 2 have given more yield and as such, the former have potentialities which could be exploited in recombination breeding to improve further the parents 1 and 2. The parents 5 and 6 appear to offer potentialities for the development of high yielding dwarf varieties by adopting a recurrent selection programme with their combinations to the parents 1 and 2.

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TABLE II. Analysis of veriance for seven characters in a set of crosses in pearl millet

Source	D. F.	Plant height (cm)	No. of tillers	Peduncle length (cm)	Panicle length (cm)	1000 grain weight (g)	Grain weight from the primary panicle (g)	Grain yield per plant (g)
Blocks	3	46.56	1.26	10.36	1.12	0.82	11.93	80.34
Entries	35	1069.27**	5.94**	38.19**	36.65**	6.17**	53 04**	607.30**
Between hybrids and parents	1	10661.58**	22.93*	334.57**	459.97**	12.62**	158.30**	3471.61**
Within hybrids	29	227.67**	4.68*	22.61**	18.62**	6.56**	38.00**	416.91**
Within parents	5	4032.06**	4.08*	55.32**	42.58**	2.58**	119.27**	1139.30**
E. S. S.	105	77.65	2.36	6.06	2.57	0.95	6,26	65 96
S. E.		6,23	1,08	1.74	1.13	0.668	1.77	5.74
C. D.		11.77	2.04	3.29	2,14	1.03	3.34	10.48

** Significant at 1% level
* Significant at 5% level

TABLE III Mean values of parents and first generation hybrids for seven characters in a set of crosses

Parents and hybrids	Plant height (cm)	No. of tillers	Peduncle length (cm)	Panicle length (cm)	1000 Grain weight (g)	Grain wt. from the primary panicle	Yield per plant (g)
1.	2.	3.	4.	5.	6.	7.	8.
MS.7625(1)	148.15	2.67	25.91	22.30	9.04	16.97	40.07
MS.7373(2)	153.82	3.90	28.82	17.75	9.98	11.82	49.45
PT.1682(3)	121.27	3.10	25 80	14.30	7.83	5 95	12.05
PT.866/2(4)	142.42	4.25	24.40	18.20	9.36	6.12	29.67
J 934(5)	72·17	4.75	18.37	15.70	8.40	2.75	8.62
J.104(6)	100.77	4.65	21.27	13.70	8.20	3.67	13.05
1 x 2	155.20	2.87	28.42	24.85	10 26	18.52	53.40
1 x 3	156.30	3.50	27.40	23.75	10.99	8.70	30.85
1 x 4	155 40	4 05	27.42	22.05	8.03	16.25	52.42
1 x 5	150.00	5.42	29.05	24.07	7.92	8.70	28.40
1 x 6	143.00	4.85	21.85	18.82	8.45	14 80	51.32
2 x 1	161.30	3.57	31.50	25.25	10.32	17.97	64.80
2 x 3	146.20	4.67	27.65	21.40	11.35	7.47	36.72
2 x 4	145.05	3.77	28.77	20.40	11.05	13.77	46.42
2 x 5	151.02	6.10	28.42	21.62	7.96	13,25	41.12
2 x 6	148 88	5.92	28 95	20,00	8.96	11.30	42.30
3 x 1	147.85	3.15	29.70	23.00	11.96	8.67	25.77
3 x 2	146.87	4.10	31.27	23.52	12.27	8.92	28.17
3 x 4	143.50	4.80	31.85	24.30	10.50	13 25	34.25
3 x 5	145.00	6.25	32 32	24.15	10 52	7.22	25.97
3 x 6	141.17	6.92	30.27	18.42	10.56	8.37	34.15
4 x 1	132 60	3.30	27.70	23 00	8.05	11.80	40.70
4 x 2	150.60	6.80	26.82	22,75	10 48	8·12	31.22
4 x 3	158.50	5.47	24.32	22.67	10.54	10.12	33.55
4 x 5	147.75	5 67	24.35	21.05	9.16	10.75	34.77
4 x 6	146.60	6.82	27.65	17.00	9.10	6,77	29.00
5 x 1	147.70	5.40	27.95	23.05	7.62	10.10	42.70
5 x 2	142.02	5.32	28.95	22.95	8.08	13.30	49.75
5 x 3	147.12	6.10	26.80	21.15	10.14	8.00	32.17
5 x 4	149.62	5.85	25.90	23.17	10 24	9.77	37.17
5 x 6	145.72	6 52	28.45	20.60	8.87	8.27	38.45
6 x 1	138.17	4.17	25.40	21.15	8.06	14.00	55 97
6 x 2	143 82	6 22	24.60	21.05	9.36	10.87	37.20
6 x 3	138.47	4.50	31.50	18.75	9.67	9.57	28.07
6 x 4	140.90	6.10	26.25	17.57	9.44	9.12	36.10
6 x 5	126.30	5 50	28.70	20.50	10.08	8.92	30.92
Mean of parents	123.10	4·05	24.09	16 99.	8.80	7.88	28.48
Mean of hybrids	146.43	5.12	28.00	21.73	30.62	10.88	38.68
S. E.	6.23	1.08	1.74	1,13	0·68	1.77	5,74
C. D.	11.77	2.04	3.29	2.14	1.03	3.34	10 48

TABLE IV Expression of Heterosis in F_1 over better parent (BP) & Mid parent (MP) in Percentage of increase

Crosses	Plant height in cm		No. of tillers		Peduncle length in cm.		Panicle length in cm.		1000 grain wt. in g.		Grain wt. from the primary panicle in g.		Grain yield per plant in g.	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
1×2	2.78	0.90	−12.77	−26.41	3.84	−1.39	24.06**	11.44*	7.89	2.81	28.61*	9.13	19.30	7.99**
1×3	16.02**	5.50	21.11	12.90	5.96	5.75	29.78**	6.50	30.21**	21.57*	−24.08	−48.73**	18.38	−23.01
1×4	6.96	4.89	2.78	−22.86	8.98	5.82	8.89	−1.12	−12.72	−14.21	−40.69	−4.24	50.33**	30.81*
1×5	36.17**	1.25	46.09	13.68	31.21**	12.12	26.68**	7.94	−9.17	−12.39	−11.76	−48.73**	16.63	−29.12*
1×6	14.90	−3.48	32.51	4.30	−7.38	−15.67*	4.56	−13.61**	−1.97	−6.53	43.41*	−12.79	115.81	43.05**
2×1	6.83	4.86	8.51	−8.46	15.09*	9.30	26.06**	13.23*	8.82	3.41	24.79	5.89	44.77**	31.04*
2×3	6.59	−4.69	33.43	19.74	1.25	−4.06	33.50	20.56	27.38**	13.73*	15.97	36.80*	19.41	−25.74*
2×4	−2.07	−5.70	−17.69	−28.19	8.12	−0.17	13.46	−17.58	14.27	10.72	53.99*	16.54	17.34	−6.13
2×5	33.65**	−1.82	14.88	28.42	20.42*	−1.39	29.23**	21.86**	−14.04	−20.24*	81.76**	−4.40	41.60*	−16.85
2×6	16.95**	−3.21	38.32	27.31	15.57*	0.45	27.15*	12.68	−4.40	−12.93	45.81*	−26.65	35.36	−14.46
3×1	9.75*	0.20	9.00	1.61	14.85*	14.63*	25.68**	3.14	31.00**	22.35	−24.35	−48.91**	−1.12	−35.69*
3×2	6.78	−4.52	17.14	5.13	14.50	8.50	46.72**	32.51**	37.71**	22.95**	0.34	−21.54	−8.39	−43.03**
3×4	14.83	−8.57	26.89**	23.45**	49.54**	32.52**	22.09*	12.18	119.37**	116.05**	64.19*	116.50**	23.35	−48.91
3×5	49.92**	24.53**	59.03*	31.58	49.31	25.27	61.00**	53.82	29.56**	25.24**	65.98	21.35	151.16*	115.93*
3×6	27.16**	22.77**	78.35*	48.82*	28.59**	17.33*	31.57**	28.81**	31.67**	28.78**	74.01*	40.67	172.11**	161.69**
4×1	−8.73*	10.50*	−16.67	−37.14	10.10*	6.91	13.58*	3.14	−12.50	−14.00	2.17	−30.47*	16.72	1.57
4×2	0.79	−6.94	26.53**	25.00**	8.38	5.01	−9.48	−31.30	−21.08	−36.87*	12.69*	60.83	3.88	−36.87*
4×3	20.21**	11.29*	30.86	4.19	3.11	−5.74	39.51**	24.56**	22.56*	12.61	67.55	65.36*	60.83*	13.08
4×5	37.70**	3.74	13.40	8.00	−13.84	−0.21	24.56**	−15.66**	3.15	−2.14	142.12**	75.65*	81.57*	17.19
4×6	20.56**	2.94	37.78	29.91	21.06*	13.32	6.58	−6.53	3.65	−2.78	38.16	10.62	35.77	−2.26
5×1	34.08**	−0.30	45.55	13.68	26.24**	7.85	21.32**	3.36	−12.62	−15.71*	24.49	40.48**	75.36**	6.56
5×2	25.68**	−7.67	22.86	12.00	22.67	0.45	37.18**	29.30**	−12.08	−19.04*	82.44**	12.52	71.32**	0.61
5×3	52.11**	21.32**	55.22*	28.42	21.32*	12.21	41.00**	34.71**	24.88*	20.71*	83.91*	34.45	211.12**	166.97**
5×4	39.44**	5.06	17.00	11.43	21.09*	6.15	37.26**	27.31**	15.32	9.40	120.03**	59.64*	94.10**	25.28
5×6	68.52**	44.61**	38.72	37.26	43.54**	33.76**	40.14**	31.21**	6.87	5.60	157.63*	125.34*	254.70**	194.64**
6×1	11.02*	−6.74	13.93	−10.32	7.67	−1.96	17.50*	−5.16	−6.50	−10.84	35.66	−17.50	110.73**	39.68*
6×2	12.98*	−6.54	45.33	33.76	−1.80	−14.64*	32.82**	18.59*	2.97	−6.21	40.26	−8.04	19.04	−24.77*
6×3	24.73**	−14.83*	15.98	−3.26	33.82**	22.09**	33.93**	31.12**	20.57*	17.93*	93.96*	60.84*	123.67*	115.70*
6×4	15.87**	−1.07	23.23	15.24	14.93	7.58	10.16	−3.46	7.52	0.86	86.12*	49.02	69.01*	21.67
6×5	46.06**	25.34**	17.02	15.79	44.80**	34.93**	39.46**	30.57**	21.45*	20.00	177.88**	143.05*	185.24**	136.93*

** Significant at 1% level * Significant at 5% level