ScienceAsia 28 (2002) : **345-350**

Heterosis for Seed Yield and Yield Components in Mungbean (*Vigna radiata* (L) Wilczek)

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Received 7 Dec 2001
Accepted 19 Apr 2002

ABSTRACT Heterosis over mid, better and top parent values for yield and yield components were determined in a half diallel cross involving six diverse mungbean genotypes. The extent of heterosis varied bi-directionally according to crosses and characters, with the maximum for seed yield per plant and harvest index in the hybrids VC 1560D x ML-5 and 6601 x VC 1560D, respectively. The hybrids with maximum heterotic effect were 6601 x ML-5 for pods per plant, VC 3902A x ML-5 for seeds per pod, 6601 x ML-5 for branches per plant and pod clusters per plant, 6601 x VC 1560D for pods per cluster, and VC 3902A x ML-5 for biological yield. The hybrids involving ML-5, VC 1560D and VC 3902A as one of the parents gave superior yield and yield components than those others. The hybrids VC 1560D x ML-5 and 6601 x VC 1560D which produced high heterotic effects for seed yield could be a good source for developing high yielding mungbean varieties.

KEYWORDS: heterosis, mungbean, *Vigna radiata.*

INTRODUCTION

The magnitude of heterosis provides a basis for determining genetic diversity and serves as a guide to the choice of desirable parents.[1] In grain legumes, the heterosis is generally due to dominance gene effects but also sometimes due to epistatic interactions.[2] In self pollinated crops, it is possible to exploit such genetic manifestation only with a potentially workable sterility mechanism, if available. A substantial component of epistatic interaction for agronomic and growth characters has been found in urdbean (black gram: *Vigna mungo*) belonging to the fixable epistasis, viz, additive x additive.[3] The information regarding epistatic interaction is useful in planning a breeding program for development of pure lines with enhanced yield potential.

The purpose of the present study was to determine the extent of heterosis in cross combinations of six mungbean genotypes diverse in seed yield and yield attributes.

MATERIALS AND METHODS

Three local (NM 92, 6601 and NM 89) and three exotic (VC 1560D, VC 3902A and ML-5) mungbean genotypes were chosen as materials in this study. They exhibited wide range of genetic variation in 10 major agronomic characters as indicated in Table 1. The lines were crossed in all possible combinations, excluding reciprocals, during wet season (July – October) 1997. The parents and F_1s were sown in spring/summer season (March – May) 1998 in a field in a randomized complete block design with three replications. The plot size for each entry was 0.3 m^2 (1 row of 1m long). At pod maturity, ten competitive plants were randomly chosen to record data for seed yield per plant, pods per plant, number of seeds per pod, 1000 seed weight, branches per plant, pod clusters per plant, pods per cluster, pod length, biological yield (fresh weight above ground portion) per plant, and harvest index (seed yield/ biological yield).

The data were subjected to analysis of variance following Steel and Torrie (1980).[4] The Bartlett's χ^2- test for homogeneity of variances among 21 treatments (6 parents & 15 F_1's) was performed on each variable. Any variable showing heterogeneous treatment mean squares would require transformation of its observations. Heterosis and heterobeltiosis were calculated as percent increase or decrease over mid and better parent values, respectively. The increase or decrease over top parent of the experiment was also calculated.

RESULTS AND DISCUSSION

The mean values of parental lines and hybrids for seed yield and yield components are presented in Table 1. The results from Bartlett's χ^2- test (not shown) revealed that the mungbean cultivars and F_1's were homogeneous in all variables observed in this study and thus the data were analyzed as such without transformation. It is observed that the parents differed significantly among themselves with respect to all the traits measured. The results regarding heterosis are presented in Table 2. For seed yield per plant, 11 hybrids produced positive heterosis over mid parents, 4 over better parents and only 1 over top parent (VC 3902A). The hybrid VC 1560D x ML-5 produced the highest average heterosis (37.25%). The average heterosis was 9.37, -3.16 and -16.24 over mid, better and top parents, respectively. High heterosis for seed yield was also observed in mungbean in other studies.[5, 6]

For pods per plant, 10 hybrids produced positive heterosis over mid parent, 6 over better parent and 2 over top parent values. Maximum average heterotic effect (20.78%) was exhibited by the hybrid 6601 x ML-5, followed by VC 3902A x ML-5 with an average value of 16.48%. The average heterosis was 9.16, -0.41 and -19.95 over mid, better and top parents, respectively. High heterotic effects observed here are similar to the earlier findings in which high heterotic effects for pods per plant were observed in chickpea and urdbean, respectively.[7, 8]

For seeds per pod, twelve crosses produced positive heterosis over mid parents, 6 over better parents and 4 over top parent. The hybrid VC 3902A x ML-5 produced the highest average heterotic effect (7.71%). The extent of heterosis for this character was low and similar to what reported earlier in mungbean.[5]

For 1000-seed weight, 6 hybrids produced positive heterosis over mid parent, however, all the

Table 1. Means and mean squares of treatments (genotype/hybrid) for seed yield and yield components in a 6 parent half diallel cross of mungbean.

Genotype/hybrid	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
NM 92	10.9	21.2	8.7	54.5	1.0	7.4	2.9^{TP}	7.5	37.1	29.4^{TP}
6601	10.8	26.5	11.0	36.5	1.7	9.3	2.8	6.8	55.7	19.5
NM 89	15.8	27.5	11.3	43.1	1.7	11.2	2.4	7.5	69.0	22.8
VC 1560D	13.1	20.6	10.8	60.9	1.7	9.5	2.2	8.5	53.3	24.5
VC 3902A	17.6^{TP}	24.1	10.3	73.5^{TP}	2.6^{TP}	9.7	2.5	9.1^{TP}	71.7^{TP}	25.8
ML-5	13.9	35.1^{TP}	11.3^{TP}	32.3	2.5	12.9^{TP}	2.7	6.4	57.0	24.5
NM 92 ¥ 6601	11.4	22.2	10.9	43.3	1.0	8.8	2.5	7.3	49.0	23.2
NM 92 ¥ NM 89	13.2	24.6	10.7	48.3	1.2	9.2	2.7	7.6	53.0	24.8
NM 92 ¥ VC 1560D	12.4	20.4	10.4	60.2	1.5	7.9	2.6	8.2	49.0	25.2
NM 92 ¥ VC 3902A	15.8	22.7	10.5	61.2	1.4	9.3	2.4	8.3	56.3	28.0
NM 92 ¥ ML-5	12.9	26.9	11.0	42.0	1.2	10.1	2.7	7.2	51.0	25.1
6601 ¥ NM 89	14.4	30.5	10.7	41.7	1.7	10.5	2.9	7.1	66.7	21.6
6601 ¥ VC 1560D	16.8	31.9	11.2	46.5	1.7	10.7	3.0	7.7	50.7	33.4
6601 ¥ VC 3902A	17.3	30.5	11.5	49.0	2.5	12.1	2.5	7.9	77.7	22.3
6601 ¥ ML-5	15.8	40.7	11.7	33.6	2.8	14.6	2.8	6.6	61.7	25.5
NM 89 ¥ VC 1560D	13.0	20.8	11.5	51.7	1.3	8.3	2.5	8.4	57.7	22.5
NM 89 ¥ VC 3902A	13.3	24.0	10.8	55.4	1.7	10.0	2.4	8.2	54.7	24.3
NM 89 ¥ ML-5	15.8	31.3	11.2	39.7	1.9	12.6	2.5	7.3	62.3	25.3
VC 1560D ¥ VC 3902A	13.6	23.1	10.9	64.2	2.2	9.9	2.3	8.2	63.0	21.5
VC 1560D ¥ML-5	20.3	34.0	11.6	50.5	2.2	12.5	2.8	7.7	66.7	30.7
VC 3902A ¥ML-5	16.5	38.5	11.3	41.9	2.3	14.5	2.7	7.3	80.7	20.5
MS (Treatments)	**17.80****	**109.8****	**1.22****	**348.2****	**0.87****	**12.12****	**0.13***	**1.36****	**322.7****	**34.47****

^{TP} = Top parent $^{*, **}$ = Significant at 0.05 and 0.01 levels of probability, respectively

X_1 = Seed yield per plant (g) X_2 = Pods per plant X_3 = Seeds per pod X_4 = 1000 seed weight (g)
X_5 = Branches per plant X_6 = Pod clusters per plant X_7 = Pods per cluster X_8 = Pod length (cm)
X_9 = Biological yield per plant (g) X_{10} = Harvest Index (%)

Table 2. Heterosis over mid, better and top parental values for seed yield and yield components in a 6 parent half diallel cross of mungbean.

Cross combination	Seed yield per plant (g)				Pods per plant			
	Heterosis (%) over			Average heterosis (%)	Heterosis (%) over			Average heterosis (%)
	MP	BP	TP		MP	BP	TP	
NM 92 X 6601	5.06	4.59	-35.22	**-8.52**	6.91	-16.23	-36.75	**-15.36**
NM 92 X NM 89	-1.12	-35.44	-25.0	**-20.52**	1.02	-10.55	-29.91	**-13.15**
NM 92 X VC 1560D	3.33	-5.34	-29.55	**-10.52**	-2.39	-3.77	-41.88	**-16.10**
NM 92 X VC 3902A	10.87	-10.23	-10.23	**-3.20**	0.22	-5.81	-35.33	**-13.64**
NM 92 X ML-5	4.03	-7.19	-26.70	**-9.95**	-4.44	13.36	-23.36	**-48.13**
6601 X NM 89	8.27	-8.86	-18.18	**-6.26**	12.96	10.91	-13.11	**3.59**
6601 X VC 1560D	40.58	28.24	-4.55	**21.42**	35.45	20.38	-9.12	**15.57**
6601 X VC 3902A	21.83	-1.70	-1.70	**6.14**	20.55	15.09	-13.11	**7.51**
6601 X ML-5	27.93	13.67	-10.23	**10.46**	32.14	15.95	14.25	**20.78**
NM 89 X VC 1560D	-10.03	-17.72	-26.14	**-17.96**	-13.51	-24.36	-40.74	**-26.20**
NM 89 X VC 3902A	-20.35	-24.43	-24.43	**-23.07**	-6.97	-12.73	-31.62	**-17.11**
NM 89 X ML-5	6.39	0.00	-11.39	**-1.67**	0.00	-10.83	-10.83	**-7.22**
VC 1560D X VC 3902A	-11.4	-22.72	-29.41	**-21.18**	3.35	-4.15	-34.19	**-11.66**
VC 1560D X ML-5	50.37	46.04	15.34	**37.25**	22.08	-3.13	-3.24	**5.24**
VC 3902A X ML-5	4.76	-6.25	-6.25	**-2.58**	30.06	9.69	9.69	**16.48**
Average	**9.37**	**-3.16**	**-16.24**		**9.16**	**-0.41**	**-19.95**	

Cross combination	Seeds per pod				1000 seed weight (g)			
	Heterosis (%) over			Average heterosis (%)	Heterosis (%) over			Average heterosis (%)
	MP	BP	TP		MP	BP	TP	
NM 92 x 6601	10.65	-0.91	-3.54	**2.07**	-4.83	-20.55	-14.09	**-9.82**
NM 92 x NM 89	7.00	-5.31	-5.31	**-1.21**	1.02	-11.38	-52.17	**-20.84**
NM 92 x VC 1560D	6.66	-3.70	-7.96	**-1.67**	4.33	-1.15	-18.10	**-4.97**
NM 92 x VC 3902A	10.52	1.94	-7.08	**1.79**	-4.37	-16.73	-16.73	**-12.61**
NM 92 x ML-5	10.00	-2.65	-2.65	**1.57**	-3.22	-22.94	-42.86	**-23.01**
6601 x NM 89	-4.03	-5.31	-5.31	**-4.88**	4.77	-3.25	-76.26	**-24.91**
6601 x VC 1560D	2.75	1.82	-0.88	**1.23**	-4.51	-23.65	-36.73	**-21.63**
6601 x VC 3902A	7.98	4.55	1.77	**4.77**	-10.90	-33.33	-33.33	**-25.85**
6601 x ML-5	4.93	3.54	3.54	**4.00**	-2.32	-7.95	-54.29	**-21.52**
NM 89 x VC 1560D	14.42	-1.77	1.77	**4.81**	-0.57	-15.11	-29.66	**-15.11**
NM 89 x VC 3902A	0.00	-4.42	-4.42	**-2.95**	4.97	-24.63	-24.63	**-14.76**
NM 89 x ML-5	-0.88	-0.88	-0.88	**-0.88**	5.30	-7.89	-45.99	**-16.19**
VC 1560D x VC 3902A	3.31	0.93	-3.54	**0.23**	-4.46	-12.65	-12.65	**-9.92**
VC 1560D x ML-5	4.97	2.65	2.65	**3.42**	8.36	-17.08	-31.29	**-13.34**
VC 3902A x ML-5	23.14	0.00	0.00	**7.71**	-20.79	-42.99	-42.99	**-35.59**
Average	**6.74**	**-0.63**	**-2.12**		**-1.81**	**-17.42**	**-35.45**	

Table 2. (cont'd)

Cross combination	Branches per plant				Pod clusters per plant			
	Heterosis (%) over			Average heterosis (%)	Heterosis (%) over			Average heterosis (%)
	MP	BP	TP		MP	BP	TP	
NM 92 x 6601	-25.92	-41.18	-61.54	**-42.88**	5.38	-5.38	-46.59	**-15.53**
NM 92 x NM 89	-11.11	-29.41	-53.85	**-31.46**	-1.07	-17.86	-28.68	**-15.87**
NM 92 x VC 1560D	11.11	-11.76	-42.31	**-14.32**	-6.50	-16.84	-38.76	**-20.70**
NM 92 x VC 3902A	-22.22	-46.15	-46.15	**-38.17**	8.77	-4.12	-27.91	**-7.75**
NM 92 x ML-5	-31.42	-52.0	-53.85	**-45.76**	-0.47	-21.71	-21.71	**-14.63**
6601 x NM 89	0.00	0.00	-34.62	**-11.54**	2.43	-6.25	-18.60	**-7.47**
6601 x VC 1560D	0.00	0.00	-34.62	**-11.54**	13.82	12.63	-17.05	**3.13**
6601 x VC 3902A	16.27	-3.85	-3.85	**2.86**	27.36	24.74	-6.20	**15.3**
6601 x ML-5	30.23	12.0	7.69	**16.64**	25.86	13.18	13.18	**17.41**
NM 89 x VC 1560D	-23.52	-23.53	-50.00	**-32.35**	-19.80	-25.89	-35.66	**-27.12**
NM 89 x VC 3902A	-20.93	-34.62	-34.62	**-30.06**	-4.30	-10.71	-22.48	**-12.50**
NM 89 x ML-5	-9.5	-31.58	-26.92	**-22.67**	4.56	-2.33	-2.33	**-0.03**
VC 1560D x VC 3902A	2.32	-15.38	-15.38	**-9.48**	3.12	2.06	-23.26	**-6.03**
VC 1560D x ML-5	4.76	-12.0	-15.38	**-7.54**	11.60	-3.10	-3.10	**1.8**
VC 3902A x ML-5	-9.8	-11.54	-11.54	**-10.96**	28.31	12.40	12.40	**17.70**
Average	**-5.98**	**-20.07**	**-31.80**		**6.60**	**-3.28**	**-17.78**	

Cross combination	Pods per cluster				Pod length (cm)			
	Heterosis (%) over			Average heterosis (%)	Heterosis (%) over			Average heterosis (%)
	MP	BP	TP		MP	BP	TP	
NM 92 x 6601	-12.28	-13.79	-13.80	**-13.29**	-2.09	-2.67	-19.78	**-8.08**
NM 92 x NM 89	1.92	-6.90	-6.90	**-3.96**	1.33	1.32	-16.48	**-4.61**
NM 92 x VC 1560D	1.96	-10.34	-10.34	**-6.24**	2.50	-9.89	-9.89	**-5.76**
NM 92 x VC 3902A	-11.11	-17.24	-17.24	**-15.18**	0.00	-8.79	-8.79	**-5.86**
NM 92 x ML-5	-3.57	-6.90	-6.90	**-5.79**	3.59	-4.00	-20.88	**-7.10**
6601 x NM 89	11.53	3.57	0.00	**5.03**	-6.99	-5.33	-21.98	**-11.43**
6601 x VC 1560D	20.00	7.14	3.45	**10.20**	0.65	-9.41	-15.38	**-8.05**
6601 x VC 3902A	-5.66	-10.71	-13.79	**-10.05**	0.00	-13.19	-13.19	**-8.79**
6601 x ML-5	1.81	0.00	-3.45	**-0.55**	0.00	-2.94	-27.47	**-10.14**
NM 89 x VC 1560D	8.69	4.17	-13.79	**-0.31**	5.00	-1.18	-7.69	**-1.29**
NM 89 x VC 3902A	-2.04	-11.11	-17.24	**-10.13**	-1.20	-9.89	-9.89	**-6.99**
NM 89 x ML-5	0.00	-7.41	-13.79	**-7.07**	5.03	-2.67	-19.78	**-5.81**
VC 1560D x VC 3902A	0.00	-14.81	-20.69	**-11.83**	-6.81	-9.89	-9.89	**-8.86**
VC 1560D x ML-5	14.28	3.70	-3.45	**4.84**	3.35	-9.41	-15.38	**-7.15**
VC 3902A x ML-5	3.84	0.00	-6.90	**-10.20**	-5.80	-19.78	-19.78	**-15.12**
Average	**1.96**	**-5.38**	**-9.66**		**-0.01**	**-7.18**	**-15.75**	

Table 2. (cont'd)

Cross combination	Biological yield (g)				Harvest index (%)			
	Heterosis (%) over			Average heterosis (%)	Heterosis (%) over			Average heterosis (%)
	MP	BP	TP		MP	BP	TP	
NM 92 x 6601	5.60	-12.03	-31.66	**-12.70**	-5.11	-21.09	-21.09	**-15.76**
NM 92 x NM 89	0.09	-23.19	-26.08	**-16.39**	-4.98	-15.65	-15.65	**-12.09**
NM 92 x VC 1560D	8.40	-8.07	-31.66	**-10.44**	-6.49	-14.29	-14.29	**-11.69**
NM 92 x VC 3902A	3.49	-21.48	-20.92	**-12.97**	1.44	-4.76	-4.76	**-2.69**
NM 92 x ML-5	8.39	-10.53	-28.87	**-10.34**	-3.83	-14.63	-14.63	**-11.03**
6601 x NM 89	6.97	-3.33	-6.97	**-1.11**	2.12	-5.26	-26.53	**-9.89**
6601 x VC 1560D	-6.97	-8.98	-29.29	**-15.08**	51.81	36.33	13.61	**33.92**
6601 x VC 3902A	21.97	8.37	8.37	**12.90**	-1.54	-13.57	-24.15	**-13.09**
6601 x ML-5	9.49	8.25	-13.95	**1.26**	15.9	4.08	-13.27	**2.24**
NM 89 x VC 1560D	-5.64	-16.38	-19.53	**-13.85**	-4.86	-8.16	-23.47	**-12.16**
NM 89 x VC 3902A	-22.24	-23.71	-23.71	**-23.22**	0.00	-5.81	-17.35	**-7.72**
NM 89 x ML-5	-1.11	-9.71	-13.11	**-7.98**	6.97	3.27	-13.95	**-1.24**
VC 1560D x VC 3902A	0.80	-12.13	-12.13	**-7.82**	-14.51	-16.67	-26.87	**-19.35**
VC 1560D x ML-5	20.94	17.02	-6.97	**10.39**	25.30	25.31	4.42	**18.34**
VC 3902A x ML-5	23.48	12.55	12.55	**16.19**	-18.48	-20.54	-30.27	**-23.10**
Average	**4.19**	**-6.89**	**-16.26**		**2.92**	**-4.76**	**-15.22**	

MP = Mid parent BP = Better parent TP = Top parent

hybrids showed negative heterosis over better and top parents. The average heterotic effect of all hybrids was negative over mid, better and top parents which imposed restriction on improving 1000-seed weight through the genotypes included in this study. Therefore, more bold - seeded mungbean germplasm should be utilized in hybridization to increase their seed size. Similarly, a negative heterosis for 1000-seed weight was reported.[5, 6]

The results for branches per plant revealed that 5 hybrids excelled over mid parents and 1 each over better and top parents. The hybrid 6601 x ML-5 produced the maximum average heterotic effect (16.64%). Average heterosis for branches per plant was negative over mid, better and top parents.

Ten crosses produced positive heterosis over mid parents, 5 over better parents and 2 over top parent for pod clusters per plants. The hybrid 6601 x ML-5 showed the maximum average heterotic effect (17.41%). The extent of average heterosis was lower for pod clusters per plant as compared to the other traits.

Data for pods per cluster revealed that 8 hybrid excelled over mid parents, 4 over better parents and 1 over top parent. The hybrid 6601 x VC 1560D produced highest values for mid, better and top parent heterosis.

For pod length, 7 hybrids produced positive heterosis over mid parents and only 1 over better parent. All the hybrids showed negative heterosis over top parent and negative average heterotic effect. The extent of heterosis for this character was very low. Similar results was reported earlier by Sekhar et al (1994).[6]

The results regarding biological yield showed that 11 hybrids excelled over mid parents, 4 over better parents and 2 over top parent. Four crosses gave positive average heterosis for biological yield. The combination VC 3902A x ML-5 produced the highest average heterotic value. The extent of heterotic effect for this character was moderate although Shinde and Deshmukh (1989)[8] reported high heterosis for biological yield in urdbean.

Six hybrids produced positive heterosis over mid parents, 4 over better parents and 2 over top parent for harvest index. Three hybrids gave a positive average heterosis. The hybrid 6601 x VC 1560D had the highest heterosis values over mid, better and top parents. The heterotic effects for harvest index was low. Similar results of low heterosis for harvest index were reported by Ghafoor *et al*. (1990).[5]

The present study indicates that the hybrids involving ML-5, VC 1560D and VC 3902A proved effective in all cross combinations. Low or negative heterosis found in 1000 seed weight, branches per plant, pod length and harvest index may restrict improvement of these traits in mungbean. Therefore, diversified mungbean germplasm is required to improve 1000 seed weight, branches per plant, pod length, and harvest index. The crosses VC 1560D x ML-5 and 6601 x VC 1560D produced high heterotic effects for seed yield per plant. Thus they should be exploited for developing high yielding mungbean varieties.

Acknowledgements

This research was supported by Nuclear Institute for Agriculture and Biology and University of Agriculture, Faisalabad, Pakistan and The Thailand Research Fund.

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