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Esimation of heterosis in mungbean [*Vigna radiata* (L.) Wilczek]

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Abstract
The present investigation on "Estimation of Heterosis in Mungbean [*Vigna radiata* (L.) Wilczek]" was conducted during *Kharif* 2016-17 using four line and six tester making 24 crosses and evaluation this material using Randomized Block Design. The cross combination BPMR 145 x BM 2011-1 recorded the highest standard heterosis over the check BM 2003-2. The cross BM 4 x TBM 9 exhibited the highest significant mid parent heterosis and heterobeltosis for the number of pods per plant. The cross AKM 8802×BM 2011-1 was found highest standard heterosis for pod length, number of pod per plant and grain yield per plant. The study further can used to breed a genotype with high yielding potential and to collect the information on the genetic mechanism controlling various traits in the material.

Keywords: Standard heterosis, mid-parent heterosis, heterobeltosis and mungbean

Introduction
Pulses, best known as "poor man's meat", constitute the major source of dietary protein of the large section of vegetarian population of the world. On an average, pulses contain 20 to 30 per cent protein, which is almost 2.5 to 3.0 times the value normally found in cereals. Pulses also play an important role by fixing biological nitrogen and thus enhance the soil fertility. It improves the nutrient status of soil through atmospheric nitrogen fixation and adds humus to the soil. Green gram belongs to family leguminaceae and sub family Papilionaceae. It's chromosome number is 2n=22. Over 2000 different types have been reported. Green gram is rapidly growing, erect or sub-erect, annual, usually 30 to 90 cm in height and showing considerable variation in form and adaptation. Study of heterosis in mungbean is important for the plant breeder to find out superior crosses. In addition to this, the magnitude of heterosis provides a basis for determining genetic diversity and also, serves as a guide to the choice of desirable parents (Swindell and Poehlman, 1976) [10]. To address the above issues in green gram, the detail study was planned to obtained information on yield and yield attributing traits by involving diverse parental lines. Six selected genotypes were crossed with four female genotypes viz., BM 4, BPMR145, AKM 8802 and VAIBHAV which exhibited several contrasting characters.

Material and Methods
The present investigation entitled "Esimation of Heterosis for Yield and Yield Contributing Charactes in Mungbean [*Vigna radiata* (L.) Wilczek]" was carried out during *Kharif* 2016 at experimental field of Agricultural Research Station, Badnapur. General methods of line x tester analysis (Kempthome, 1957) [4] were followed in the present investigation by using 4 lines, 6 testers and their 24 F1's along with check BM2003-2. During *kharif* 2016, the hybrids and parental lines with one check were planted in randomised block design with two replications to study the combining ability, gene action and heterosis. Sowing was done on 24th June 2016. Experimental plot for each entry consisted of one row of 4.0 meter length spaced 45 cm apart with 10 cm plant to plant distance. The differences in the magnitude of heterosis were tested following the procedure given by Panse and Sukhatme (1976).

Result and Discussion
Heterosis was worked out in the form of deviations of F1's from mid and better parents and standard heterosis over the standard check.

The general and specific combining ability variances and GCA effects of lines and testers, and SCA effects of twenty four F1s and gene action were estimated for all the 10 characters by adapting a line x tester analysis of Kempthorne (1957) [4]. The *per se* performance alone may not be useful to predict the best cross combination. The studies on extent of heterosis are useful to support the results on the basis of *per se* performance particularly undertaken in comparison with the checks for their practical utility at field level. The heterosis plays an important role for increasing the productivity of crop without much increase in the cost of production. Therefore, it is of great importance to plant breeders. The aim of the present study was to identify superior cross combinations which will exhibit good amount of heterosis for grain yield per plant and its component traits.

For days to maturity the highest negative mid parent heterosis was observed in BPMR 145 x BM 2011-1 (-12.00%). The highest significant negative better parent was observed by cross combination BPMR 145 x BPMR 135 (-17.73%). These results are in consonance with the finding of Halkunde (1992) [1], Patil (1992) [6], Kelkar (1993) [3] and Tyagi *et al.*, (2006).

For plant height the highest positive significant mid parent and better parent heterosis was recorded in cross BM 4 x BMG 108(25.13%) and (21.20%). respectively. These results were in agreement with the finding of Halkunde (1992) [1], Patil (1992) [6], Kelkar (1993) [3] and Jahagirdar (2001) [2].

For number of clusters per plant the highest positive significant mid parent heterosis recorded in BPMR 145 x BPMR 135 (85.03%), the highest better parent heterosis observed in BPMR 145 x BPMR 135 (54.55%) and highest significant positive standard heterosis was recorded in cross combination BPMR 145 x BPMR 135 (119.35%) Similar results have also been reported by Halkunde (1992) [1], Patil (1992) [6], Kelkar (1993) [3] and Jahagirdar (2001) [2].

For number of pods per cluster the highest mid parent recoreded in VAIBHAV xTBM 9 (25.71%) and better parent heterosis was recorded in cross combination BM 4 x TBM 11 (20.93%). The highest positively significant standard heterosis was recorded in BM 4 x TBM 11 (44.44%). These results were in agreement with the finding of Halkunde (1992) [1], Patil (1992) [6] and Sonawane (1995) [8].

For number pods per plant the highest positively significant mid parent and better parent heterosis was recorded in cross combination BM 4 x TBM 9 (123.50%) and (104.12%) respectively. The highest standard heterosis was a recorded in hybrid BPMR 145 x BM 2011-1 (175.93%). These results were in agreement with the finding of Kelkar (1993) [3], Jahagirdar (2001) [2] and Patel *et al.*, (2009) [7].

For pod length the highest significant better parent heterosis was recorded in cross VAIBHAV x BPMR 135 (29.45).This result was in agreement with the finding of Srivastava *et al.* (2013) [9].

For 100 seed weight the highest significant mid parent heterosis was recorded in AKM 8802 x BPMR 135 (40.63%%). The highest better parent heterosis was observed in AKM 8802 x BPMR 135(34.33%). While the highest standard heterosis was recorded in BPMR 145 x BPMR 75 (21.74%). Similar results have also been reported by Halkunde (1992) [1], Patil (1992) [6] and Kelkar (1993) [3]. For seed yield per plant, the highest mid parent and better parent and standard heterosis was recorded in BM 4 x BPMR 145 (155.41%), (149.85%) and (47.30%) respectively. Similar results have also been reported by Halkunde (1992) [1], Patil (1992) [6], Lakshmi *et al.*, (2003) [5], Patel *et al.*, (2009) [7] and Srivastava and singh (2013) [9]. The significant heterosis for yield and yield component has been observed in crosses highest standard heterosis for seed yield, number of pod per plant was recorded by F1 crosses BPMR 145 x BM 2011-1, BM 4 x TBM 11,AKM 8802 x BM 2011-1 and BPMR 145 x BM 2011-1 and BMPR 145 x BPMR 135 showed high percentage of heterosis for days to maturity, number of cluster per plant, number of pods per cluster, and test weight respectively.

Table 4.9: Per cent relative heterosis, heterobeltiosis and standard heterosis in mungbean (*Vigna radiate* (L.) Wilczek)

S. No	Crosses	Day to 50% flowering			Day to maturity		
		RH	HB	SH	RH	HB	SH
1	BM 4 X TBM 9	12.33**	5.13	20.59**	3.64	3.23	3.23
2	BM 4 X TBM 11	12.00**	2.44	23.53**	-0.80	-1.59	0.00
3	BM 4 X BM 2011-1	15.28**	9.21**	22.06**	-6.20*	-9.70**	-2.42
4	BM 4 X BMG 108	21.85**	10.84**	35.29**	4.42	4.00	4.84
5	BM 4 X BPMR 75	17.24**	10.39*	25.00**	-2.46	-4.03	-4.03
6	BM 4 X BPMR 135	10.81**	2.50	20.59**	2.04	0.81	0.81
7	BPMR 145×TBM 9	2.53	1.25	19.12**	-10.61**	-16.31**	-4.84
8	BPMR 145×TBM 11	1.23	0.00	20.59**	-5.62	-10.64**	1.61
9	BPMR 145×BM 2011-1	11.54**	8.75*	27.94**	-12.00**	-14.18**	-2.42
10	BPMR 145×BMG 108	4.29	2.41	25.00**	-1.50	-7.09*	5.65
11	BPMR 145×BPMR 75	5.73	3.75	22.06**	-7.28*	-14.18**	-2.42
12	BPMR 145×BPMR 135	6.25	6.25	25.00**	-11.45**	-17.73**	-6.45
13	VAIBHAV×TBM 9	9.33*	5.13	20.59**	-0.40	-1.59	0.00
14	VAIBHAV×TBM 11	9.09*	2.44	23.53**	0.79	0.79	2.42
15	VAIBHAV×BM 2011-1	13.51**	10.53*	23.53**	-5.38	-8.21*	-0.81
16	VAIBHAV×BMG 108	9.68**	2.41	25.00**	-2.79	-3.17	-1.61
17	VAIBHAV×BPMR 75	12.75**	9.09*	23.53**	0.00	-2.38	-0.81
18	VAIBHAV×BPMR 135	9.21*	3.75	22.06**	5.26	3.17	4.84
19	AKM 8802×TBM 9	5.48	-1.28	13.24**	-5.18	-7.03*	-4.03
20	AKM 8802×TBM 11	6.67	-2.44	17.65**	-7.87*	-8.59*	-5.65
21	AKM 8802×BM 2011-1	9.72*	3.95	16.18**	-8.40**	-10.45**	-3.23
22	AKM 8802×BMG 108	4.64	-4.82	16.18**	-4.35	-5.47	-2.42
23	AKM 8802×BPMR 75	10.34**	3.90	17.65**	-4.03	-7.03*	-4.03
24	AKM 8802×BPMR 135	4.05	-3.75	13.24**	-6.83*	-9.38*	--6.45
	CD at 5%	2.66	3.09	3.09	3.77	4.35	4.35

*and ** indicates significance at 5 and 1 per cent level respectively

Continue 1.

S. No	Crosses	Plant height(cm)			No. of cluster/plant		
		RH	HB	SH	RH	HB	SH
1	BM 4 X TBM 9	9.13	-15.24	-27.60**	57.98**	44.62*	51.61**
2	BM 4 X TBM 11	-17.36*	-19.82*	-31.51**	27.49*	-6.84	75.81**
3	BM 4 X BM 2011-1	5.24	-3.90	-0.65	4.19	-23.01*	40.32**
4	BM 4 X BMG 108	25.13**	21.20**	10.47	20.50	-9.35	56.45**
5	BM 4 X BPMR 75	5.76	0.14	-4.30	34.67*	5.21	62.90**
6	BM 4 X BPMR 135	-2.19	-10.15	-8.33	12.68	-9.09	29.03
7	BPMR 145×TBM 9	-2.66	-32.02**	-19.01**	62.90**	55.38**	62.90**
8	BPMR 145×TBM 11	-14.88*	-28.74**	-15.10*	5.68	-20.51	50.00**
9	BPMR 145×BM 2011-1	-23.70**	-28.74**	-15.10*	23.26	-6.19	70.97**
10	BPMR 145×BMG 108	-24.21**	-33.11**	-20.31**	-22.89	-40.19**	3.23
11	BPMR 145×BPMR 75	-3.94	-13.44*	3.13	44.52**	16.67	80.65**
12	BPMR 145×BPMR 135	-9.33	-15.85**	0.26	85.03**	54.55**	119.35**
13	VAIBHAV×TBM 9	-22.07**	-46.48**	-32.29**	38.81*	34.78	50.00*
14	VAIBHAV×TBM 11	-29.50**	-42.36**	-27.08**	-13.98	-31.62**	29.03
15	VAIBHAV×BM 2011-1	-17.31**	-24.87**	-4.95	-26.37*	-40.71**	8.06
16	VAIBHAV×BMG 108	-20.32**	-31.45**	-13.28	-32.95**	-44.86**	-4.84
17	VAIBHAV×BPMR 75	-18.39**	-28.37**	-9.38	-38.18**	46.88**	-17.74
18	VAIBHAV×BPMR 135	-17.27**	-25.28**	-5.47	-21.02	-29.55*	0.00
19	AKM 8802×TBM 9	-23.41*	1.42	-25.52**	-30.43*	-34.25*	-22.58
20	AKM 8802×TBM 11	2.96	-1.46	-20.83**	-40.00**	-51.28**	-8.06
21	AKM 8802×BM 2011-1	9.28	-6.55	-3.39	-19.35	-33.63**	20.97
22	AKM 8802×BMG 108	13.92	2.86	-6.25	-31.11*	-42.06**	0.00
23	AKM 8802×BPMR 75	8.47	-4.09	-8.33	-36.09**	-43.75**	-12.90
24	AKM 8802×BPMR 135	12.5	-3.25	-1.00	-37.89**	-43.18**	19.35
	CD at 5%	4.43	5.12	5.12	2.08	2.40	2.40

*and ** indicates significance at 5 and 1 per cent level respectively

Continue 1.

S. No	Crosses	No. of pod/cluster			No. of pod/plant		
		RH	HB	SH	RH	HB	SH
1	BM 4 X TBM 9	15.79	2.33	22.22*	123.50**	104.12**	159.72**
2	BM 4 X TBM 11	31.65**	20.93*	44.44**	46.51**	1.81	174.69**
3	BM 4 X BM 2011-1	-1.23	-6.98	11.11	9.63	-24.77**	112.41**
4	BM 4 X BMG 108	-3.70	-9.30	8.33	40.88**	0.56	147.31**
5	BM 4 X BPMR 75	-3.37	-6.52	19.44	36.54**	-3.28	144.07**
6	BM 4 X BPMR 135	1.23	-4.65	13.89	28.81**	-3.29	102.76**
7	BPMR 145×TBM 9	9.33	-2.38	13.89	85.01**	78.57**	144.21**
8	BPMR 145×TBM 11	2.56	-4.76	11.11	19.42*	-10.02	142.76**
9	BPMR 145×BM 2011-1	7.50	2.38	19.44	31.68**	-2.77	175.93**
10	BPMR 145×BMG 108	5.00	0.00	16.67	-21.32**	-38.78**	50.55**
11	BPMR 145×BPMR 75	-2.27	-6.52	19.44	35.09**	4.15	162.83**
12	BPMR 145×BPMR 135	11.25	5.95	23.61*	52.10**	25.66**	163.45**
13	VAIBHAV×TBM 9	25.71**	18.92	22.22*	94.41**	84.56**	161.31**
14	VAIBHAV×TBM 11	15.07	13.51	16.67	-14.17	-34.56**	76.55**
15	VAIBHAV×BM 2011-1	6.67	5.26	11.11	-27.12**	-45.29**	54.48**
16	VAIBHAV×BMG 108	14.67	13.16	19.44	-28.21**	-43.44**	39.10*
17	VAIBHAV×BPMR 75	1.20	-8.70	16.67	-32.42**	-47.25**	33.10
18	VAIBHAV×BPMR 135	6.67	5.26	11.11	15.96	-29.61**	47.59**
19	AKM 8802×TBM 9	-2.70	-12.20	0.00	-31.14**	-41.01**	5.38
20	AKM 8802×TBM 11	3.90	-2.44	11.11	-36.05**	-46.83**	43.45*
21	AKM 8802×BM 2011-1	1.27	-2.44	11.11	-11.77	-27.94**	103.45**
22	AKM 8802×BMG 108	6.33	2.44	16.67	-25.18**	-35.39**	58.90**
23	AKM 8802×BPMR 75	-21.84**	-26.09**	-5.56	-51.44**	-58.51**	4.69
24	AKM 8802×BPMR 135	-8.86	-12.20	0.00	-41.42**	-45.72**	13.79
	CD at 5%	0.64	0.74	0.74	4.26	4.92	4.92

* and ** indicates significance at 5 and 1 per cent level respectively

Continue 1.

S. No	Crosses	No. of seed/pod			Pod length(cm)		
		RH	HB	SH	RH	HB	SH
1	BM 4 X TBM 9	9.36	6.73	-23.45**	-9.88	-17.05	-36.52**
2	BM 4 X TBM 11	-8.6	-13.68	-30.34**	-10.03	-24.89**	-27.83**
3	BM 4 X BM 2011-1	7.18	6.67	-22.76**	2.53	-3.57	-29.57**
4	BM 4 X BMG 108	8.49	6.48	-20.69**	0.96	-4.24	-31.30**

5	BM 4 X BPMR 75	12.08	11.54	-20.00**	2.55	-3.01	-30.00**
6	BM 4 X BPMR 135	-0.99	-3.58	-31.03**	-2.04	-2.70	-37.39**
7	BPMR 145×TBM 9	10.28	2.61	-18.62**	13.54	11.93	-14.35
8	BPMR 145×TBM 11	0.86	0.00	-19.32**	0,00	-11.31	-14.78
9	BPMR 145×BM 2011-1	14.55	9.57	-13.10	10.32	9.36	-18.70*
10	BPMR 145×BMG 108	3.14	0.00	-20.69**	12.50	10.53	-17.83*
11	BPMR 145×BPMR 75	6.42	0.87	-20.00**	9.20	7.60	-20.00*
12	BPMR 145×BPMR 135	1.41	-6.09	-25.52**	11.67	3.51	-23.04**
13	VAIBHAV×TBM 9	13.59	9.35	-19.31**	-3.45	-4.55	-26.96**
14	VAIBHAV×TBM 11	1.79	-2.56	-21.38**	-2.80	-13.57	-16.96*
15	VAIBHAV×BM 2011-1	7.55	6.54	-21.38**	0.59	1.79	-25.65**
16	VAIBHAV×BMG 108	-0.47	-0.93	-26.21**	-2.08	0.00	-28.26**
17	VAIBHAV×BPMR 75	-5.71	-7.48	-31.72**	3.55	5.42	-23.91**
18	VAIBHAV×BPMR 135	8.29	3.74	-23.45**	18.87	29.45**	-17.83*
19	AKM 8802×TBM 9	3.77	-2.65	-24.14**	-2.30	-3.41	-26.09**
20	AKM 8802×TBM 11	-0.87	-2.56	-21.38**	-0.25	-11.31	-14.78
21	AKM 8802×BM 2011-1	4.59	0.88	-21.38**	2.94	1.74	23.91**
22	AKM 8802×BMG 108	-3.17	-5.31	-26.21**	6.82	4.65	-21.74**
23	AKM 8802×BPMR 75	13.43	8.41	-15.52*	7.69	5.81	-20.87*
24	AKM 8802×BPMR 135	11.37	3.98	-18.97**	5.03	-2.91	-27.39**
	CD at 5%	1.65	1.90	1.90	1.54	1.78	1.78

Continue 1.

S. No	Crosses	100 Seed weight(gm)			Seed yield per plant(gm)		
		RH	HB	SH	RH	HB	SH
1	BM 4 X TBM 9	-6.33	-7.50	-19.57*	81.53**	71.24*	-3.43
2	BM 4 X TBM 11	-16.48*	-26.92**	-17.39*	47.04**	13.12	18.43
3	BM 4 X BM 2011-1	-1.82	-6.90	-11.96	80.11**	61.32**	14.96
4	BM 4 X BMG 108	-4.14	-10.99	-11.96	70.21**	63.84*	-0.13
5	BM 4 X BPMR 75	4.94	1.19	-7.61	155.41**	149.85**	47.30**
6	BM 4 X BPMR 135	-2.07	-8.97	-22.83**	74.13**	66.36*	3.00
7	BPMR 145×TBM 9	26.83**	23.81	13.04	150.31**	123.06**	42.57*
8	BPMR 145×TBM 11	8.51	-1.92	10.87	62.92**	32.19*	37.35*
9	BPMR 145×BM 2011-1	20.47*	18.39*	11.96	125.15**	113.54**	52.17**
10	BPMR 145×BMG 108	15.43*	10.99	9.78	122.91**	117.76**	39.17*
11	BPMR 145×BPMR 75	33.33**	33.33**	21.74*	126.19**	117.41**	38.96*
12	BPMR 145×BPMR 135	27.55**	14.64	4.67	112.58**	109.25**	33.74*
13	VAIBHAV×TBM 9	15.44	-1.87	-14.67	93.18**	92.00**	4.00
14	VAIBHAV×TBM 11	5.00	-19.23*	-8.70	78.05**	31.02	37.17*
15	VAIBHAV×BM 2011-1	21.68*	0.00	-5.43	47.46*	24.83	-11.04
16	VAIBHAV×BMG 108	14.29	-7.69	-8.70	130.97**	109.06**	27.43
17	VAIBHAV×BPMR 75	21.43*	1.19	-7.61	92.94**	77.29**	4.52
18	VAIBHAV×BPMR 135	36.59**	25.37*	-8.70	102.34**	81.88**	12.61
19	AKM 8802×TBM 9	31.91**	16.25	1.09	51.94*	114.70	7.35
20	AKM 8802×TBM 11	22.42**	-2.88	9.78	18.28	10.71	15.91
21	AKM 8802×BM 2011-1	37.84**	17.24	10.87	106.58	83.90**	67.91**
22	AKM 8802×BMG 108	39.47**	16.48	15.22	40.89	17.48	7.26
23	AKM 8802×BPMR 75	21.38*	4.76	-4.35	28.13	5.43	-3.74
24	AKM 8802×BPMR 135	40.63**	34.33**	-2.17	3.41	-13.43	-20.78
	CD at 5%	0.66	0.76	0.76	3.17	3.66	3.66

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