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Heterosis studies in green gram (*Vigna radiata* (L.) Wilczek) for earliness, grain yield and yield contributing character

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Abstract
In the present investigation, a study was consisting of six female parents and three male parents were effected in line × tester (6 x 3) program. The resulting 18 F1s were evaluated along with the nine parents and one check (PKV Green Gold) in Randomized Block Design with three replications during the *Kharif*-2014. The observations on five randomly selected plants in each replication were recorded for four characters *viz*; days to 50 percent flowering, days to maturity, grain yield per plant (g), and seeds per pods. A considerable amount of heterosis was observed for all characters. The highest heterotic effect was observed in BM-2002-1 x AKM-0603 (145.93percent) for grain yield per plant. The hybrids showed significant positive heterosis over check PKV green gold for all the characters under study. The cross combination BPMR-145 x AKM-10-07 for earliness and grain yield per plant is recommended for heterosis breeding for earliness and to boost low yield levels of green gram.

Keywords: Line x tester, earliness and pods yield

Introduction
Pulses are one of the important segments of Indian agriculture after cereals in production. Mungbean is an important pulse crop and it is considered to be the hardiest among the pulse crops. On an average, pulses contain 20 to 30 percent protein, which is almost 2.5 to 3.0 times the value normally found in cereals. Besides their high nutritional value, they have unique characteristics of maintaining and restoring soil fertility through biological nitrogen fixation and thus play a vital role in sustainable agriculture. The important pulse crops grown in India are bengal gram, lentil, green gram, black gram, cowpea, red gram, and pea. Sprouted mungbean are used as fresh vegetables making noodles and other textured preparations. It is rich in vitamin B and regarded as a remedy for the disease Beriberi. When it is allowed to sprout, ascorbic acid (Vit. *C*) is synthesized. The amount of riboflavin and thiamin in mungbean are also high. It contains 24 percent proteins with all essential amino acids.
According to Vavilov (1926), mungbean originated from the Indian sub-continent. Maximum diversity among related species is limited to the upper Western Ghats and Deccan hills. Several plant researchers have emphasized on the use of heritability and genetic advance in the identification of desirable populations in legumes. Development of a new variety with high yield, long pod, bold seed, non-shattering and having stable performance is the main aim of all the plant breeders. The earliest step in a successful crop breeding program is to select appropriate parents.
In heterosis breeding programs, a large number of hybrids are produced and evaluated to exploit hybrid vigor, which usually requires more resources and manpower. It is possible to select the parental lines based on their genetic diversity status to effect limited crosses with better success, if there is a relationship between heterosis for yield and genetic diversity.

Materials and Methods
The present study was undertaken on Line × Tester analysis in which set of 18 different crosses, 9 inbred lines, comprising 6 females and 3 males, and 1 check were used showed in Table no 1. The inbred lines were collected from the Principal Scientist, Pulses Improvement Project M.P.K.V. Rahuri; Genotype possessing diversity for yield and other components were

selected. A total of 18 crosses were effected. The cross seed was obtained during *Rabi*-2013 at Post Graduate Research Farm, College of Agriculture, Kolhapur. The hybrids (18) along with parents (9) and 1 check were grown and tested in RBD with three replications during *Kharif*-2014.

All possible care was taken at the time of pollination to avoid contamination. The crossing was done in line × tester fashion and selfing of parents to obtain seeds of 18 crosses and 9 parents. All the package of practices was followed for good crop growth.

Five random plants from each treatment in each replication were selected for recording observations. The selected plants were tagged at the age of 30 days. The observations on five randomly selected plants in each replication were recorded for four-character *viz*; days to 50 percent flowering, days to maturity, grain yield per plant (g), and seeds per pods.

Table 1: List of parents, hybrids and check

Treat. No.	Genotypes	Treat. No.	
	Female		**Hybrids**
1	BM-2002-1	1	BM2002xAKM10-07
2	Vaibhav	2	BM2002xAKM-10-13
3	PM-402	3	BM2002xAKM0603
4	BM-2003-2	4	VibhavXAKM10-07
5	BPMR-145	5	VaibhavXAKM10-13
6	AKM-8802	6	VaibhavXAKM0603
		7	BM2003xAKM10-07
	Male	8	BM2003xAKM10-13
1	AKM-10-07	9	BM2003xAKM0603
2	AKM-10-13	10	PM402xAKM10-07
3	AKM-0603	11	PM402xAKM10-13
		12	PM402xAKM0603
	Check	13	BPMR145xAKM10-07
1	PKV Green gold	14	BPMR145xAKM10-13
		15	BPMR145xAKM0603
		16	AKM8802xAKM10-07
		17	AKM8802xAKM10-13
		18	AKM8802xAKM0603

Results and Discussion

Heterosis

Almost all the hybrids showed a considerable amount of heterosis over better parent. The degree of heterosis, however, differed for different characters. The crosses showing maximum beneficial heterosis over superior parents are presented in Table No 2.

1. Days to 50 percent flowering

Two hybrids showed highly significant negative relative heterobeltosis for days to 50 percent flowering. The negative heterosis for this character is of interest to the breeders as it indicates earliness. The hybrid, vaibhav x AKM-10-13 and vaibhav x AKM-0603 exhibited the maximum negative heterosis (-6.61). The negative heterosis for days to 50% flowering was also previously reported by Sonawane (1995) [16] and M.B. Patel *et al*. (2009).

2. Days to maturity

In respect of days to maturity, eight hybrids exhibited significant negative heterosis over superior parent, ranging from -2.49 to -6.10 percent in the set of crosses. The hybrid vaibhav x AKM-O603 exhibited maximum (-6.10) negative heterobeltiosis. The expression of negative heterosis for this trait was also reported by Naidu and Satyanarayan (1993) [9], Sonawane (1995) [16], and Reddy (1998) [12]

3. Grain yield per plant (g)

The cross BM-2003 x AKM0603 had produced a higher magnitude of sca (145.93 percent) followed by vaibhav x AKM-10-13 (126.20 percent), BM-2003 x AKM-10-13(121.09), vaibhav x AKM-0603 (109.40 percent) vaibhav x AKM-10-07 (104.10 percent) indicating selected female and male parent were good combiner for such an important trait under investigation. Similar results were reported by Bhatnagar and Singh (1964) [2], Singh and Jain (1970) [15], Swindell and Poehlman (1976), Sarode *et al.,* (2000) [14], and Barad *et al.,* (2008) [1]. The heterotic effects, for grain yield per plant, were found to be mostly influenced by heterosis for either one or more of the yield contributing attributes.

4. Seeds per pods

None of the crosses showed significant positive heterobeltiosis for seeds per pod indicating the unwillingness of parents to improve this character. These results were in agreement with earlier reports made by. Tewari and Pandey (1987) [17], Kumar and Bahl (1988) [8], Katiyar and Katiyar (1993) [7], and Sarode *et al.,* (2000) [14].

Table 2: Partitioning of variance for four different characters in L x T mating design in Green gram

Sr. No	Source of Variation	df	Days to50% flowering	Days to Maturity	Grain yield / plant	Seeds/Pod
1	Replication	2	1.92	0.33	0.09	0.06
2	Parent	8	4.33	6.95	23.23	1.41
3	Female	5	6.62	10.88	29.95	1.75
4	Male	2	0.44	0.44	18.02	0.27
5	Female Vs Male	1	0.66	0.29	0.04	2.00
6	Hybrids	17	0.94	3.28	116.89	0.79
7	Parents Vs Hybrids	1	0.22	1.38	2996.24	0.24
8	Error	52	0.43	0.39	8.45	0.363

Table 2: Percent heterosis for four quantitative characters in Green gram

Sr. No	Hybrids	Days to 50% flowering			Days to maturity		
		MP	BP	SC 1	MP	BP	SC 1
1	BM2002xAKM10-07	-1.82	-1.82	-14.96**	-1.00	-1.00	-7.44**
2	BM2002xAKM-10-13	0.00	-0.89	-12.60**	0.50	0.50	-6.05
3	BM2002xAKM0603	1.80	0.89	-11.02**	1.49*	0.99	-4.66**
4	VAibhavXAKM10-07	-1.30	-5.79**	-10.24**	-0.48	-3.29**	-4.19**
5	VaibhavXAKM10-13	-3.00*	-6.61**	-11.02**	-1.93**	-4.69**	-5.58**
6	VaibhavXAKM0603	-3.00*	-6.61**	-11.02**	-3.85**	-6.10**	-6.98**

7	BM2003xAKM10-07	1.82	1.82	-11.81**	0.25	-0.50	-6.98**
8	BM2003xAKM10-13	0.00	-0.89	-12.60**	0.25	-0.50	-6.98**
9	BM2003xAKM0603	-0.90	-1.79	13.39**	-0.75	-1.97*	-7.44**
10	PM402xAKM10-07	0.45	0.00	-12.60**	-0.74	-0.99	-6.98**
11	PM402xAKM10-13	-0.45	-0.89	-12.60**-	-1.74*	-1.98*	-7.91**
12	PM402xAKM0603	0.45	0.00	-11.81**	-3.21**	-3.45**	-8.84**
13	BPMR145xAKM10-07	2.24	0.88	-10.24**	0.50	0.00	-5.58**
14	BPMR145xAKM10-13	1.33	0.88	-10.24**	1.49*	0.99	-4.65**
15	BPMR145xAKM0603	-1.33	-1.77	-12.60**	0.99	0.99	-4.65**
16	AKM8802xAKM10-07	1.37	0.91	-12.60**	3.02**	1.99*	-4.65**
17	AKM8802xAKM10-13	-1.36	-2.68	-14.17**	-1.51*	-2.49**	-8.84**
18	AKM8802xAKM0603	1.36	0.00	-11.81**	0.50	-0.99	-6.51**
	S.E. _+	0.46	0.54		0.44	0.51	
	CD at 5%	0.95	1.09		0.90	1.04	
	CD at 1%	1.27	1.47		1.21	1.40	

Sr. No	Hybrids	Grain yield / plant (g)			Seeds/Pod		
		MP	BP	SC 1	MP	BP	SC 1
1	BM2002xAKM10-07	29.91*	11.30	112.05**	1.40	-0.46	12.87**
2	BM2002xAKM-10-13	94.45**	91.27**	178.87**	-8.27**	-8.92	0.91
3	BM2002xAKM0603	95.72**	94.24**	178.15**	5.49	5.24	14.95**
4	VAibhavXAKM10-07	143.11**	104.10**	288.86**	10.89**	2.75	16.51**
5	VaibhavXAKM10-13	139.71**	126.20**	229.81**	2.76	-3.76	6.63
6	VaibhavXAKM0603	120.02**	109.40**	199.86**	5.32	-0.48	8.19*
7	BM2003xAKM10-07	5.67	-11.36	68.89	7.81	0.00	13.93**
8	BM2003xAKM10-13	134.50	121.09**	222.36**	1.69	-0.94	9.75
9	BM2003xAKM0603	158.64**	145.93**	252.17**	-2.68	-4.31	4.03
10	PM402xAKM10-07	21.08	10.75	111.00**	-4.08	-8.26	4.03
11	PM402xAKM10-13	34.38	29.20	104.12**	2.43	-0.94	9.75
12	PM402xAKM0603	73.45**	65.33**	161.22**	1.72	-0.72	7.93*
13	BPMR145xAKM10-07	87.63**	76.09**	282.56**	-2.55	-3.44	9.49
14	BPMR145xAKM10-13	69.91**	41.97**	208.43**	-4.22	-4.44	6.37
15	BPMR145xAKM0603	119.93**	82.45**	296.38**	0.71	-0.47	10.79**
16	AKM8802xAKM10-07	76.29**	70.87**	225.54**	-3.91	-4.13	8.71*
17	AKM8802xAKM10-13	127.24**	106.27**	268.81**	-5.58	-6.45	5.59
18	AKM8802xAKM0603	84.94**	66.53**	197.76**	-0.94	-2.76	9.75*
	S.E. _+	2.05	2.37		0.42	0.49	
	CD at 5%	4.17	4.82		0.86	1.005	
	CD at 1%	5.61	6.47		1.16	1.34	

*, ** indicates at 5% and 1% level of significant, respectively.
(Standard Check: - SC 1: PKV Green gold)

Summary and Conclusion

The cross combination vaibhav x AKM-10-13 and vaibhav x AKM-0603 produced maximum heterobeltosis for earliness character. The promising outcome of this investigation was increment shown by almost all hybrids except BM-2003 x AKM-10-07, BM-2002 x AKM-10-07, PM-402 x AKM-10-07 and PM-402 x AKM-10-13 for yield per plant (g) over best parent. It was ranged between 41.97 to 145.93. The highest performance for such an important character was recorded by BM-2002 x AKM-0603 (145.93 percent) provides an opportunity to boost the low yield levels in green gram by cultivating hybrids. None of the hybrid had displayed the encouraging performance for seeds per pod, over the best parent.

The hybrids BM-2003 x AKM-0603 for grain yield, BPMR-145 x AKM-10-07 for earliness, and grain yield per plant are recommended for heterosis breeding for earliness and to boost low yield levels of green gram.

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