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Neeraj Ankur Toppo
Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, India

SK Nair
Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, India

HC Nanda
Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, India

Corresponding Author:
Neeraj Ankur Toppo
Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, India

Heterotic analysis in blackgram (*Vigna mungo* (L.) Hepper

Neeraj Ankur Toppo, SK Nair and HC Nanda

Abstract

Heterosis study was carried out in blackgram at experimental research cum instructional farm IGKV. Twenty-one crosses are examined for twelve quantitative traits for better parent heterosis, heterobeltiosis and standard heterosis. The heterosis estimates among the crosses for 12 traits indicated that all the traits distinctly varied for the upper limit in both negative and positive direction. The magnitude of standard heterosis was high for number of pods per plant, seeds per pod, 100 seed weight and seed yield per plant. The observation of the heterotic trend revealed that out of 21 crosses TU-103 x LBG-623 registered significant and high heterosis for seed yield per plant.

Keywords: Blackgram, heterosis, heterobeltiosis, standard heterosis

Introduction

Blackgram is a self-pollinated diploid crop with chromosome no. 2n=2x=22, and has a small genome size ~574 Mbp (Arumuganathan and Earle, 1991) [3]. India is the largest producer and consumer of the pulses in the world. However, pulse production has been stagnant between 11 and 14 million tonnes over the last 2 decades. Per capita pulse consumption has come down from 61 gm/day in 1951 to 30 gm/day in 2008. However, the disturbing feature in pulse production are poor establishment and low harvest index. (Nithila and Sivakumar, 2017) [12]. Among the legumes blackgram is one of the narrow genetic base crop represents smaller variability in primary gene pool. Lack of newer varieties and genotype adapted to local environment is among the factors affecting its production necessitating, the development of new varieties adapt to local condition (Thamodharan *et al.*, 2016) [20]. Heterosis has important implications for both F_1 and for adopting transgressive segregates in F_2 generation (Bhagirath *et al.*, 2013) [7]. The presence of heterosis in food legumes has been reported by Rama Kant and Srivastava, 2012 [13]. Little information about heterosis and gene action is available in blackgram. The using of heterosis in blackgram has not been commercialized due to limited extent of out crossing (Singh, 2000) [17]. Even so, highly heterotic crosses can be used for development of high yielding pure line varieties in this self-pollinated crop.

Materials and Methods

Twenty-one F_1 hybrids were evaluated during *Kharif*-2018 at research cum instructional farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur. Hybrids were sown in Randomized Block Design with two replication and line to line and plant to plant distance was kept 30 cm and 10 cm. Recommended cultivation practices were adopted and necessary prophylactic measures were adopted to raise a healthy crop. The data were recorded on five randomly selected plants in each entry in each replication for 12 characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of primary branches, number of pods per plant, pod length (cm), number of seeds per pod, hundred seed weight (g), seed yield per plant (g), biological yield per plant, harvest index and protein content. Heterosis was estimated over mid parent (Average heterosis/Heterosis), better parent (Heterobeltiosis) and standard check (Standard heterosis).

Result and Discussion

The advancement in the performance of F_1 over the parents in terms of characters under studies is referred to as heterosis or hybrid vigour". Heterosis estimates in crosses made from diverse genotypes would always useful in choosing the best performing crosses for further selection process. In the present study heterosis is estimated for 21 cross combinations over mid parent heterosis (relative heterosis), better parent heterosis (heterobeltiosis) and over standard variety (standard heterosis) which is accessible in Table 1. For days to 50% flowering negative significant heterosis over mid parent was observed in MASH-1008 x LBG-17 (-6.60) similar results also reported by Thamodharan *et al.*, (2016) [20], Rashwan *et al.*, (2012) [14], and Naik *et al.*, (2007) [11]. For days to maturity heterosis over mid parent for days to maturity ranged from -7.89 to 11.19. Negative significant heterosis over mid parent was observed in MASH-1008 x LBG-17 (-7.89). Heterobeltiosis was recorded in MASH-1008 x LBG-17 (-7.89) and INDIRA URD PRATHAM x LBG-17 (-7.89). MASH-1008 x LBG-17 showed negative significant heterosis among all the three heterosis classes (-7.89) so this cross can be further explored for selection of early maturing individuals in the screening generations. Results supported by Vijay Kumar *et al.*, (2017) [21], Alle *et al.*, (2014) [2] and Singh and Singh, (2006) [18].

Table 1: Estimates of Relative Heterosis (RH), Heterobeltiosis (HB) and Standard Heterosis (SH) for days to 50 % flowering, days to maturity, plant height and branches per plant

Crosses	Days to 50 % flowering			Days to maturity			Plant height (cm)			Branches per plant		
	RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
TU-103 x MASH-1008	2.08	0.00	-1.01	-3.68	-5.26	-5.26	-11.48	-16.92	-50.00**	-16.67	-28.57	-54.55*
TU-103 x IUP	-2.15	-3.19	-8.08*	3.23	-2.04	-5.26	-15.60	-19.30	-57.41**	0.00	-14.29	-45.45*
TU-103 x PU-11-14	2.13	2.13	-3.03	3.18	-0.68	-3.95	-51.15**	-56.76**	-70.37**	-25.00	-33.33	-45.45*
TU-103 x TU-94-2	-1.04	-3.06	-4.04	-5.72	-6.67	-7.89*	-34.86**	-51.69**	-47.22**	0.00	-11.11	-27.27
TU-103 x LBG-623	4.40	1.06	-4.04	5.26	2.04	-1.32	55.86*	28.41**	4.63	6.67	0.00	-27.27
TU-103 x LBG 17	-2.59	-5.05	-5.05	-5.02	-6.58	-6.58	-53.94**	-64.81**	-64.81**	-22.22	-36.36	-.36.36
MASH-1008 x IUP	-1.05	-4.08	-5.05	4.23	-2.63	-2.63	11.11	0.00	-39.81**	60.00**	60.00**	-27.27
MASH-1008 x PU-11-14	1.04	-1.02	-2.02	4.17	-1.32	-1.32	13.67	6.76	-26.85**	28.57	0.0	-18.18
MASH-1008 x TU-94-2	-3.06	-3.06	-4.04	-0.6	-1.32	-1.32	14.75	-11.02	-2.78	42.86	11.11	-9.09
MASH-1008 x LBG-623	1.08	-4.08	-5.05	-1.38	-5.92	-5.92	38.56**	20.45*	-1.85	23.08	0.00	-27.27
MASH-1008 x LBG17	-6.60*	-7.07	-7.07	-7.89*	-7.89*	-7.89	-5.20	-24.07**	-24.07**	25.00	-9.09	-9.09
IUP x PU-11-14	6.45	5.32	0.00	11.19**	9.56*	-1.97	-14.29	-27.03*	-50.00**	14.29	-11.11	-27.27
IUP x TU-94-2	1.05	-2.04	-3.03	1.42	-4.67	-5.92	-4.71	-31.36**	-25.00**	0.00	-22.22	-36.36
IUP x LBG-623	7.78*	5.43	-2.02	8.15*	5.80	-3.95	18.57	-5.68	23.15**	-23.08	-37.50	-54.55*
IUP x LBG-17	0.52	-3.03	-3.03	-1.41	-7.89*	-7.89*	-1.25	-26.85**	-26.85**	0.00	-27.27	-27.27
PU-11-14 x TU-94-2	0.00	-2.04	-3.03	0.00	-4.67	-5.92	-20.83**	-35.59**	-29.63**	-33.33	-33.33	-45.45*
PU-11-14 x LBG-623	2.20	-1.06	-6.06	5.11	4.35	-5.26	-17.28	-23.86*	-37.96**	-5.88	-11.11	-27.27
PU-11-14 x LBG-17	-0.52	-3.03	-3.03	6.25	0.66	0.66	-23.08**	-35.19**	-35.19**	-60.00**	-63.64**	-63.64**
TU-94-2 x LBG-623	6.45	1.02	0.00	2.08	-2.00	-3.29	-17.48*	-27.97**	-21.30**	5.88	0.00	-18.18
TU-94-2 x LBG-17	-0.51	-1.01	-1.01	-1.32	-1.97	-1.97	-19.47**	-22.88**	-15.74*	-40.00*	-45.45*	-45.45*
LBG-623 x LBG-17	11.23**	5.05	5.05	10.34**	5.26	5.26	10.20	0.00	0.00	5.26	-9.09	-9.09
Range Lowest	-6.60	-7.07	-8.08	-7.89	-7.89	-7.89	-53.94	-64.81	-70.37	-60.00	-63.64	-63.64
Highest	11.23	5.43	5.05	11.19	9.56	5.26	55.86	28.41	23.15	60	60.00	-9.09
S.E.(±)	1.58	1.82	1.82	2.21	2.56	2.56	3.56	4.10	4.10	0.94	1.09	1.09

*, ** Significant at 5% and 1% level of probability, respectively
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Table 2: Estimates of Relative Heterosis (RH), Heterobeltiosis (HB) and Standard Heterosis (SH) for pod plant^{-1}, pod length, seeds pod^{-1} and seed yield plant^{-1}

Crosses	Pods plant^{-1}			Pod length (cm)			Seeds pod^{-1}			Seed yield plant^{-1}		
	RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
TU-103 x MASH-1008	16.28	6.38	72.41	-8.57	-11.11	-11.11	-3.70	-7.14	8.33	-19.03	-30.41	-43.74
TU-103 x IUP	22.92	3.51	103.45	2.70	0.00	5.56	11.11	7.14	25.00*	-26.18	-35.62	-30.06
TU-103 x PU-11-14	-4.48	-17.95	10.34	-27.78**	-27.78*	-27.78**	-4.00	-14.29	0.00	-70.21	-76.80*	-81.25*
TU-103 x TU-94-2	-24.79	-43.59*	51.72	8.57	5.56	5.56	-11.11	-14.29	0.00	-34.51	-43.15	-37.56
TU-103 x LBG-623	127.78**	110.26**	182.76**	-2.86	-5.56	-5.56	11.11	7.14	25.00*	100.45*	45.57	17.70
TU-103 x LBG 17	26.47	10.26	48.28	-11.11	-11.11	-11.11	7.69	0.00	16.67	-55.28	-59.56	-59.56
MASH-1008 x IUP	3.85	-5.26	86.21	-11.11	-15.79*	-11.11	-15.38	-15.38	-8.33	-61.60	-70.53*	-67.99*
MASH-1008 x PU-11-14	62.67	29.79	110.34*	2.86	0.00	0.00	8.33	0.00	8.33	-15.46	-24.95	-56.39
MASH-1008 x TU-94-2	15.20	-7.69	148.28**	0.00	0.00	5-56	-15.38	-15.38	-8.33	-27.08	-44.25	-38.77
MASH-1008 x LBG-623	67.50*	42.55	131.03*	11.76	11.76	5.56	0.00	0.00	8.33	-37.52	-49.09	-70.42*
MASH-1008 x LBG-17	113.16**	72.34*	179.31**	-2.86	-5.56	-5.56	-4.00	-7.69	0.00	-20.51	-37.16	-37.16
IUP x PU-11-14	41.18	5.26	106.90	2.70	0.00	5.56	8.33	0.00	8.33	-25.31	-47.17	-42.60
IUP x TU-94-2	34.81	16.67	213.79**	-16.67*	-21.05**	-16.67*	-7.69	-7.69	0.00	9.06	8.47	19.12
IUP x LBG-623	66.67*	31.58	158.62**	0.00	-5.26	0.00	30.77**	30.77**	41.67**	60.28	7.12	16.38
IUP x LBG-17	55.81	17.54	131.03*	2.70	0.00	5.56	4.00	0.00	8.33	4.49	0.34	9.01
PU-11-14 x TU-94-2	0.00	-32.05	82.76	-2.86	-5.56	-5.56	16.67	7.69	16.67	-24.69	-46.90	-41.68
PU-11-14 x LBG-623	37.70	27.27	44.83	-2.86	-5.56	-5.56	8.33	0.00	8.33	-7.67	-16.35	-62.31*
PU-11-14 x LBG-17	33.33	31.03	31.03	-16.67*	-16.67*	-16.67*	21.74*	16.67	16.67	-39.77	-56.31	-56.31
TU-94-2 x LBG-623	58.56*	12.82	203.45**	11.76	11.76	5.56	15.38	15.38	25.00*	-29.46	-52.98	-48.36
TU-94-2 x LBG-17	19.63	-17.95	120.69*	-2.86	-5.56	-5.56	4.00	0.00	8.33	-31.27	-34.34	-27.89
LBG-623 x LBG-17	197.77**	178.79**	217.24**	-2.86	-5.56	-5.56	-12.00	-15.38	-8.33	-44.85	-62.33*	-62.33*

Range Lowest	-24.79	-43.59	31.03	-27.78	-27.78	-27.78	-15.38	-15.38	-8.33	-70.21	-76.80	-81.25
Highest	196.77	178.79	217.24	11.76	11.76	5.56	30.77	30.77	41.67	100.45	45.57	19.12
S.E.(±)	6.56	7.58	7.58	0.28	0.33	0.33	0.49	0.57	0.57	4.95	5.71	5.71

*, ** Significant at 5% and 1% level of probability, respectively
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Table 3: Estimates of Relative Heterosis (RH), Heterobeltiosis (HB) and Standard Heterosis (SH) for 100 seed weight, biological yield plant^{-1}, harvest index and protein content

Crosses	100 seed weight			Biological yield plant^{-1}			Harvest index			Protein content		
	RH	HB	SH	RH	HB	SH	RH	HB	SH	RH	HB	SH
TU-103 x MASH-1008	0.00	-6.41*	-2.67	-22.70	-27.55	-42.09	4.19	-3.77	-5.59	4.21**	2.97**	-23.87**
TU-103 x IUP	10.20**	3.85	8.00**	-18.82	-29.84	-23.03	-9.67	-11.05	-12.74	-1.68**	-3.62**	-25.81**
TU-103 x PU-11-14	-43.84**	-47.44**	-45.33**	-70.63*	-75.06*	-80.07**	3.70	-5.90	-7.68	-16.27**	-23.54**	-31.58**
TU-103 x TU-94-2	6.04*	1.28	5.33*	-35.10	-43.59	-38.94	0.51	0.36	-1.25	-10.27**	-11.55**	-32.68**
TU-103 x LBG-623	-10.67**	-14.10**	-10.67**	87.89*	44.85	15.78	7.13	-1.95	-3.81	-5.81**	-15.05**	-21.85**
TU-103 x LBG 17	-15.03**	-16.67**	-13.33**	-57.67*	-61.92*	-61.92*	6.28	5.28	5.28	-9.46**	-21.26**	-21.26**
MASH-1008 x IUP	-5.11*	-5.80*	-13.33**	-60.95*	-68.04*	-64.93*	0.66	-5.69	-10.30	-18.44**	-20.98**	-39.17**
MASH-1008 x PU-11-14	39.71**	39.71**	26.67**	-24.08	-31.74	-52.29	10.68	8.58	-9.75	-20.27**	-27.98**	-35.56**
MASH-1008 x TU-94-2	2.16	0.00	-5.33*	-16.03	-30.90	-25.20	-9.46	-16.49	-17.83*	-0.40	-2.98**	-26.15**
MASH-1008 x LBG-623	-4.29	-6.94*	-10.67**	-31.25	-44.32	-61.08*	-9.59	-10.48	-25.59**	-28.37**	-36.09**	-41.21**
MASH-1008 x LBG-17	7.69**	2.67	2.67	-22.40	-34.07	-34.07	1.57	-7.01	-7.01	-10.67**	-23.09**	-23.09**
IUP x PU-11-14	-5.11*	-5.80*	-13.33**	-23.82	-42.54	-36.96	5.00	-3.37	-8.09	-15.92**	-21.79**	-30.02**
IUP x TU-94-2	12.86**	11.27**	5.33*	6.71	6.00	16.29	4.48	2.74	1.09	-11.16**	-11.66**	-32.00**
IUP x LBG-623	14.89**	12.50**	8.00**	39.60	-2.64	6.80	21.47*	12.77	7.25	-0.37	-8.50**	-15.83**
IUP x LBG-17	8.33**	4.00	4.00	2.05	-2.46	7.00	1.11	-1.36	-1.36	-15.12**	-24.89**	-24.89**
PU-11-14 x TU-94-2	5.04*	2.82	-2.67	-30.80	-47.57	-43.25	12.71	2.15	0.51	-10.11**	-16.82**	-25.58**
PU-11-14 x LBG-623	7.14**	4.17	0.00	-19.42	-28.43	-60.07*	14.25	13.18	-7.78	-24.68**	-25.71**	-31.65**
PU-11-14 x LBG-17	3.50	-1.33	-1.33	-19.31	-37.14	-37.14	-24.90**	-32.42**	-32.42**	-20.49**	-24.68**	-24.68**
TU-94-2 x LBG-623	7.69**	6.94*	2.67	-15.79	-41.05	-36.19	-11.63	-19.23*	-20.52*	-12.21**	-19.78**	-26.21**
TU-94-2 x LBG-17	-1.37	-4.00	-4.00	-24.42	-27.30	-21.31	-8.69	-9.42	-9.42	-13.99**	-24.26**	-24.26**
LBG-623 x LBG-17	-2.04	-4.00	-4.00	-16.60	-40.24	-40.24	-31.57**	-37.90**	-37.90**	-19.12**	-22.36**	-22.36**
Range Lowest	-43.84	-47.44	-45.33	-70.63	-75.06	-80.07	-31.57	-37.90	-37.90	-28.37	-36.09	-41.21
Highest	39.71	39.71	26.67	87.89	44.85	16.29	21.47	13.18	7.25	4.21	2.97	-15.83
S.E.(±)	0.08	0.09	0.09	12.88	14.87	14.87	2.62	3.02	3.02	0.07	0.08	0.08

*, ** Significant at 5% and 1% level of probability, respectively
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In plant height heterobeltiosis was observed significant negative for TU-103 x LBG-17 (-64.81), TU-103 x PU-11-14 (-56.76) and TU-103 x TU-94-2 (-51.69) while, TU-103 x LBG-623 (28.41) and MASH-1008 x LBG-623 (20.45) were positive significant. Standard heterosis was ranged from -70.37 to 23.15, among which INDIRA URD PRATHAM x LBG-623 (23.15) showed positive significant heterosis. Similar results were reported by Mehta and Lal, (2018) [10], Alle *et al.*, (2014) [2], Beena and Sreekumar, (2008) [6] and Singh and Singh, (2006) [18]. For the trait number of branches per plant almost all the crosses showed non-significant heterosis over mid parent except for PU-11-14 x LBG-17 (-60.00) and TU-94-2 x LBG-17 (-40.00) which showed negative significance while, heterobeltiosis was observed from -63.64 to 60.00. All the crosses were showed negative heterosis for standard heterosis. Thamodharan *et al.*, (2016) [20], Alle *et al.*, (2014) [2], Barad *et al.*, (2008) [5], Saravanan *et al.*, (2004) [15] and Aher *et al.*, (2000b) [1] also reported similar findings. Number of pods per pod were Posses positive heterosis for almost all the three crosses was observed for pods per plant in all three type of heterosis. Among them LBG-623 x LBG-17 was observed to be best cross combination for all three type of heterosis. Similar results were also reported by Mehta and Lal, (2018) [10]. Pod length was ranged for over mid parent from -27.78 to 11.76. Heterobeltiosis was ranged from -27.78 to 11.76 and standard heterosis was ranged from -27.78 to 5.56. Similar results were also reported by Thamodharan *et al.*, (2016) [20], Kumari *et al.*, (2012) [9] and Bhuvneshwari and Muthiah, (2005) [8]. For seed yield per pod INDIRA URD PRATHAM x LBG-623 (30.77) found heterotic over mid parent. Standard heterosis was ranged from -8.33 to 41.67, INDIRA URD PRATHAM x LBG-623 (41.67), TU-103 x MASH-1008 (25.00), TU-103 x LBG-623 (25.00) and TU-94-2 x LBG-623 (25.00) find significant effect on yield enhancement. Similar findings were reported by Mehta and Lal, (2018) [10], Alle *et al.*, (2014) [2], Singh *et al.*, (2003) [19] and Sarode *et al.*, (2000) [16]. Most of the crosses showed negative heterosis for seed yield per plant over mid parent except for TU-103 x LBG-623 (100.45). The crosses showed significance in negative direction for heterobeltiosis and standard heterosis. The finding also correspondence with the findings of Mehta and Lal, (2018) [10], Vijay Kumar *et al.*, (2017) [21], Naik *et al.*, (2007) [11] and Singh *et al.*, (2003) [19]. In 100 seed weight, for all the three types of heterotic classes MASH-1008 x PU-11-14, INDIRA URD PRATHAM x LBG-623 and INDIRA URD PRATHAM x TU-94-2 showed positive significant heterosis. Similar results were reported by Mehta and Lal, (2018) [10], Thamodharan *et al.*, (2016) [20], Alle *et al.*, (2014) [2], Bakshi and Distidar, (2006) [4] and Sarode *et al.*, (2000) [16]. For biological yield per plant heterosis over mid parent was ranged from -70.63 to 87.89. Most of the crosses exhibited negative heterosis, while cross TU-103 x LBG-623 (87.89) showed positive significant heterosis over mid parent. Heterobeltiosis was ranged from -75.06 to 44.85 and standard heterosis was ranged from -80.07 to 16.29 none of the crosses showed positive significant heterosis in both the heterotic classes. Similar findings were reported by Mehta and Lal, (2018) [10]. In harvest index cross INDIRA URD PRATHAM x LBG-623 (21.47) over mid parent reported for positive significance. This indicates the presence of luxuriance for harvest index trait in all the F_1 crosses. The result of present investigation corresponds with Mehta and Lal, (2018) [10]. Relative heterosis for protein content among the crosses ranged from -28.37 to 4.21. Heterobeltiosis for protein content varied from -36.09 to 2.97 and for standard heterosis range was -41.21 to -15.83.

Conclusion

The magnitude of heterosis for plant height, pods per plant, number of seeds per pod and seed yield per plant were high. Through direct utilization of heterosis as hybrid is not convenient in blackgram, such traits can be improved through transgressive segregation in subsequent generations. The cross TU-103 x LBG-623 was highly heterotic for seed yield per plant and it can be utilized in development of superior genotypes for higher yield.

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