Bangladesh J. Bot. **54**(3): 601-609, 2025 (September) DOI: https://doi.org/10.3329/bjb.v54i3.84575

ESTIMATION OF COMBINING ABILITY AND HETEROSIS IN BOTTLE GOURD

MM Rahaman, MK Hossain and Nazmul Alam*

Department of Botany, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh

Keywords: Combining ability, Gene action, Heterobeltiosis, Half -diallel analysis

Abstract

To develop high yielding and early maturing hybrid, an experiment was conducted to assess the combining ability and heterosis in bottle gourd. This study utilized 30 genotypes, comprising 7 diverse parental lines (HAJARI, BG714, BG717, BG719, BG720, BG722, and BG725), 21 F1 hybrids generated through a 7 × 7 half-diallel crossing method, and two commercial checks (Diana and Moyna). The experimental design followed a Randomized Complete Block Design (RCBD) with three replications. Analysis of variance revealed significant differences among parents, hybrids, and their interactions across all 11 evaluated traits. Combining ability analysis showed that both general combining ability (GCA) and specific combining ability (SCA) variances were highly significant. GCA/SCA ratios for key traits such as yield per plant (0.33) and harvest duration (0.30) were below 1, indicating the predominance of non-additive gene action and confirming the suitability of hybrid breeding for trait improvement. BG714 exhibited superior GCA effects for both early harvesting and higher yield. Crosses BG714 × BG722 and BG714 × BG717 showed the highest positive SCA and heterosis for yield per plant and fruit number. HAJARI × BG719 and BG719 × BG722 displayed significant standard heterosis compared to both checks for yield and earliness. These findings underscore the genetic potential of these hybrids for commercial cultivation and highlight the value of hybrid breeding in bottle gourd for enhancing productivity, earliness, and adaptability under diverse growing conditions.

Introduction

Bottle gourd [*Lagenaria siceraria* (Molina) Stand L.] is one of the most important cucurbitaceous vegetables cultivated in Bangladesh (Yawalkar 1985). It is widely distributed across tropical and subtropical regions due to its adaptability and economic importance (Pandey and Riya 2023). In Bangladesh, bottle gourd is cultivated extensively during both the winter and summer seasons. According to the Bangladesh Bureau of Statistics, the country produced approximately 0.314 million metric tons (MT) of bottle gourd from 0.02 million ha with an average yield of 15.45 MT/ha (BBS 2025). The crop is known for its high-water content, dietary fiber, vitamins, and low caloric value, making it particularly beneficial for individuals with diabetes, digestive disorders, or convalescent health conditions (Dhakad *et al.* 2022).

To improve yield potential and agronomic performance, hybrid breeding in bottle gourd has gained increasing attention. Combining ability analysis has become a vital biometrical tool for selecting superior parents and identifying promising hybrid combinations in breeding programs (Manivannan 2024). General combining ability (GCA) helps to determine the breeding value of individual parents, while specific combining ability (SCA) evaluates hybrid vigor in particular crosses. These analyses also provide insights into the nature of gene action-whether additive or non-additive-guiding the choice of appropriate breeding strategies.

Heterosis, or hybrid vigor, remains a cornerstone for crop improvement, often leading to significant enhancements in yield, quality, and stress tolerance (Paril *et al.* 2024). In bottle gourd, exploiting both heterobeltiosis and standard heterosis is crucial for the development of robust hybrid cultivars (Yadav *et al.* 2023). However, the magnitude of heterosis can vary significantly across environments, necessitating multi-location trials to validate performance.

*Author for correspondence: <botanyju1986@yahoo.com>.

Hybrid breeding not only enhances yield and quality traits but also strengthens resistance to diseases and environmental stresses, ultimately promoting sustainable production and farmer profitability. The integration of combining ability and heterosis studies offers a comprehensive approach for effective selection and hybrid development (Mkhize *et al.* 2021). Such systematic improvement strategies are essential to meet the rising demand for nutritious and resilient vegetable crops in Bangladesh. Considering the above context, the present investigation was undertaken to evaluate the combining ability and heterosis in bottle gourd.

Materials and Methods

The investigation was carried out during the monsoon season of 2024 at the ACI Plant Genetic Research and Development Center, Gazipur and Bogura, and Farmers' field at Dinajpur to evaluate the performance of bottle gourd genotypes. A total of 30 genotypes, comprising of 7 inbred lines from ACI vegetable genetics, 21 hybrids developed through a 7 × 7 half diallel mating design, and 2 commercial checks (Diana from Lal Teer and Moyna from ACI), were evaluated across three diverse locations: Bogura (24.78°N, 89.35°E), Dinajpur (25.47°N, 88.35°E), and Gazipur (24.00°N, 90.43°E). The genotypes were grown in a 47m x 10m experimental plots by following the Randomized Complete Block Design (RCBD) with 3 replications. The 15-day-old healthy seedlings were transplanted at a spacing of 1.5 meters between plants and 1.75 meters between rows. Standard agronomic and plant protection practices were followed uniformly. Data were collected from 5 randomly selected plants per genotypes per replications for 11 key traits: node of first male flower (NFMF), node of first female flower (NFFF), days to 50% male flowering (DFMF), days to 50% female flowering (DFFF), days to first edible harvest (DFEH), fruit length (FL), fruit diameter (FD), average fruit weight (FW), fruits per plant (FPP), yield per plant (YPP), and harvest duration (HD). The recorded data were compiled and statistically analyzed using PB Tools, version 1.3, and Microsoft Excel. Combining ability analysis was conducted following Griffing's Method II (Griffings 1956) to assess general and specific combining abilities among the genotypes. Heterosis was calculated over the better parent (heterobeltiosis) and the standard check varieties, Diana and Moyna, as per Hallauer *et al.* (2010) to determine the hybrid vigor and performance efficiency of F1 combinations.

Results and Discussion

The analysis of variance (ANOVA) for 11 agronomic traits revealed significant differences among genotypes, including parents (P), hybrids (F_1s), and parent vs. hybrid (P vs. F_1) comparisons. All sources of variation showed highly significant effects across all traits evaluated in this study.

The variance analysis revealed highly significant outcomes for both GCA and SCA over all 11 traits, suggesting that both additive and non-additive gene actions were essential for character expression (Table 1). In this study, the GCA and SCA ratios were below 1 for all traits, except for the node of the first male flower and fruit diameter. The similar lower GCA/SCA result were also found in all the characters except fruit diameter in bottle gourd (Tulluru *et al.* 2023). The lowest GCA/SCA was 0.33 for yield per plant, followed by 0.30 for harvest duration, which indicated the greater quantity of dominance gene action and suggested heterosis breeding. The ratio of GCA to SCA was 0.97, close to 1, suggesting that both additive and non-additive gene effects were important in the trait inheritance of the initial female flower node in bottle gourd. A greater GCA and SCA ratio than unity was found for 1.56, followed by 1.33 for the trait node first male flower and fruit diameter, respectively (Table 2). Thus, additive gene action played a significant role that suggesting pure line breeding for the said traits in this study. The higher GCA and SCA ratios were also found for the trait's protein, dry matter, ascorbic acid, total soluble solids and yield per plant in bottle gourd (Jha *et al.* 2016).

Table 1. Analysis of variance (ANOVA) showing mean sum square for 7 x 7 half diallel populations of 11 agronomic traits in bottle gourd.

Source of variance	Traits											
	df.	NFMF	NFFF	DFMF	DFFF	DFEH	FL	FD	FW	FPP	YPP	HD
Replications	2	4.72**	3.38**	0.85**	1.49**	1.88**	2.84**	0.53**	0.03**	2.25**	20.05**	0.22**
Genotypes	27	2.85**	10.35**	50.51**	54.76**	53.29**	31.04**	1.21**	0.10**	6.82**	49.75**	196.22**
Parents	6	1.55**	2.52**	34.36**	30.65**	31.12**	24.64**	2.43**	0.07**	2.67**	34.84**	53.45**
F_1s	20	3.37**	12.38**	46.17**	55.41**	53.39**	26.62**	0.87**	0.11**	6.65**	43.64**	229.30**
P vs F_1s	1	0.44**	16.86**	234.32**	186.52**	184.23**	157.95**	0.67**	0.19**	35.16**	261.28**	391.09**
Error	54	0.04	0.06	0.07	0.05	0.04	0.00	0.00	0.00	0.41	1.36	0.05

NFMF: node of first male flower, NFFF: node of first female flower, DFMF: days to 50% male flowering, DFFF: days to 50% female flowering, DFEH: days to first edible harvest, FL: fruit length in cm, FD: fruit diameter in cm, FW: average fruit weight in kg., FPP: fruit per plant in number, YPP: yield per plant in kg., and HD: harvest duration in days. Level of significance: ** for 1% and * for 5% level of significance.

Table 2. GCA and SCA effects in ANOVA for 7 x 7 half diallel populations of 11 agronomic traits in bottle gourd.

Source of variance	Traits											
	df.	NFMF	NFFF	DFMF	DFFF	DFEH	FL	FD	FW	FPP	YPP	HD
GCA	6	1.32**	3.37**	10.24**	15.99**	14.48**	7.27**	0.50**	0.03**	1.08*	6.50**	23.47**
SCA	21	0.85**	3.48**	18.72**	18.90**	18.70**	11.23**	0.37**	0.04**	2.62**	19.46**	77.39**
Error	54	0.04	0.06	0.07	0.05	0.04	0.00	0.00	0.00	0.41	1.36	0.05
GCA/SCA		1.56	0.97	0.55	0.85	0.77	0.65	1.33	0.68	0.41	0.33	0.30

GCA: general combining ability, SCA: specific combining ability, GCA/SCA: additive and dominance ratio.

The GCA variance was estimated for choosing parents for hybridization. The maximum GCA effect was solely found for the parent BG714, which was a significant and positive value for 1.21* and 0.68* in the trait yield per plant and fruits per plant, respectively (Table 3). The significant and positive value (2.42**) was found as well in the trait harvest duration for this parent. Thus, BG714 was considered a superior general combiner among the parents for enhancing the fruits, yield, and harvest duration and suggested for selecting parents in hybridization in bottle gourd. Similar findings were reported in lablab bean, where notable and positive GCA variance indicated the selection of parents in the trait yield per plant (Rony and Islam 2025). The parents, BG722 and BG717, were found to have significant positive values 0.07** and 0.04*, respectively, for fruit weight. The significant and negative GCA effects were observed for all the parents except HAJARI (0.39**) and BG725 (0.26**) for fruit diameter. Thus, HAJARI parent was proven for good general combiner followed by BG725 for increasing fruit diameter. In the case of, fruit length, all the parents showed significant and positive scores except HAJARI (-1.94**) and BG725 (0.02). The parents BG714, BG717, BG719, and BG720 showed significant negative GCA effects for the traits of days to the first female flower and days to the first edible harvest. The notable and largest negative GCA impacts of -1.48** and -1.52** were noted in BG714 for the first edible harvest duration and the days to first female flower, respectively. A similar result of significant and negative GCA variance was found in the parents' 72-1-1-1-4 and 62-12-1-1-1-4 suggested a good general combiner for the first female flower in bottle gourd (Masud *et. al.* 2021). BG714 was considered a good general combiner for early harvest in this study.

Significant SCA effects indicated that heterosis breeding could be used to enhance traits that demonstrate non-additive gene action (Mkhize *et. al.* 2021). The SCA effects were analyzed to identify the suitability of heterosis breeding in 21 crosses (Table 4). The significant and sequential positive SCA effect was exhibited 5.62**, 4.51**, 2.75* and 2.55* in BG714 × BG722, BG714 × BG717, HAJARI × BG719 and BG719 × BG725, HAJARI × BG714, respectively for the trait yield per plant. The positive but non-significant SCA effects were 2.08, 1.18, 1.07, and 0.41 for BG720 × BG725, BG714 × BG720, BG722 × BG725, and HAJARI × BG714, respectively. The remaining hybrids showed negative and significant or non-significant results for yield per plant in this study. The BG714 × BG717, BG714 × BG722, and HAJARI × BG719 hybrids exhibited significant specific combining ability effects with values of 6.90** 6.22** and 4.76** for harvest duration in addition to yield per plant. The highest positive and significant SCA effect 9.78** was observed for BG719 × BG720 followed by 7.85** in BG717 × BG725 for the trait harvest duration. The significance of these hybrids was limited to harvest duration. The top yield-scoring hybrids, BG714 × BG717 and BG714 × BG722, also exhibited significant and positive SCA effects for fruits per plant, with values of 1.86** and 1.81**, respectively. HAJARI × BG719, BG714 × BG722, and BG719 × BG725 hybrids were considered superior specific combiners as showing significant and positive values of 0.24**, 0.17**, and 0.15**, respectively, in fruit weight besides yield. BG714 × BG722, a hybrid, was found most extreme negative value of -7.09** and -6.82** for the different traits, days to first female flower opening and days to first edible harvest, respectively. The similar result was estimated for Pant Lauki-3 × NDBG-104 with a significant maximum negative SCA value of -4.24** and -5.34 ** for days to first female flowering and days to first fruit harvest, respectively (Keshari and Singh 2024). The significant and negative values of -6.82**, -6.60**, -5.38**, -2.84** and -0.95** were noticed in BG714 × BG722, BG719 × BG725, BG720 × BG725, BG714 × BG720 and BG714 × BG717, respectively for days to first edible harvest. These hybrids were also observed in a similar order of significant and negative SCA effects with values of -7.09**, -6.42**, -5.42**, -2.67** and -0.69** for days to first female flower opening.

Table 3. Estimation of general combining ability (GCA) effects for 7 parents of 11 agronomic traits in bottle gourd.

Parents	Traits										
	NFMF	NFFF	DFMF	DFFF	DFEH	FL	FD	FW	FPP	YPP	HD
HAJARI	0.81**	-0.60**	1.44**	2.17**	1.95**	-1.94**	0.39**	-0.10**	-0.13	-1.40**	-2.22**
BG714	-0.27**	-1.01**	-1.13**	-1.52**	-1.48**	0.34**	-0.09**	-0.01	0.68*	1.21*	2.42**
BG717	-0.13	0.29**	-0.65**	-1.27**	-1.28**	0.12**	-0.16**	0.04*	0.14	0.75	-0.20*
BG719	-0.03	0.04	0.22*	-0.58**	-0.40**	0.12**	-0.03*	0.02	-0.23	-0.29	-1.18**
BG720	-0.18*	0.28**	-1.27**	-0.29**	-0.39**	0.56**	-0.13**	-0.01	0.09	0.04	-0.11
BG722	-0.30**	0.81**	1.14**	1.25**	1.25**	0.78**	-0.24**	0.07**	-0.34	0.19	-0.49**
BG725	0.09	0.19*	0.25*	0.24*	0.35*	0.02	0.26**	0.00	-0.21	-0.50	1.78**
SE(gi) =	0.06	0.07	0.08	0.07	0.06	0.01	0.01	0.01	0.20	0.36	0.07
SE(sij) =	0.18	0.22	0.24	0.20	0.18	0.04	0.03	0.04	0.57	1.05	0.19

Table 4. Estimation of specific combining ability effects for 21 crosses synthesized from a 7 x 7 half diallel populations of 11 agronomic traits in bottle gourd.

Crosses	Traits										
	NFMF	NFFF	DFFM	DFFFO	DFEH	FL	FD	FW	FPP	YPP	HD
HAJARI × BG714	0.09	1.83**	0.49*	0.30	0.20	-0.22**	0.43**	0.01	0.21	0.41	1.22**
HAJARI × BG717	0.02	-1.85**	1.14**	2.21**	2.21**	-0.98**	-0.27**	0.06	-0.40	-0.18	-0.42*
HAJARI × BG719	-0.09	-1.60**	3.23**	2.38**	2.49**	2.94**	-0.58**	0.24**	0.01	2.55*	4.76**
HAJARI × BG720	0.95**	1.50**	5.72**	4.36**	4.66**	-3.37**	-1.23**	-0.23**	-1.51*	-5.00**	-7.67**
HAJARI × BG722	0.19	-1.33**	0.29	0.55**	0.17	-2.62	-0.37**	-0.04	-1.43*	-2.91*	-0.56**
HAJARI × BG725	0.68**	1.58**	4.27**	3.83**	3.92**	-5.77**	0.26**	-0.30**	0.33	-2.73*	-4.55**
BG714 × BG717	-0.08	-0.56*	-0.41	-0.69**	-0.95**	-2.28**	0.22**	0.08	1.86**	4.51**	6.90**
BG714 × BG719	1.00**	-0.45*	6.81**	6.20**	6.37**	-3.26**	-0.10**	-0.24**	-0.89	-4.32**	-5.24**
BG714 × BG720	-1.22**	-1.36**	-4.03**	-2.67**	-2.84**	-2.72**	-0.75**	0.14**	-0.12	1.18	-3.76**
BG714 × BG722	-2.13**	-1.89**	-4.69**	-7.09**	-6.82**	1.95**	0.11**	0.17**	1.81**	5.62**	6.62**
BG714 × BG725	-0.30	0.95**	1.69**	1.09**	1.00**	3.69**	-0.21**	-0.03	-0.57	-1.34	-4.37**
BG717 × BG719	-0.41*	0.84**	0.17	0.58**	0.45*	-2.07**	-0.04	-0.09*	0.52	-0.22	-2.61**
BG717 × BG720	1.08**	2.90**	5.69**	4.66**	4.51**	-0.54**	0.26**	-0.20**	-1.80**	-5.44**	-11.69**
BG717 × BG722	-0.05	3.47**	-0.82**	-0.16	0.22	-1.75**	0.36	-0.02	-4.16**	-8.51**	-19.09**
BG717 × BG725	-0.28	0.69**	2.34**	1.98**	1.93**	1.95**	-1.09**	-0.18**	-0.07	-2.24*	7.85**
BG719 × BG720	-0.28	1.97**	2.99**	2.58**	2.97**	-0.54**	1.08**	-0.05	-0.41	-1.30	9.78**
BG719 × BG722	-0.15	1.36**	-0.56*	1.04**	1.30**	-2.73**	0.24**	-0.23**	-1.51*	-5.13**	-18.17**
BG719 × BG725	-1.42**	-2.25**	-5.09**	-6.42**	-6.60**	1.95**	-0.27**	0.15**	0.54	2.75*	-2.10**
BG720 × BG722	1.10**	0.09	4.96**	6.28**	5.36**	-4.14**	0.34**	-0.29**	0.75	-2.22*	8.15**
BG720 × BG725	-0.39*	-1.75**	-5.42**	-5.42**	-5.38**	3.47**	-0.16**	0.31**	-0.63	2.08	5.89**
	0.83**	1.28**	1.48**	2.48**	2.80**	0.38**	0.70**	0.18**	-0.37	1.07	2.87**
SEd (gi-gj) =	0.09	0.11	0.12	0.11	0.09	0.02	0.01	0.02	0.30	0.55	0.10
SEd (Sij-Sik) =	0.27	0.32	0.35	0.30	0.26	0.06	0.04	0.06	0.85	1.56	0.28

The mean values of 7 parents, 21 crosses, and two commercial check varieties were determined for 11 traits, and their differences in bottle gourd (Table 5). Superior hybrids were identified through heterosis estimation in bottle gourd (Doloi *et. al.* 2018). The better parent heterosis and standard heterosis for the check varieties Diana and Moyna were analyzed concerning the key traits yield per plant and days to the first edible harvest (Table 5). The highest positive statistically significant heterobeltiosis 26.37% was observed for HAJARI × BG725, followed by three high scores 24.56, 24.07 and 22.21% for HAJARI × BG719, BG719 × BG722, and HAJARI × BG720, respectively, for yield per plant in bottle gourd. It was noted that the highest mean performance was associated with HAJARI × BG719 value of 28.29 kg/plant, which was significantly similar to BG719 × BG722, with 27.77 kg/plant. The hybrid, BG719 × BG720, was found -15.30% which was the maximum negative and statistically significant heterobeltiosis for days to first edible harvest. The lowest mean performer was 58.58 days for the hybrid BG719 × BG722. The mean performance of BG719 × BG720 was marked for 60.51 days, which was statistically similar to 58.58 days in BG719 × BG722. Besides, earliness and yield traits, the mean values for different traits were statistically varied. The maximum value of 96.82 days among the 21 crosses for harvest duration was found for the HAJARI × BG719, HAJARI × BG725, and BG719 × BG722. These hybrids were mathematically alike to check varieties of Diana and Moyna with values of 96.20 days and 94.87 days, respectively. HAJARI × BG719 hybrid was estimated maximum mean performance of 2.07 kg for single fruit weight.

Standard heterosis is very important for the selection of commercial hybrids compared to market-leading varieties (Nedi *et al.* 2017). HAJARI × BG719, the hybrid manifested the highest positive and significant standard heterosis for both the check varieties of Diana and Moyna, giving values were 14.09% and 8.96%, respectively, in yield per plant. In consideration of early edible harvest, comparing the checks, the highest negative standard heterosis was exhibited -5.90 and -7.52% in BG719 × BG722 for both the check varieties of Diana and Moyna, respectively, (Table 6). Thus, HAJARI × BG719 was manifested superior hybrid in terms of yield, followed by earliness based on standard heterosis estimation. In, contrast, BG719 × BG722 was identified as the worthier hybrid when reviewed as an early variety, followed by yield in the case of standard heterosis estimation. The maximum average performance of 28.29 kg/plant was detected by the hybrid, HAJARI × BG719, followed by 27.77 kg/plant in BG719 × BG722, which was statistically equivalent. In consideration of the average performer of the first edible harvest, the lowest value was 58.18 days by BG719 × BG722, followed by 58.49 days recorded in HAJARI × BG719, which was also not statistically different. The hybrid, HAJARI × BG719 and BG719 × BG722, were selected together for superior performance in yield and earliness in accordance with the mean performer, as well as estimation of standard heterosis of Diana and Moyna. Therefore, this study suggested that HAJARI × BG719, a hybrid, was superior for higher yield and early harvest in bottle gourd.

The present study emphasized the importance of GCA and SCA influences, demonstrating that both additive and non-additive gene effects were essential for the manifestation of all 11 traits. The ratios of GCA/SCA for yield per plant and harvest duration were significantly below one, indicating the existence of non-additive gene action in trait inheritance. The BG714 was identified as a sole parent for enhancing yield besides earliness. The hybrid, BG714 × BG722, was considered the top specific combiner with the value for increasing yield and early harvest in bottle gourd and suggested for heterosis breeding in bottle gourd. The significant maximum positive heterobeltiosis was estimated in HAJARI × BG725 for the trait yield per plant. The most average performance of 28.29 kg/plant corresponded to the HAJARI × BG719 hybrid. The hybrids, HAJARI × BG719 and BG719 × BG722, were selected as superior for their higher yield and early harvest, consistent with the average performance and heterosis evaluation for Diana and Moyna.

Table 5. Mean performance table of seven parents, 21 crosses, and two check varieties for 11 traits in bottle gourd.

Crosses	Traits										
	NFMF	NFFF	DFFM	DFFFO	DFEH	FL	FD	FW	FPP	YPP	HD
HAJARI	7.36	16.37	56.27	57.42	66.22	35.35	9.67	1.67	11.07	18.76	97.13
BG714	7.20	17.48	56.27	58.18	67.40	33.39	11.56	1.77	10.67	19.21	96.20
BG717	7.20	17.41	55.13	58.18	67.38	31.43	10.62	1.67	9.13	15.53	67.87
BG719	6.33	13.19	49.71	49.71	58.58	35.35	10.62	1.97	11.31	22.71	86.20
BG720	8.30	16.37	59.16	63.71	71.44	30.46	10.62	1.58	11.71	18.77	95.27
BG722	7.20	13.92	47.89	51.00	59.80	37.31	10.62	2.11	10.47	22.38	95.27
BG725	8.30	17.48	57.20	60.44	69.62	34.44	11.37	2.06	10.29	21.51	91.87
HAJARI × BG714	8.39	13.92	49.64	54.00	62.31	34.37	12.32	1.74	12.36	21.89	86.87
HAJARI × BG717	8.46	13.92	52.13	54.87	63.78	35.35	10.62	1.74	11.42	20.14	91.87
HAJARI × BG719	7.28	13.04	48.98	49.64	58.49	36.33	10.62	2.07	13.51	28.29	96.82
HAJARI × BG720	8.30	15.34	51.00	52.13	60.93	35.35	10.43	1.96	11.62	23.01	92.13
HAJARI × BG722	6.72	14.07	46.82	51.00	59.80	38.29	10.62	1.95	13.27	26.19	87.13
HAJARI × BG725	7.20	15.34	56.27	57.42	66.22	39.27	9.48	2.06	12.98	27.18	96.82
BG714 × BG717	8.30	15.34	55.20	58.18	67.09	30.46	11.56	1.76	11.18	19.96	88.47
BG714 × BG719	8.31	15.41	55.13	57.42	65.89	31.43	11.37	1.72	11.98	20.97	89.13
BG714 × BG720	8.38	13.04	56.27	59.58	68.11	30.46	10.62	1.81	10.82	19.93	84.87
BG714 × BG722	8.38	13.04	59.22	60.44	69.27	34.37	10.43	1.96	10.87	21.61	89.07
BG714 × BG725	9.27	16.37	60.22	62.71	71.44	28.50	9.67	1.47	9.67	14.40	77.71
BG717 × BG719	8.38	14.07	57.20	60.44	68.60	29.48	10.43	1.74	9.31	16.64	84.44
BG717 × BG720	9.27	16.37	60.29	62.71	71.44	25.56	11.56	1.41	11.20	16.13	82.71
BG717 × BG722	7.20	13.92	52.13	53.00	61.51	31.43	10.62	1.93	13.89	27.21	96.82
BG717 × BG725	8.38	13.78	60.22	60.58	69.71	30.46	10.43	1.58	10.78	17.35	83.71
BG719 × BG720	6.01	13.11	47.89	52.00	60.51	31.43	9.67	1.93	11.87	23.18	86.27
BG719 × BG722	4.98	13.11	49.64	49.11	58.18	36.33	10.43	2.04	13.36	27.77	96.27
BG719 × BG725	7.20	15.34	55.13	56.29	65.09	37.31	10.62	1.77	11.11	20.12	87.53
BG720 × BG722	7.12	16.37	54.07	55.20	64.00	31.43	10.43	1.78	11.64	20.99	83.71
BG720 × BG725	8.46	18.67	58.09	59.58	68.07	33.39	10.62	1.64	9.64	16.11	75.71
Diana	7.20	13.19	49.78	51.00	61.82	32.41	10.62	2.06	11.89	24.79	96.20
Moyna	6.09	14.07	49.71	52.13	62.91	31.43	10.62	1.98	12.91	25.96	94.87
HSD =	1.69	2.11	3.25	3.44	4.98	1.92	1.14	0.31	5.15	12.39	4.61
CV =	12.42	7.82	3.36	3.43	4.28	3.23	6.00	9.46	25.51	32.89	2.92

Table 6. Estimation of heterobeltiosis and standard heterosis over Diana and Moyna, for 21 hybrids in a 7 x 7 half diallel population in bottle gourd.

Crosses	Heterobeltiosis		Standard heterosis (Diana)		Standard heterosis (Moyna)	
	DFEH	YPP	DFEH	YPP	DFEH	YPP
HAJARI × BG714	-7.55**	16.69**	0.79**	-11.70**	-0.95**	-15.67**
HAJARI × BG717	-5.34**	7.34**	3.16**	-18.77**	1.38**	-22.42**
HAJARI × BG719	-11.68**	24.56**	-5.39**	14.09**	-7.03**	8.96**
HAJARI × BG720	-14.71**	22.61**	-1.44**	-7.21**	-3.14**	-11.38**
HAJARI × BG722	-9.70**	17.02**	-3.27**	5.62**	-4.95**	0.88
HAJARI × BG725	-4.88**	26.37**	7.12**	9.63**	5.26**	4.71**
BG714 × BG717	-0.46**	3.93**	8.52**	-19.49**	6.64**	-23.11**
BG714 × BG719	-2.24**	-7.66**	6.58**	-15.42**	4.73**	-19.22**
BG714 × BG720	-4.67**	6.18**	10.17**	-19.64**	8.27**	-23.25**
BG714 × BG722	2.77**	-3.43**	12.04**	-12.83**	10.10**	-16.75**
BG714 × BG725	2.62**	-33.05**	15.56**	-41.92**	13.56**	-44.53**
BG717 × BG719	1.81**	-26.74**	10.96**	-32.90**	9.04**	-35.91**
BG717 × BG720	0.00^{NS}	-14.04**	15.56**	-34.95**	13.56**	-37.87**
BG717 × BG722	-8.71**	21.60**	-0.50**	9.76**	-2.23**	4.83**
BG717 × BG725	0.13 ^{NS}	-19.34**	12.76**	-30.02**	10.81**	-33.17**
BG719 × BG720	-15.30**	2.09*	-2.12**	-6.49**	-3.81**	-10.70**
BG719 × BG722	-2.71**	24.07**	-5.90**	11.99**	-7.52**	6.95**
BG719 × BG725	-6.51**	-11.39**	5.28**	-18.84**	3.46**	-22.49**
BG720 × BG722	-10.42**	-6.20**	3.52**	-15.33**	1.73**	-19.14**
BG720 × BG725	-2.23**	-25.13**	10.10**	-35.04**	8.19**	-37.96**
BG722 × BG725	-6.03**	-41.12**	5.82**	-46.85**	3.99**	-49.24**
S.E.	0.16	0.95	0.16	0.94	0.16	0.94
C.D. value (0.05)	0.33	1.96	0.32	1.94	0.32	1.94
C.D. value (0.01)	0.44	2.64	0.43	2.62	0.43	2.62

References

BBS (Bangladesh Bureau of Statistics) 2025. Yearbook of Agricultural Statistics 2024. Statistics and Information Division, Ministry of Planning, Bangladesh. 313 pp.

Dhakad GG, Tambe KP and Jaiswal SP 2022. Review on study of bottle gourd on human health. Res. J. Pharmac. Pharmacodyn. **14**(3): 174-178.

Doloi N, Patel JN and Acharya RR 2018. Heterosis studies in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. Vegetos **31**(1): 1-5.

Griffing B 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci. **9**(4): 463-493.

Hallauer AR, Carena MJ and Miranda Filho JB 2010. Quantitative Genetics in Maize Breeding. 3rd ed. Springer, New York. pp. 400-418.

Jha A, Mishra S, Singh B and Pandey S 2016. Combining ability and heterosis for yield and quality characters in bottle gourd. Veg. Sci. **43**(2): 163-167.

Keshari D and Singh DK 2024. Estimation of combining ability effect for hybrid breeding in bottle gourd [*Lagenaria siceraria* (Molina) Standl.] using diallel mating design. J. Exp. Agric. Int. **46**(9): 376-384.

Manivannan A 2024. Combining ability studies in desi cotton (*Gossypium arboreum* L.) genotypes. J. Cotton Res. **7**(37): 1-11.

Masud MAT, Azam MG, Hasan MZ, Rashid ASMH, Bagum SA and Uddin MS 2021. Heterosis and combining ability for yield and yield contributing characters in bottle gourd. J. Global Agric. Ecol. **11**(4): 13-20.

Mkhize P, Mashilo J and Shimelis H 2021. Progress on genetic improvement and analysis of bottle gourd [*Lagenaria siceraria* (Molina) Standl.] for agronomic traits, nutrient compositions, and stress tolerance: A review. Front. Sustain. Food Syst. **5**: 683635.

Nedi G, Tulu L and Alamerew S 2017. Standard heterosis of the selected maize (*Zea mays* L.) inbred lines hybrids for grain yield and yield component at Jimma, South West Oromia Region, Ethiopia. J. Biol. Agric. Healthcare **7**(17): 51-58.

Pandey R and Riya SR 2023. Production Technology of Vegetable Crops. Daya Publishing House, Himachal Pradesh, India. pp. 336-337.

Paril J, Reif JC, Level AF and Pourkheirandish M 2024. Heterosis in crop improvement. Plant J. **117**(1): 23-32.

Rony MBU and Islam AKMA 2025. Combining ability and heterosis of yield related traits in lablab bean. Vegetos **38**(3): (In press).

Tulluru NK, Jyothi KU, Babu MR, Paratpararao M, Kumari KU and Sekhar V 2023. Exploitation of additive and non-additive gene action for qualitative and quantitative traits in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.). Pharma Innov. J. **12**(8): 2120-2122.

Yadav A, Yadav GC, Abha R, Singh V and Yadav P 2023. Estimation of heterosis for yield and quality traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] over seasons under salt affected soil. Int. J. Plant Soil Sci. **35**(18): 1887-1903.

Yawalkar KS 1985. Vegetable Crops of India. Agri-Hortic. Publ. House. 500 pp.

(Manuscript received 20 July, 2025; revised on 22 September, 2025)