International Journal of Plant & Soil Science

Volume 35, Issue 21, Page 470-486, 2023; Article no.IJPSS.108199
ISSN: 2320-7035

Interpretation of Mean Values and Extent of Heterosis Bottle Gourd [*Lagenaria siceraria* (Mol.) Standl.]

C. J. Patel [a], R. N. Patel [b], R. A. Gami [c*] and B. A. Gameti [a]

[a] Department of Genetics and Plant Breeding, CPCA, S. D. Agricultural University, Sardarkrushinagar- 385 506, Gujarat, India.
[b] Potato Research Station, S.D. Agricultural University, Deesa-385 535, Gujarat, India.
[c] Centre for Millets Research, S.D. Agricultural University, Deesa-385 535, Gujarat, India.

Authors' contributions

This work was carried out in collaboration among all authors. Authors CJP, RNP and RAG equally contributed in the research work and manuscript preparation. Author BAG helped to performed the statistical analysis and manuscript preparation. All authors read approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i214001

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/108199

Original Research Article

Received: 17/08/2023
Accepted: 19/10/2023
Published: 20/10/2023

ABSTRACT

Aims: To Study the mean values and heterosis for fruit yield with associated traits of bottle gourd.
Study Design: Randomized block design.
Place and Duration of Study: The seeds of F_1 hybrids were produced during summer 2021 at Potato Research Station, S. D. Agricultural University, Deesa.
Methodology: The experimental material consisted of twelve parents, their 35 Line × Tester crosses and one standard check (ABGH 1).
Results: The study was undertaken to reveal mean and per cent heterosis level in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. An examination of mean data of parents with (F_1) hybrids for fruit yield and associated traits revealed that DBG 5 amongst females and ABGS 11-17 amongst

**Corresponding author: E-mail: ramangami@sdau.edu.in;*

males, while NDBG 132 × PUNJAB LONG, LOCAL × ABGS 14-25, and LOCAL × ABGS 11-17 amongst hybrids exhibited higher mean value for fruit yield per plant with some of its associated traits. The significant relative heterosis, heterobeltiosis and standard heterosis were perceived in many hybrids for different component traits. The F_1 hybrids, NDBG 132 × PUNJAB LONG (75.30, 53.04 & 21.64 %), LOCAL × ABGS 14-25 (34.99, 27.77 and 20.71 %) and LOCAL × ABGS 11-17 (31.82, 23.49 and 19.27 %) manifested significant and positive heterosis over mid parent, better parent and the standard check ABGH 1 for fruit yield per plant. These crosses were also given best mean performance, hence hold promising for commercial exploitation.

Conclusion: The analysis of variance revealed that significant differences among the parents for all traits. This indicated a sufficient variability in the parents (*i.e.*, lines and testers) for studied trait. The best heterotic crosses NDBG 132 × PUNJAB LONG, LOCAL × ABGS 14-25, LOCAL × ABGS 11-17 and GPBG 108 × ABGS 11-24 for fruit yield per plant revealed significant positive heterosis over mid parent, better parent and standard check.

Keywords: Fruit yield; heterobeltiosis; L × T analysis; mean performance; relative heterosis and standard heterosis.

1. INTRODUCTION

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is one of the important cucurbitaceous vegetable having a wide range of uses and it is cultivated largely in the tropics and subtropics for its edible fruits. It is a commonly grown vegetable in India throughout the year having chromosome number of 2n = 22. This vegetable is also known by various names *viz*., bottle squash, calabash gourd, trumpet gourd, Zucca melon, white flowered gourd, doodhi, lowki, *etc*. It is an important warm-season fruit vegetable. The center of origin has been located in the coastal areas of Malabar (North Kerala) and the humid forests of Dehradun (North India).

Heterosis is a per cent rise or in performance of hybrid over the parental performance given by Mutazing [1]; Pal and Singh [2]. The information on the extent of heterosis for yield and associated characters is vital to choose better combinations to exploit them through heterosis breeding. Heterosis has been effectively exploited in both allogamous and autogamous crops. One of the present research goals was to evaluate hybrid vigour to recognize the genetic makeup of parents and to create Mendelian variability through segregation or recombination in advanced generations of the crosses. In real plant breeding, the heterosis estimated over better parent and standard parent is more accurate and more practical.

2. MATERIALS AND METHODS

The study was undertaken to reveal mean and per cent heterosis level in bottle gourd. The 35 (F_1) hybrids were generated through L × T fashion during early summer, 2021 at Potato Research Station, S. D. Agricultural University, Deesa (Gujarat) using five females (ABG 1, NDBG 132, GPBG 108, DBG 5 and Local) and seven males (ABGS 11-24, ABGS 11-19, ABGS 14-25, ABGS 14-27, Punjab Long, ABGS 11-17, GPBG 109). The resulting 35 hybrids with twelve parents and one standard check (ABGH 1) were evaluated in Randomized Block Design (RBD), in four replications during *Kharif*, 2021. Each genotype was sown in two rows with the plot size 4 m × 5 m. The distance between rows and within row was 2 m and 1 m, respectively. Observations on various quantitative as well as qualitative characters were recorded from three randomly selected plants in each genotype in each replication. The average of three plants for each genotype in each replication has been worked out for each character. The moisture content in randomly selected three fruits was determined on a fresh weight basis. A quantity of 100 g of fresh fruit was taken, cut into small pieces and allowed for sun-drying and then dried in the oven at 100°C for 8-10 hours till the complete drying to have constant weight and moisture percentage was calculated as:

$$\text{Moisture content (\%)} = \frac{\text{W1} - \text{W2}}{\text{W1}} \text{ x } 100$$

Where,

W_1= Mass of the original sample (g)
W_2= Mass of the sample after drying (g)

Total soluble solids calculated as after harvesting the fruits were cutted into small pieces and juice were extracted by squeezing and observed using hand refractometer (IRMA Japan make); reading

were recorded through eye lens. Chlorophyll *a, b* and total were estimated by the method described by Hiscox and Israelstam [3]. They were calculated by the formula as given by Arnon [4].

$$\text{Chlorophyll } a = \frac{12.7(A_{663})\text{-}2.69(A_{645})\times V}{w}$$

$$\text{Chlorophyll } b = \frac{22.8(A_{645})\text{-}4.68(A_{663})\times V}{w}$$

Total chlorophyll = Chlorophyll a + Chloropyll b

Where,

A_{645} = Absorbance at 645 nm,
A_{663} = Absorbance at 663 nm,
w = Fresh weight (g) of tissue extracted, and
v = The final volume of chlorophyll extract in DMSO (ml).

Based on mean data, the analysis of variance (ANOVA) was carried out as per the method suggested by Snedecor and Cochran [5] and reviewed by Panse and Sukhatme [6]. The per cent heterosis was estimated as per cent increase or decrease in the mean value of F_1 hybrid over mid parent, *i.e.,* relative heterosis by Briggle [7], over better parent, *i.e.,* heterobeltiosis by Fonseca and Patterson [8] and over standard check, *i.e.,* standard heterosis by Meredith and Bridge [9] for each character.

Relative heterosis was measured in percentage by using following formula

$$\text{Relative heterosis (\%)} = \frac{\overline{F_1}\text{-}\overline{MP}}{\overline{MP}}\times 100$$

Heterobeltiosis was measured in percentage by using following formula

$$\text{Heterobeltiosis (\%)} = \frac{\overline{F_1}\text{-}\overline{BP}}{\overline{BP}}\times 100$$

The standard heterosis was measured in percentage by using following formula

$$\text{Standard heterosis (\%)} = \frac{\overline{F_1}\text{-}\overline{SC}}{\overline{SC}}\times 100$$

Where,

$\overline{MP}$ = Mean performance of mid parent
$\overline{BP}$ = Mean performance of better parent
$\overline{SC}$ = Mean performance of standard check *i.e.,* ABGH 1.
$\overline{F_1}$ = Mean value of F_1.

The significance of heterosis value was tested using‘t’ test

$$t = \frac{\overline{F_1}\text{-}\overline{MP} \text{ OR } \overline{BP} \text{ OR} \overline{SC}}{\text{S. E of heterosis over MP or BP or SC}}$$

Calculated ‘t’ value was equated with table’ t’ value sat error degree of freedom for test of significance.

The heterosis can be classified as low, moderate and high based on estimates. The level of heterosis varies from trait to trait. In the present study following criteria was used to classify heterosis level, *i.e.,* low, moderate and high described by Joshi et al*.* [10].

Lowest range = X + lowest value,

Moderate range = 2X + lowest value, and

High range = 3X + lowest value (rest upper).

Where,

X= Mean value obtained by total range value divided by three.

3. RESULTS AND DISCUSSION

The analysis of variance for all the characters studied is presented in Table 1. The result revealed that the mean squares due to genotypes were highly significant for all the characters except fruit girth, which was significant. The significant differences among the parents were observed for all the traits except fruit girth. This indicated an adequate amount of variability in the parents (*i.e*., lines and testers) for all the traits for fruit girth. The mean sum of squares due to females (lines) were also significant for all the traits for the fruit girth and total soluble solids. The mean sum of squares due to males (testers) were also significant for all the traits except fruit girth. Further, the mean sum of squares for the hybrids were highly significant for all the traits. The mean sum of squares due to females *vs.* males were significant for days to first male flower appearance, days to first female flower appearance, node number at which first male flower appearance, number of branch per plant, fruit length, average fruit weight, number of fruit

per plant, fruit yield per plant, moisture content, chlorophyll *b* and total chlorophyll. The mean sum of squares due to parents *vs.* hybrids were significant for days to first male flower appearance, days to first female flower appearance, node number at which first male flower appearance, node number at which first female flower appearance, number of branch per plant, fruit length, number of fruit per plant, fruit yield per plant, total soluble solids, chlorophyll a, chlorophyll b and total chlorophyll which indicated the presence of enormous heterosis for these traits. The mean sum of squares due to females *vs.* males were significant for days to first male flower appearance, days to first female flower appearance, node number at which first male flower appearance, number of branch per plant, fruit length, average fruit weight, number of fruit per plant, fruit yield per plant, moisture content, chlorophyll *b* and total chlorophyll.

The mean performance of parents and hybrids for yields and their traits is presented in Table 2. None of the parents (i.e., females or males) shows consistently good performance for all the traits. Considering the primary breeding objective, i.e., high yielding, the parental genotype DBG 5 was rewarded with higher fruit yield per plant (kg). In addition, it was also performed considerably good for the number of fruit per plant.

In the case of hybrids, the cross NDBG 132 × PUNJAB LONG was exhibited its superiority for fruit yield per plant (kg). On the other hand, the hybrid LOCAL × ABGS 11-17 showed superior mean performance for average fruit weight (g), number of fruit per plant and total soluble solids (ºBrix). The hybrids GPBG 108 × ABGS 14-27, ABG 1 × GPBG 109, ABG 1 × ABGS 14-27, NDBG 132 × ABGS 11-19, DBG 5 × ABGS 11-17 and DBG 5 × ABGS 11-19 were found better for node number at which first male flower appearance, node number at which first female flower appearance, number of branch per plant, fruit length (cm), fruit girth (cm) and moisture content (%), respectively. The high-yielding cross combination NDBG 132 × PUNJAB LONG took a minimum days to set first female flower. The cross combination ABG 1 × GPBG 109 showed maximum content of chlorophyll a and total chlorophyll (µg/g F.W.).

In the present investigation, the heterosis was measured over mid parent, better parent and standard check ABGH 1 presented in Table 3. In the present study, for fruit yield per plant, out of 35 hybrids, nineteen, eleven and four hybrids registered significant and positive heterosis over the mid parent, better parent and the standard check ABGH 1, respectively. A wide range of heterosis over mid parent, better parent and the standard check was recorded, i.e., -51.17 to 75.30 over mid parent (relative heterosis), -52.60 to 53.04 per cent over the better parent (heterobeltiosis) and -61.18 to 21.64 per cent over standard check ABGH 1 for fruit yield per plant. The hybrids NDBG 132 × PUNJAB LONG (75.30, 53.04 & 21.64%), LOCAL × ABGS 14-25 (34.99, 27.77 & 20.71%), LOCAL × ABGS 11-17 (31.82, 23.49 & 19.27%) and GPBG 108 × ABGS 11-24 (42.43, 41.15 & 13.17%) manifested significant and positive heterosis over mid parent, better parent and the standard check ABGH 1 for fruit yield per plant. The positive and significant heterotic values were also reported by Ray et al. [11], Parmar et al. [12], Doloi et al. [13], Mishra et al. [14], Odedara et al. [15] and Lal et al. [16] for fruit yield per plant.

A comparative study of best heterotic crosses NDBG 132 × PUNJAB LONG, LOCAL × ABGS 14-25, LOCAL × ABGS 11-17 and GPBG 108 × ABGS 11-24 for fruit yield per plant revealed significant positive heterosis over mid parent, better parent and standard check. These hybrids also showed significant and positive heterosis over mid parent, better parent or standard check for various component characters viz., days to first male flower appearance, days to first female flower appearance, node number at which first male flower appearance, node number at which first female flower appearance, number of branch per plant, fruit length, average fruit weight, number of fruit per plant, fruit yield per plant, moisture content, total soluble solids, chlorophyll *a,* chlorophyll *b* and total chlorophyll presented in Table 4.

The results revealed that the extent of heterosis varied from the cross to cross for all the traits. For any one trait, certain hybrids expressed considerable high heterosis, while it was low in other hybrids, suggesting that the selection of parents has an important bearing on the performance of any hybrid. The superiority of hybrids over standard check was presented in Table 5. Such hybrids might be exploited as a basic material for breeding purposes.

Table 1. Analysis of variance showing mean sum of squares for various characters in bottle gourd

Sources of variation	d.f.	Days to first male flower appearance	Days to first female flower appearance	Node number at which first male flower appearance	Node number at which first female flower appearance	Number of branch per plant	Fruit length	Fruit girth
Replications	**3**	4.59	1.19	1.44	1.93	1.62*	24.10	2.70
Genotypes	**47**	58.37**	92.71**	19.44**	36.32**	97.97**	165.21**	16.51*
Parents	**11**	55.92**	75.29**	8.49**	7.19**	16.39**	114.50**	4.37
Females (Lines)	**4**	113.23**	73.70**	13.32**	7.89**	16.15**	258.04**	5.63
Males (Testers)	**6**	18.21**	87.77**	4.94**	7.88**	6.47**	25.20**	4.03
Hybrids	**34**	53.64**	100.16**	20.64**	38.08**	9.40**	143.09**	19.68**
Females *vs.* males	**1**	52.98**	6.83*	10.42**	0.21	76.85**	76.13**	1.42
Parents *vs.* hybrids	**1**	276.49**	77.73**	118.30**	331.10**	3882.11**	430.12**	28.55
Error	**141**	2.81	1.12	0.76	1.33	0.57	10.04	9.64
Replications	**3**	224.37	0.49*	0.06	2.15	0.22	44.13	4.15	32.55
Genotypes	**47**	60508.86**	20.46**	3.61**	26.81**	0.59**	12333.06**	1424.87**	11706.57**
Parents	**11**	50215.87**	23.21**	3.03**	29.41**	0.34**	6588.60**	1657.20**	5792.11**
Females (Lines)	**4**	24992.17**	3.16**	1.68**	54.24**	0.06	289.82**	222.81**	519.36**
Males (Testers)	**6**	69004.22**	38.40**	4.19**	3.89**	0.59**	11882.16**	1784.42**	9035.41**
Hybrids	**34**	65607.89**	19.61**	3.84**	27.26**	0.69**	14524.15**	909.94**	13693.55**
Females *vs.* males	**1**	38380.63**	12.26**	1.54**	83.24**	0.02	22.34	6631.49**	7423.29**
Parents *vs.* hybrids	**1**	364.60	12.08**	2.96**	0.10	0.52*	1025.08**	16376.74**	9208.43**
Error	**141**	98.25	0.17	0.03	0.96	0.11	56.64	19.10	70.10

** and ** indicate significant at 5% and 1% levels of significance, respectively. Total genotypes include 1 standard check*

Table 2. Mean performance of parents and their hybrids for various characters in bottle gourd

Genotypes	Days to first male flower appearance	Days to first female flower appearance	Node number at which first male flower appearance	Node number at which first female flower appearance	Number of branch per plant	Fruit length (cm)	Fruit girth (cm)
Parents:							
Females/Lines							
ABG 1	47.00	47.08	11.83	13.32	12.92	38.42	18.25
DBG 5	46.58	52.08	10.92	13.17	8.75	38.25	17.50
GPBG 108	53.83	57.25	15.00	10.83	8.58	29.25	19.58
NDBG 132	59.42	47.08	11.72	14.66	8.92	49.25	16.92
LOCAL	50.67	49.00	10.25	12.42	11.75	47.25	19.50
Males/Testers							
ABGS 11-17	47.50	52.58	10.00	14.67	12.67	40.00	19.25
ABGS 11-19	49.75	48.18	10.09	12.92	14.50	37.75	17.92
ABGS 11-24	48.83	47.42	10.50	14.58	12.00	33.33	18.67
ABGS 14-25	52.17	61.08	12.58	11.42	12.50	40.17	17.75
ABGS 14-27	45.92	49.59	12.58	11.42	10.75	37.67	18.75
GPBG 109	50.83	51.25	10.75	13.92	14.17	40.17	17.42
PUNJAB LONG	50.58	48.75	10.50	12.18	12.67	36.42	16.25
Hybrids:							
ABG 1 × ABGS 11-17	47.42	53.42	12.00	13.83	23.00	39.17	17.92
ABG 1 × ABGS 11-19	47.67	47.75	7.58	7.50	23.92	46.92	19.00
ABG 1 × ABGS 11-24	46.17	53.00	8.08	9.17	22.42	43.83	17.92
ABG 1 × ABGS 14-25	45.00	48.17	7.42	5.92	22.83	34.83	17.42
ABG 1 × ABGS 14-27	48.17	59.75	12.00	14.25	24.17	41.33	18.50
ABG 1 × GPBG 109	46.17	47.00	7.25	3.50	19.33	35.83	17.58
ABG 1 × PUNJAB LONG	52.75	50.33	9.75	13.92	21.92	47.17	20.17
DBG 5 × ABGS 11-17	46.83	48.50	7.67	7.08	22.67	54.33	27.67
DBG 5 × ABGS 11-19	52.00	56.08	10.50	14.58	22.83	44.75	19.92
DBG 5 × ABGS 11-24	52.92	58.00	10.50	13.25	22.67	37.33	15.75
DBG 5 × ABGS 14-25	49.33	45.83	11.33	10.92	22.75	37.00	18.50
DBG 5 × ABGS 14-27	42.00	47.83	7.80	7.67	20.25	46.50	19.83

Genotypes	Days to first male flower appearance	Days to first female flower appearance	Node number at which first male flower appearance	Node number at which first female flower appearance	Number of branch per plant	Fruit length (cm)	Fruit girth (cm)
DBG 5 × GPBG 109	51.58	50.83	10.83	12.25	23.17	43.33	19.17
DBG 5 × PUNJAB LONG	46.50	44.50	9.83	11.42	17.83	34.00	18.04
GPBG 108 × ABGS 11-17	44.75	55.25	12.25	13.58	19.08	32.08	17.92
GPBG 108 × ABGS 11-19	57.92	60.25	11.72	12.00	21.83	43.50	19.92
GPBG 108 × ABGS 11-24	52.58	51.17	11.50	12.75	23.75	37.58	17.00
GPBG 108 × ABGS 14-25	47.58	47.92	11.67	8.50	23.00	42.83	19.25
GPBG 108 × ABGS 14-27	45.83	52.50	6.50	9.00	23.58	37.33	18.92
GPBG 108 × GPBG 109	44.25	43.58	8.00	11.92	23.17	38.58	18.42
GPBG 108 × PUNJAB LONG	47.33	46.25	14.08	12.92	23.33	30.67	21.50
NDBG 132 × ABGS 11-17	43.83	44.42	12.67	12.17	21.92	41.25	16.08
NDBG 132 × ABGS 11-19	47.75	48.83	7.17	6.33	21.17	56.75	19.00
NDBG 132 × ABGS 11-24	46.25	47.25	7.58	12.92	19.75	52.75	16.17
NDBG 132 × ABGS 14-25	44.83	45.25	7.33	6.33	22.17	46.58	20.08
NDBG 132 × ABGS 14-27	48.67	47.08	7.92	6.33	22.17	39.67	20.33
NDBG 132 × GPBG 109	44.25	45.75	13.83	11.42	22.42	42.17	21.17
NDBG 132 × PUNJAB LONG	42.08	42.92	9.92	6.54	21.50	49.83	17.58
LOCAL × ABGS 11-17	44.25	52.42	13.33	12.83	22.67	40.33	15.92
LOCAL × ABGS 11-19	48.17	47.92	7.25	8.42	22.75	45.17	19.33
LOCAL × ABGS 11-24	42.58	43.00	7.67	8.25	23.25	42.08	18.42
LOCAL × ABGS 14-25	44.92	43.58	9.42	9.17	19.25	43.67	20.00
LOCAL × ABGS 14-27	54.17	44.17	7.92	5.25	23.42	44.50	20.00
LOCAL × GPBG 109	45.17	59.83	6.58	7.17	20.75	43.33	18.58
LOCAL × PUNJAB LONG	50.00	51.17	8.25	7.92	22.92	49.17	23.42
ABGH 1 (STANDARD CHECK)	45.50	46.43	9.75	11.40	11.91	24.00	21.58
Parental mean	**50.26**	**50.95**	**11.39**	**12.96**	**11.68**	**38.99**	**18.15**
Hybrid mean	**47.48**	**49.47**	**9.57**	**9.91**	**22.10**	**42.46**	**19.04**
General mean (μ)	**48.13**	**49.79**	**10.03**	**10.71**	**19.30**	**41.21**	**18.88**
Range (Overall)	**42.00 to 59.42**	**42.92 to 61.08**	**6.50 to 15.00**	**3.50 to 14.67**	**8.58 to 24.17**	**24.00 to 56.75**	**15.75 to 27.67**
S.Em.±	**0.84**	**0.53**	**0.44**	**0.58**	**0.38**	**1.58**	**1.55**

Genotypes	Days to first male flower appearance	Days to first female flower appearance	Node number at which first male flower appearance	Node number at which first female flower appearance	Number of branch per plant	Fruit length (cm)	Fruit girth (cm)
CD at 5%	**2.34**	**1.48**	**1.23**	**1.61**	**1.06**	**4.43**	**4.34**
CV%	**3.48**	**2.13**	**8.78**	**10.78**	**3.93**	**7.69**	**16.45**

Genotypes	Average Fruit weight (g)	Number of fruit per plant	Fruit yield per plant (kg)	Moisture content (%)	Total soluble solids (ºBrix)	Chlorophyll *a* (µg/g F.W.)	Chlorophyll *b* (µg/g F.W.)	Total Chlorophyll (µg/g F.W.)
Parents:								
Females/Lines								
ABG 1	370.00	8.92	3.58	85.43	4.84	473.94	49.98	523.92
DBG 5	478.33	10.50	4.48	90.78	4.61	470.70	51.72	522.42
GPBG 108	446.67	8.17	3.61	94.24	4.89	458.83	39.90	498.73
NDBG 132	576.67	9.25	2.67	94.50	4.71	453.56	58.04	511.59
LOCAL	529.33	9.83	3.80	90.39	4.72	460.63	41.75	502.38
Males/Testers								
ABGS 11-17	579.58	10.75	4.35	94.11	4.58	434.78	44.17	478.95
ABGS 11-19	750.83	8.67	2.50	91.68	5.10	426.73	71.74	498.47
ABGS 11-24	463.32	10.08	3.55	94.19	4.32	553.09	53.53	606.62
ABGS 14-25	466.67	11.58	4.26	93.70	4.83	418.92	92.42	511.34
ABGS 14-27	666.25	2.33	1.44	94.65	5.45	427.39	104.75	532.15
GPBG 109	400.42	7.08	3.20	93.48	4.69	464.09	74.33	538.42
PUNJAB LONG	435.83	7.67	3.58	94.34	4.53	529.40	63.89	593.29
Hybrids:								
ABG 1 × ABGS 11-17	566.25	11.75	4.43	94.27	4.48	461.57	15.83	477.40
ABG 1 × ABGS 11-19	543.33	8.33	2.34	89.93	4.47	546.82	16.58	563.40
ABG 1 × ABGS 11-24	389.58	12.42	4.30	93.93	5.52	433.11	38.31	471.42
ABG 1 × ABGS 14-25	545.42	8.58	3.57	88.47	4.48	463.16	33.23	496.40
ABG 1 × ABGS 14-27	483.75	7.08	2.47	92.26	5.11	475.12	34.82	509.95
ABG 1 × GPBG 109	501.67	11.83	3.73	95.23	4.45	754.88	36.96	791.84
ABG 1 × PUNJAB LONG	381.67	6.50	1.75	93.62	5.49	483.92	63.20	547.13
DBG 5 × ABGS 11-17	550.00	10.50	4.19	91.03	5.41	365.95	30.89	396.84
DBG 5 × ABGS 11-19	655.42	7.73	3.47	95.84	4.88	452.65	14.21	466.86

Genotypes	Average Fruit weight (g)	Number of fruit per plant	Fruit yield per plant (kg)	Moisture content (%)	Total soluble solids (ºBrix)	Chlorophyll *a* (µg/g F.W.)	Chlorophyll *b* (µg/g F.W.)	Total Chlorophyll (µg/g F.W.)
DBG 5 × ABGS 11-24	372.08	7.58	2.62	94.42	4.87	414.84	41.23	456.07
DBG 5 × ABGS 14-25	567.50	7.42	3.36	88.80	5.38	412.12	59.13	471.25
DBG 5 × ABGS 14-27	728.33	8.92	4.65	92.48	4.90	467.67	41.39	509.06
DBG 5 × GPBG 109	395.42	7.92	3.65	88.05	5.38	464.68	33.22	497.90
DBG 5 × PUNJAB LONG	545.83	10.50	4.54	86.34	5.51	524.81	30.69	555.50
GPBG 108 × ABGS 11-17	470.00	6.25	3.21	93.94	5.27	464.87	34.24	499.11
GPBG 108 × ABGS 11-19	472.92	8.17	2.54	95.29	4.69	473.92	34.72	508.64
GPBG 108 × ABGS 11-24	395.00	12.08	5.10	90.48	4.44	465.73	37.19	502.93
GPBG 108 × ABGS 14-25	392.08	9.14	4.22	92.13	5.36	546.63	25.92	572.55
GPBG 108 × ABGS 14-27	398.75	8.75	2.68	94.07	5.02	465.08	40.16	505.24
GPBG 108 × GPBG 109	743.75	9.00	3.59	94.46	4.69	461.30	28.47	489.77
GPBG 108 × PUNJAB LONG	365.40	10.58	4.52	89.72	4.49	474.87	44.73	519.60
NDBG 132 × ABGS 11-17	569.17	10.83	3.60	94.93	4.04	466.10	39.24	505.34
NDBG 132 × ABGS 11-19	469.58	7.50	3.55	94.53	4.56	461.65	40.88	502.53
NDBG 132 × ABGS 11-24	377.08	8.67	3.42	94.30	4.45	464.38	40.97	505.34
NDBG 132 × ABGS 14-25	581.25	11.42	4.53	90.82	5.26	462.02	60.92	522.94
NDBG 132 × ABGS 14-27	514.58	10.83	3.46	94.84	4.57	424.20	62.31	486.51
NDBG 132 × GPBG 109	447.92	11.67	3.39	94.17	4.85	472.51	46.69	519.20
NDBG 132 × PUNJAB LONG	514.17	11.42	5.48	89.85	4.46	462.23	30.85	493.08
LOCAL × ABGS 11-17	826.67	12.75	5.38	95.33	5.53	419.73	40.41	460.14
LOCAL × ABGS 11-19	759.66	7.83	3.58	87.92	4.96	473.99	34.15	508.14
LOCAL × ABGS 11-24	735.83	11.25	4.39	93.80	4.83	433.50	63.25	496.75
LOCAL × ABGS 14-25	374.58	11.17	5.44	91.38	4.68	428.62	90.13	518.74
LOCAL × ABGS 14-27	389.58	2.33	1.80	94.88	5.06	469.72	47.18	516.89
LOCAL × GPBG 109	445.42	7.58	2.52	93.03	5.32	457.43	45.77	503.20
LOCAL × PUNJAB LONG	396.67	9.83	4.29	95.53	4.38	469.45	49.46	518.90
ABGH 1 (STANDARD CHECK)	386.67	11.83	4.51	94.22	4.91	437.04	82.06	519.10
Parental mean	**513.66**	**8.74**	**3.42**	**92.62**	**4.77**	**464.34**	**62.18**	**526.52**

Genotypes	Average Fruit weight (g)	Number of fruit per plant	Fruit yield per plant (kg)	Moisture content (%)	Total soluble solids (ºBrix)	Chlorophyll *a* (µg/g F.W.)	Chlorophyll *b* (µg/g F.W.)	Total Chlorophyll (µg/g F.W.)
Hybrid mean	**510.47**	**9.32**	**3.71**	**92.57**	**4.89**	**469.69**	**40.78**	**510.47**
General mean (µ)	**508.68**	**9.22**	**3.65**	**92.62**	**4.86**	467.67	**46.99**	514.67
Range (Overall)	**365.40 to 826.67**	**2.33 to 12.75**	**1.44 to 5.48**	**85.43 to 95.84**	**4.04 to 5.53**	**365.95 to 754.88**	**14.21 to 104.75**	**396.84 to 791.84**
S.Em.±	**4.96**	**0.21**	**0.08**	**0.49**	**0.16**	3.76	2.18	4.19
CD at 5%	13.86	**0.58**	**0.22**	**1.37**	**0.46**	10.52	6.11	11.70
CV%	1.95	**4.51**	**4.32**	**1.06**	**6.72**	1.61	9.30	1.63

Table 3. Number of (F_1) hybrids depicted significant heterotic effect in bottle gourd

Characters	Over mid parent				Over better parent				Over standard check (ABGH 1)			
	+ve	-ve	Total	Range	+ve	-ve	Total	Range	+ve	-ve	Total	Range
Days to first male flower appearance	06	21	27	-23.49 to 12.17	09	14	23	-16.81 to 17.97	12	03	15	-7.70 to 27.29
Days to first female flower appearance	10	16	26	-20.82 to 23.61	14	13	27	-16.30 to 26.90	19	07	26	-7.56 to 29.78
Node number at which first male flower appearance	05	22	27	-52.87 to 31.68	07	17	24	-48.34 to 34.12	11	17	28	-33.34 to 44.45
Node number at which first female flower appearance	03	21	24	-74.31 to 15.13	06	21	27	-73.75 to 25.50	06	18	24	-69.30 to 27.93
Number of branch per plant	35	00	35	42.75 to 143.97	35	00	35	36.46 to 119.37	35	00	35	49.76 to 102.94
Fruit length	16	01	17	-11.35 to 38.88	08	08	16	-19.79 to 35.85	35	00	35	27.78 to 136.46
Fruit girth	03	00	03	-17.84 to 50.55	01	00	01	-18.36 to 43.70	01	05	06	-27.03 to 28.19
Average fruit weight	13	20	33	-34.83 to 75.60	08	24	32	-41.53 to 66.51	23	02	25	-5.51 to 113.80
Number of fruit per plant	18	13	31	-61.66 to 87.05	12	16	28	-76.28 to 32.72	01	26	27	-80.29 to 7.75
Fruit yield per plant	19	10	29	-51.17 to 75.30	11	16	27	-52.60 to 53.04	04	24	28	-61.18 to 21.64
Moisture content	14	10	24	-6.72 to 6.45	02	15	17	-8.48 to 4.53	01	15	16	-8.36 to 1.72

Characters	Over mid parent				Over better parent				Over standard check (ABGH 1)			
	+ve	-ve	Total	Range	+ve	-ve	Total	Range	+ve	-ve	Total	Range
Total soluble solids	12	03	15	-12.93 to 20.51	09	05	14	-16.24 to 19.53	07	05	12	-17.66 to 12.57
Chlorophyll *a*	16	14	30	-19.17 to 60.95	06	17	23	-25.00 to 59.28	27	05	32	-16.27 to 72.73
Chlorophyll *b*	03	30	33	-76.98 to 34.34	01	31	32	-80.20 to 18.16	01	34	35	-82.69 to 9.83
Total Chlorophyll	08	22	30	-20.74 to 49.07	04	25	29	-24.82 to 47.07	05	20	25	-23.56 to 52.55

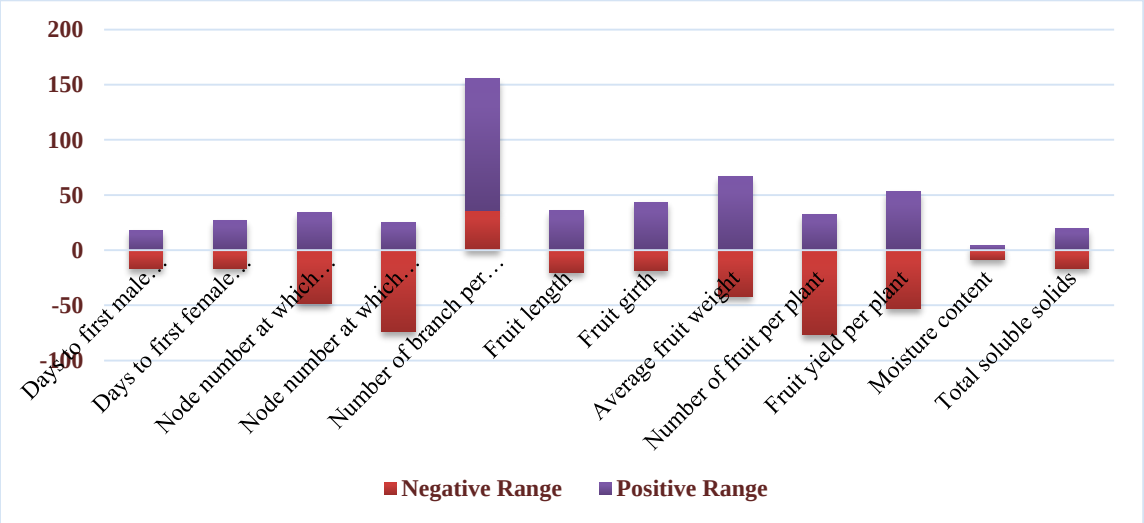


Fig. 1. The extent of heterobeltiosis in bottle gourd

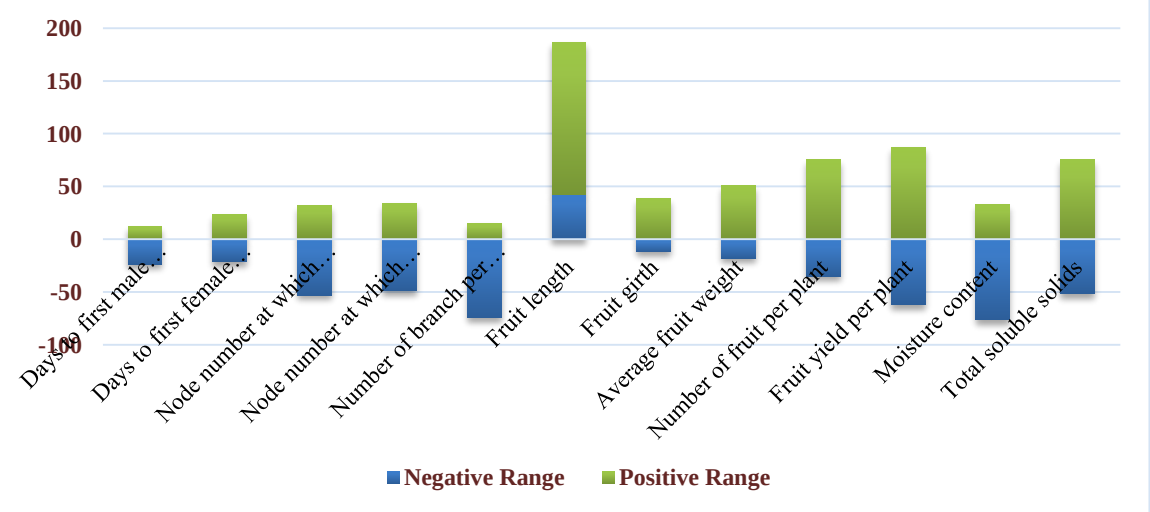


Fig. 2. The extent of relative heterosis in bottle gourd

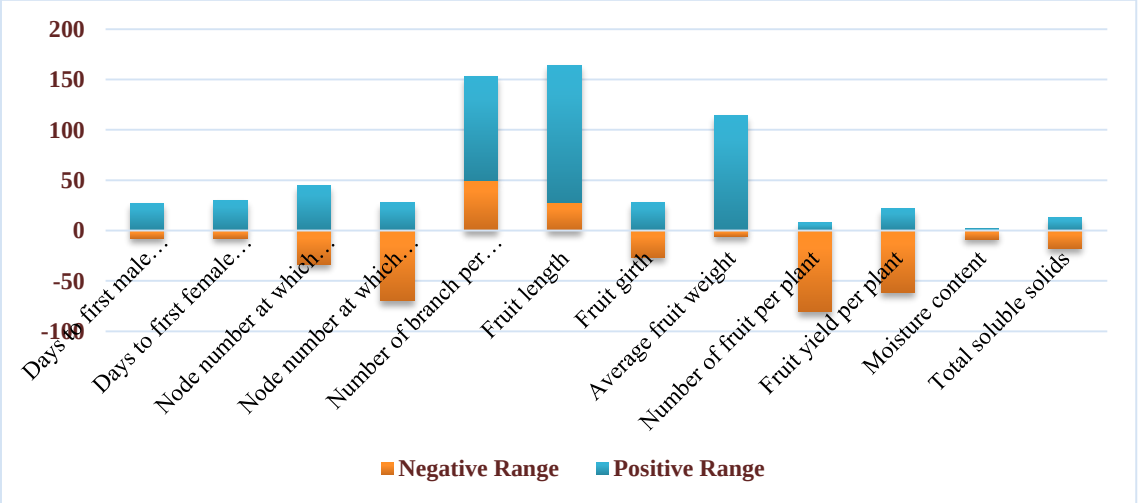


Fig. 3. The extent of standard heterosis over check ABGH 1

Table 4. Comparative study of heterotic crosses in bottle gourd for fruit yield per plant, with other components

Sr. No.	Heterotic crosses	Fruit yield per plant (kg)	Heterosis for fruit yield over MP	BP	SC	Desired and significant heterosis over MP for component traits	Desired and significant heterosis over BP for component traits	Desired and significant heterosis over SC for component traits
1.	NDBG 132 × PUNJAB LONG	5.48	75.30**	53.04**	21.64 **	A, B, C, D, E, F, H, I	A, B, D, E, H, I	A, B, D, E, F, G, I
2.	LOCAL × ABGS 14-25	5.44	34.99 **	27.77 **	20.71 **	A, B, C, D, E, I, K	A, B, D, E, I	B, D, E, F, I, M
3.	LOCAL × ABGS 11-17	5.38	31.82 **	23.49 **	19.27 **	A, E, G, H, I, J, K	A, E, G, H, I, K	E, F, G, H, I, K
4.	GPBG 108 × ABGS 11-24	5.10	42.43 **	41.15 **	13.17 **	E, F, H, I, N	E, H, I	E, F, I, L

** and ** indicate significant at 5% and 1% levels of significance, respectively*

Where,

A *:Days to first male flower appearance*
B *:Days to first female flower appearance*
C *:Node number at which first male flower appearance*
D *:Node number at which first female flower appearance*
E *:Number of branch per plant*
F *:Fruit length*
G *:Average fruit weight*
H *:Number of fruit per plant*
I *:Fruit yield per plant*
J *:Moisture content*
K *:Total soluble solids*
L *:Chlorophyll a*
M *:Chlorophyll b*
N *:Total Chlorophyll*

Table 5. The overall picture of heterosis level in promising heterotic crosses of bottle gourd for fruit yield and its attributes

Sr. No.	Hybrids	Days to first male flower appearance	Days to first female flower appearance	Node number at which first male flower appearance	Node number at which first female flower appearance	Number of branch per plant	Fruit length	Fruit girth
1	NDBG 132 × PUNJAB LONG	Low	Low	Moderate	Low	Low	Moderate	Low
2	LOCAL × ABGS 14-25	High	Low	Moderate	High	Low	Low	Moderate
3	LOCAL × ABGS 11-17	Low	Moderate	High	High	Low	Low	Low
4	GPBG 108 × ABGS 11-24	Moderate	Moderate	Moderate	High	Low	Low	Low

Sr. No.	Hybrids	Average fruit weight	Number of fruit per plant	Fruit yield per plant	Moisture content	Total soluble solids	Chlorophyll *a*	Chlorophyll *b*	Total Chlorophyll
1	NDBG 132 × PUNJAB LONG	Low	High	High	Moderate	Low	Low	Low	Low
2	LOCAL × ABGS 14-25	Low	High	High	Moderate	Moderate	Low	High	Low
3	LOCAL × ABGS 11-17	High	High	High	High	High	Low	Moderate	Low
4	GPBG 108 × ABGS 11-24	Low	High	High	Moderate	Low	Low	Low	Low

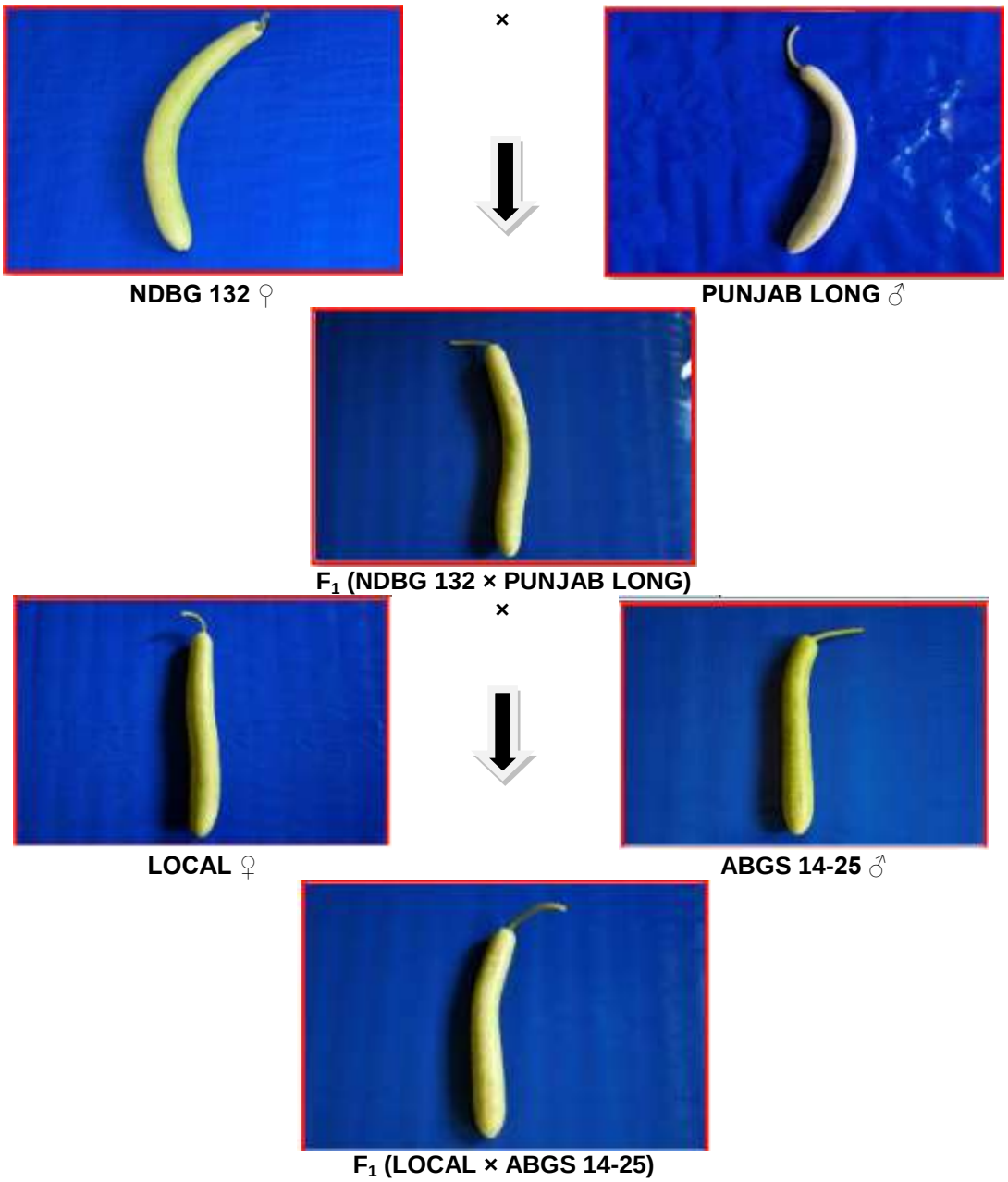
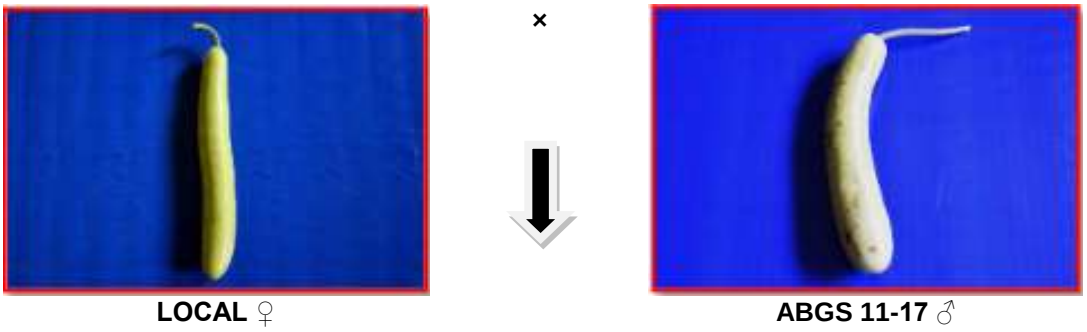


Plate. 1. Promising hybrids with their parents



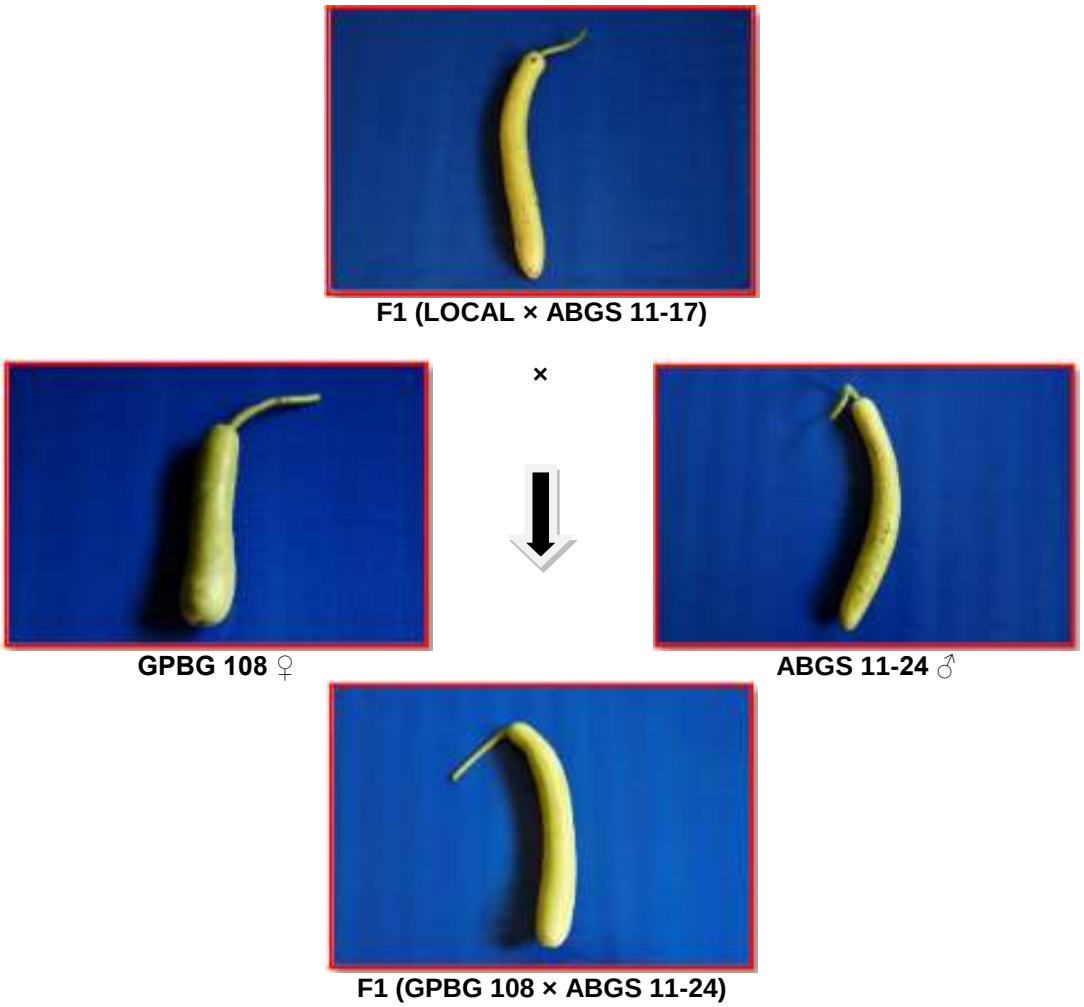


Plate 2. Promising hybrids with their parents

4. CONCLUSION

The analysis of variance revealed that significant differences were observed among the parents for all traits except fruit girth. This indicated a sufficient variability in the parents (*i.e*., lines and testers) for all the traits except fruit girth. The parental genotype DBG 5 was rewarded with higher fruit yield per plant (kg) and it was also performed considerably good for the number of fruit per plant. In the case of hybrids, the cross NDBG 132 × PUNJAB LONG was exhibited its superiority for fruit yield per plant (kg). It also took a minimum days to set first female flower too. A comparative study of best heterotic crosses NDBG 132 × PUNJAB LONG, LOCAL × ABGS 14-25, LOCAL × ABGS 11-17 and GPBG 108 × ABGS 11-24 for fruit yield per plant revealed significant positive heterosis over mid parent, better parent and standard check. These crosses can also be used to throw off transgressive segregants in segregating generations to improve yield and specific attributing traits. It can also used as commercial hybrid after multilocation testing.

ACKNOWLEDGEMENTS

The Authors are highly thankful for Potato Research Station and Sardarkrushinagar Dantiwada Agricultural University for fund and facilities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mutazing, A. Hybrid vigour in crosses between purelines of Galeopsis and tetrant. Hereditas. 1945;31:391-398.

2. Pal, BP and Singh H. Studies in hybrid vigourin brinjal and bitter gourd. Indian Journal of Genetics and Plant Breeding. 1946;6:19-33.
3. Hiscox JD and Israelstam GF. A method for the extraction of chlorophyll from leaf tissue without maceration. Canadian Journal of Botany. 1979;57(12): 1332-1334.
4. Arnon DI. Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. Journal of Plant Physiology. 1949;24:1-15.
5. Snedecor GW and Cochran WG Statistical methods.6th edition. Ames, The Iowa State University Press, Ames, Iowa; 1967
6. Panse VG. and Sukhatme PV. Statistical methods for agricultural workers.4th edition. ICAR, New Delhi. 1985;97-156.
7. Briggle LW. Heterosis in wheat a review. Crop Science. 1963;3:407-412.
8. Fonseca S. and Patterson FC. Hybrid vigour in a seven parent diallel cross in common winter wheat. Crop Science. 1968;8:85-88.
9. Meredith WR and Bridge RR. Heterosis and gene action in cotton (*G. Hirsutum L*.). Crop Science. 1972;12: 304-310. DOI:10.2135/cropsci1972.0011183X00120 0030015x
10. Joshi, A. H.; Gami R. A.; Patel R. N. and Arvinth S. Interpretation of mean value and extent of heterosis in fodder and grain yield with associated traits of sorghum [*Sorghum bicolour* (L.) Moench]. Journal of Crop and Weed. 2021;17(3):206-213. DOI:https://doi.org/10.22271/09746315.20 21.v17.i3.1511
11. Ray PK, Yadav GC, Baranwal DK and Singh HK. Genetic estimates and gene action for obtaining promising heterotic hybrids in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. The Bioscan. 2015;10(2):801-806.
12. Parmar. Heterosis and combining ability for yield and quality traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.]. Environment and Ecology.
13. Doloi N, Patel JN and Acharya, RR. Heterosis studies in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]. Vegetos. 2018;31:1-3.
14. Mishra S, Pandey S, Kumar N, Pandey VP and Singh T. Studies on the extent of heterosis for the quantitative characters in *kharif* season bottle gourd [*Lagenaria siceraria* (Molina) Standl.]. Journal of Pharmacognosy and Phytochem. 2019;8(1):29-38.
15. Odedara GN, Patel, JB and Gauswami JJ. Studies on heterosis and inbreeding depression in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]. Indian Journal of Pure and Applied Biosciences. 2021;9(1):132-139. DOI:http://dx.doi.org/10.18782/2582-2845.8505
16. Lal M, Ram CN, Nath S and Gautam SK. Estimation of heterosis in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] for growth and earliness. The Pharma Innovation Journal. 2021;10(7):1585-1592.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/108199