Electronic Journal of Plant Breeding, 1(4): 783-788 (July 2010)

**Research Article**

# Heterosis in relation to combining ability for yield and quality attributes in Brinjal (*Solanum melongena* L.)

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**Abstract :**
Genetical studies on fruit yield per plant and its attributing traits alongwith quality traits like total soluble solids (TSS) and rind thickness were conducted following line x tester mating design comprising of 8 lines and 6 testers at Horticulture Research Farm, Indira Gandhi Agricultural University, Raipur. The analysis revealed that all the parents were found good general combiners for most of the characters. However, line IGBO 65 and tester KS 327 were found best combiners for fruit yield per plant. The ratio of gca variance/ sca variance were observed less than unity for all the characters which revealed the predominance of non-additive gene action. The hybrid, IGBL 70 X PPL was found best on the basis of specific combining ability and heterosis for fruit yield per plant. A high magnitude of heterosis (115.84%) for fruit yield per plant over better parent was observed. There was high heterosis response in most of the hybrids which supports the role of non-additive gene effects. The heterosis in relation to combining ability for quality parameters i.e. TSS and rind thickness were also found significantly high in the respective hybrids, IGBO 40 X KS 331 and IGBR 44 X IVBL 9. Indirect selection for traits such as, plant height, fruits per plant, fruit length, fruit girth and branches per plant could be done in order to achieve higher yield through heterosis breeding in brinjal.

**Key words:**
Line x tester, combining ability, gene action, heterosis.

## Introduction

Brinjal (*Solanum melongena* L.), also known as eggplant, is an important solanaceous vegetable crop grown round the year in India. It is grown for its immature, unripe fruits which are used in the variety of ways as cooked vegetable in curries. It is grown extensively in all parts of India except at higher altitude. It is popular among people of all social strata and hence, it is rightly called as vegetable of masses. (Patel and Sarnaik, 2003). With increasing popularity of $F_1$ hybrids in brinjal, it is imperative to obtain such hybrids, having excellent quality coupled with high yields. A knowledge of general combining ability (gca) and specific combining ability (sca) helps in choice of parents or hybrids and the nature of gene action acts as a basis for choosing an effective breeding methodology. The present investigation therefore was undertaken to identify potential parental combinations in order to have superior hybrids of excellent qualities coupled with high yields.

## Materials and methods

The present investigation was undertaken during rainy season 2003-04 and 2004-05 at Horticulture Research Farm, Indira Gandhi Agricultural University, Raipur (C.G.) India. The biological materials used in the study comprised of eight local genotypes of Chhattisgarh as lines, *viz.,* IGBR 44, IGBO 65, IGBO 71, IGBL 67, IGBL 70, IGBO 40, IGBO 43 and IGBO 83; six improved varieties of brinjal as testers, *viz.*, KS 331, IVBL 9, BB 93, JNDBL 1, KS 327 and PPL and their resulting forty eight cross combinations. Crosses were made in line x tester fashion during rainy season 2003-04 and the resulting 48 $F_1$'s alongwith the parents were grown in Randomized Block Design at 60 x 45 cm spacing in three replications during 2004-05. Standard cultural practices were followed to raise the normal crop. Data were recorded on five randomly selected plants in each treatment over replication for all the characters *viz*., days to first flowering, plant height, number of primary branches per plant, average fruit weight, fruit length, fruit girth, number of fruits per cluster, number of fruits per plant, total soluble solids, rind thickness and total fruit yield per plant. The observation on total soluble solids (TSS) was recorded with the help of an Erma hand refractometer ($0\text{-}32^0$ Brix range) and rind thickness was measured with the help of vernier caliper.

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Line X tester analysis was carried out by the method suggested by Kempthorne (1957). Heterosis was worked out over better parent and mid parent.

**Results and discussion**

Analysis of variance (Table 1) revealed that variance due to lines was significant for all the characters except number of fruits per cluster, TSS and rind thickness. The variance due to testers was found significant for all the characters except number of primary branches per plant. While, the variance due to lines x testers was significant for all the characters except for rind thickness that revealed the importance of additive component of genetic variance in the inheritance of these traits. The gca/ sca variance ratio being less than unity for all the characters revealed predominance of non-additive components of variance (Table 2). The importance of both additive as well as non-additive components for fruits per plant, branches per plant, days to flowering, plant height and yield per plant in brinjal was reported by Ramesh *et al*. (1996), Das and Sarma Barua (2001) and Singh *et al.* (2003).

The general combining ability (gca) effects revealed that none of the parents were found good general combiner for all the characters. However among the parents lines, IGBL 67, IGBO 40, IGBL 70, IGBO 83 and IGBO 65 and testers JNDBL 1, BB 93, KS 331 and KS 327 were good general combiners for as many as four to five characters on the strength of the magnitude of gca effects for various traits. The results are in agreement with those of Ramesh *et al*. (1996), Padmanabham and Jagdish (1996), Das and Sarma Barua (2001) and Singh *et al.* (2003).

As regard to specific combining ability (sca) effects the cross, IGBO 70 X PPL significantly scored for total fruit yield and three other characters viz., number of fruits per plant, fruit length and number of primary branches per plant. Other cross combinations *viz*., IGBO 43 X KS 331, IGBO 65 X JNDBL 1, IGBO 43 X KS 327 and IGBL 67 X BB 93 were also significant for yield and most of the yield related traits. These crosses exhibited significant sca effects indicating the presence of dominance and epistatic (non-additive) type of gene action (Table 3). Similar results were reported by Kele *et al.* (1992) and Singh *et al*. (2003). As far as quality characters are concerned the line IGBO 65, IGBO 40 and tester KS 327 were found best general combiners for TSS and rind thickness. Cross IGBO 40 X KS 331 recorded high sca effects for TSS and IGBR 44 X IVBL 9 for rind thickness.

Among the eleven attributes studied highly significant and negative heterosis for days to first flowering was observed while highly significant and positive heterosis over better parent (Table 4) was observed in order of magnitude by total fruit yield per plant (115.84 %) followed by number of fruits per plant (102.79 %), number of fruits per cluster (98.73 %), average fruit weight (83.27 %), TSS (78.06 %), fruit girth (50.96 %), number of primary branches per plant (41.69 %), rind thickness (24.72 %), plant height (22.38 %), fruit length (13.55 %) and days to first flowering (-14.66 %). Singh *et al*. (2003), Kumar and Pathania (2003) and Pratibha *et al*. (2004) also reported highly significant heterosis for fruit yield and its contributing traits in brinjal.

The maximum heterosis for fruit yield per plant over better parent was exhibited by the cross IGBL 70 X PPL (115.84 %) followed by IGBO 40 X KS 327 (83.61 %), IGBO 83 X KS 327 (69.40 %) and IGBO 43 X KS 327 (68.75 %). Similar trend was also reported by Das and Sarma Barua (2001) and Singh *et al*. (2003).

The high heterosis response observed in most of the hybrids further supported the predominant role of non-additive component in the characters studied. The top three hybrids selected separately on the basis of high sca effects and heterosis over better parent for various yield and quality characters are presented in Table 4. Some of the crosses were observed superior for sca effects as well as heterosis. On the basis of above findings it can be concluded that characters like days to first flowering may be improved through selection while yield and its contributing traits fruits per plant, fruit length, fruit girth, fruits per cluster, number of fruits per plant and number of primary branches per plant may be improved through heterosis breeding. The superior crosses attempted through line X tester mating design utilizing local germplasm of brinjal on the basis of significant heterosis over better parent and sca effects can be further exploited for commercial cultivation after multilocation testing.

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**Table 1: Analysis of variance for line X tester analysis for fruit yield and its component characters**

| Source | D.F. | Characters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **1** | **2** | 3 | *4* | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| Replication | 2 | 1.22 | 116.73 | 7.81 | 2621.37 | 17.87 | 8.92 | 5.97 | 50.39 | 0.007 | 0.14 | 67549.59 |
| Parents | 13 | 258.10* | 113.73* | 1.95* | 2850.04* | 48.38* | 49.07* | 3.62* | 47.99* | 1.05* | 2.71* | 24166.00* |
| Hybrids | 47 | 57.97* | 88.50* | 3.23* | 3813.26* | 34.49* | 25.55* | 2.45* | 41.85* | 2.79* | 0.78* | 77689.02* |
| Parents Vs. hybrids | 1 | 981.15* | 257.14* | 2.88* | 18638.62* | 3.39* | 0.61* | 0.40* | 12.42* | 30.28* | 0.06 | 458632.00* |
| Lines | 7 | 311.58* | 99.08* | 1.48* | 5170.25* | 14.60* | 68.26* | 0.45 | 46.45* | 0.33 | 0.94 | 21312.00* |
| Testers | 5 | 234.83* | 156.67* | 0.80 | 159.85* | 19.43* | 23.27* | 8.30* | 59.71* | 2.21* | 2.88* | 32972.80* |
| Line X Tester | 35 | 36.47* | 46.56* | 3.51* | 2793.87* | 27.33* | 22.27* | 1.57* | 35.65* | 2.47* | 0.73 | 78436.29* |
| Error | 122 | 4.57 | 12.84 | 0.36 | 140.91 | 1.28 | 0.82 | 0.018 | 3.84 | 0.069 | 0.11 | 5502.58 |

* Significant at P = 0.05 level

1. Days to I$^{st}$ Flowering
2. Plant height (cm)
3. No. of primary branches/ plant
4. Average fruit weight (g)
5. Fruit length (cm)
6. Fruit girth (cm)
7. No. of fruits/ cluster
8. Total no. of fruits/ plant
9. TSS (%)
10. Rind thickness (mm)
11. Total fruit yield/ plant (g)

**Table 2: Magnitude of gca variance and sca variance for fruit yield and other characters**

| Source of variance | Characters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| GCA | 4.94 | 9.21 | -0.05 | 234.38 | 1.56 | 0.83 | 0.20 | 1.33 | 0.07 | 0.09 | 63.23 |
| SCA | 10.56 | 10.86 | 1.06 | 876.23 | 8.69 | 7.15 | 0.52 | 10.57 | 0.80 | 0.21 | 24085.07 |
| var. gca/ var. sca | 0.46 | 0.84 | -0.04 | 0.26 | 0.17 | 0.11 | 0.38 | 0.12 | 0.08 | 0.04 | 0.03 |

**Table 3: General Combining Ability (GCA) effects of lines and testers for fruit yield and its components**

| Parents | Characters | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| **Lines** | | | | | | | | | | | |
| IGBR 44 | 0.56 | -0.76 | 0.59* | -3.29 | 0.05 | -0.04 | -0.33* | -0.67 | -0.30* | 0.03 | -58.48* |
| IGBO 65 | 1.50* | -2.16* | -0.51* | 3.48 | -0.63* | -0.12 | 0.19* | 3.24* | 0.13* | 0.15* | 83.15* |
| IGBO 71 | -0.27 | -1.77 | -0.15 | -12.49* | -1.99* | 0.90* | 0.11* | -1.55* | -0.46* | -0.36* | -36.60 |
| IGBL 67 | -2.34* | 0.91 | 0.34* | 4.44 | -0.77* | -0.75* | 0.33* | 0.04 | -0.13* | -0.07 | 58.70* |
| IGBL 70 | -0.22 | -0.68 | -0.06 | 13.11* | 1.55* | 0.38 | -0.16* | -0.94 | 0.30* | -0.21* | -15.89 |
| IGBO 40 | -0.37 | 3.90* | 0.01 | 13.09* | -0.06 | 1.29 | -0.13* | -0.02 | 0.70* | 0.24* | 42.13* |
| IGBO 43 | 0.81 | 0.30 | -0.10 | -16.98* | -0.27 | -1.00* | 0.16* | 0.87 | -0.34* | -0.11 | -11.21 |
| IGBO 83 | 0.34 | 0.26 | -0.11 | -1.36 | 2.12* | -0.66* | -0.17* | -0.96* | 0.11 | 0.33* | -61.81* |
| **Testers** | | | | | | | | | | | |
| KS 331 | 0.23 | 1.46 | 0.52* | -16.34* | -2.28* | -0.25 | -0.33* | 0.60 | 0.23* | -0.07 | -36.94 |
| IVBL 9 | -0.78 | -2.41* | -0.23 | -16.96* | 0.70* | -1.18* | -0.32* | -2.33* | 0.33* | -0.02 | -55.79* |
| BB 93 | 2.33* | 4.58* | -0.47* | -0.83 | -1.92* | 1.46* | 1.36* | 0.79 | -0.17* | 0.25* | 64.51* |
| JNDBL 1 | 4.95* | 3.97* | 0.21 | 36.85* | 2.37* | 2.31* | -0.35* | -1.92* | -0.82* | -0.18* | -75.23* |
| KS 327 | -3.00* | -6.35* | -0.17 | 19.29* | -0.68* | -0.08 | -0.19* | 0.04 | 0.47* | 0.21* | 85.55* |
| PPL | -3.74* | -1.25 | 0.13 | -22.00* | 1.80* | -2.27* | -0.16* | 2.81* | -0.03 | -0.91* | 17.89 |
| SE (lines) | 0.43 | 0.73 | 0.11 | 2.49 | 0.22 | 0.18 | 0.03 | 0.39 | 0.05 | 0.07 | 15.25 |
| SE (testers) | 0.36 | 0.61 | 0.10 | 2.11 | 0.18 | 0.15 | 0.02 | 0.33 | 0.04 | 0.06 | 12.89 |

* Significant at P = 0.05 level

1. Days to I$^{st}$ Flowering
2. Plant height (cm)
3. No. of primary branches/ plant
4. Average fruit weight (g)
5. Fruit length (cm)
6. Fruit girth (cm)
7. No. of fruits/ cluster
8. Total no. of fruits/ plant
9. TSS (%)
10. Rind thickness (mm)
11. Total fruit yield/ plant (g)

**Table 4: Top three hybrids selected separately on the basis of heterosis over better parent and sca effects**

| S. No. | Characters | Cross | Heterosis | Cross | sca effects |
|---|---|---|---|---|---|
| 1. | Days to I$^{st}$ flowering | IGBO 40 X BB 93 | 7.30* | IGBO 40 X BB 93 | -7.20* |
| | | IGBO 40 X IVBL 9 | 7.34* | IGBO 83 X PPL | -6.99* |
| | | IGBO 43 X KS 331 | 8.50* | IGBL 67 X PPL | -4.76* |
| 2. | Plant height | IGBL 70 X KS 331 | 22.38* | IGBR 44 X KS 331 | 5.46* |
| | | IGBO 43 X KS 331 | 22.25* | IGBO 65 X BB 93 | 3.93* |
| | | IGBO 40 X PPL | 20.45* | IGBO 71 X IVBL 9 | 2.18* |
| 3. | Number of primary branches per plant | IGBO 83 X BB 93 | 41.69* | IGBO 83 X BB 93 | 2.36* |
| | | IGBR 44 X KS 331 | 40.35* | IGBL 70 X PPL | 2.15* |
| | | IGBO 43 X KS 331 | 23.22* | IGBR 44 X KS 331 | 1.62* |
| 4. | Average fruit weight | IGBL 70 X BB 93 | 83.27* | IGBL 67 X KS 331 | 64.10* |
| | | IGBO 40 X PPL | 77.91* | IGBO 40 X PPL | 63.86* |
| | | IGBL 67 X KS 331 | 65.02* | IGBR 44 X BB 93 | 56.32* |
| 5. | Fruit length | IGBL 70 X BB 93 | 13.55* | IGBL 70 X BB 93 | 5.34* |
| | | IGBO 65 X IVBL 9 | 13.15* | IGBO 65 X IVBL 9 | 5.18* |
| | | IGBL 70 X JNDBL 1 | 7.78* | IGBO 71 X PPL | 4.96* |
| 6. | Fruit girth | IGBL 70 X IVBL 9 | 50.96* | IGBO 43 X PPL | 6.31* |
| | | IGBL 67 X KS 331 | 41.05* | IGBO 83 X KS 327 | 5.48* |
| | | IGBO 40 X KS 327 | 23.13* | IGBL 67 X KS 331 | 5.73* |
| 7. | Number of fruits per cluster | IGBO 83 X KS 327 | 98.73* | IGBO 65 X BB 93 | 1.31* |
| | | IGBL 70 X PPL | 87.24* | IGBO 83 X KS 327 | 1.05* |
| | | IGBO 43 X PPL | 35.01* | IGBL 70 X PPL | 1.02* |
| 8. | Total number of fruits per plant | IGBO 43 X KS 331 | 102.79* | IGBO 43 X KS 331 | 8.64* |
| | | IGBO 65 X PPL | 69.52* | IGBL 70 X PPL | 7.21* |
| | | IGBO 40 X IVBL 9 | 45.42* | IGBO 40 X IVBL 9 | 4.54* |
| 9. | Total soluble solids (TSS ) | IGBO 40 X KS 331 | 78.06* | IGBO 40 X KS 331 | 2.90* |
| | | IGBL 70 X KS 327 | 63.65* | IGBO 65 X JNDBL 1 | 1.62* |
| | | IGBO 65 X JNDBL 1 | 60.17* | IGBO 83 X IVBL 9 | 1.03* |
| 10. | Rind thickness | IGBO 65 X KS 327 | 24.72* | IGBR 44 X IVBL 9 | 0.83* |
| | | IGBR 44 X IVBL 9 | 17.28* | IGBO 65 X KS 327 | 0.81* |
| | | IGBL 67 X KS 327 | 11.44* | IGBL 70 X JNDBL 1 | 0.76* |
| 11. | Total fruit yield per plant | IGBL 70 X PPL | 115.84* | IGBL 70 X PPL | 392.57* |
| | | IGBO 40 X KS 327 | 83.61* | IGBO 43 X KS 331 | 222.57* |
| | | IGBO 83 X KS 327 | 69.40* | IGBO 65 X JNDBL 1 | 219.62* |