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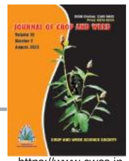

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# Genetic study of combining ability for fruit yield attributing traits in brinjal (*Solanum melongena* L.) over different environments

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## ABSTRACT

*Line × tester analysis was conducted to assess the GCA for 12 parents and the SCA for 32 hybrids of the eggplant. The combining ability investigation revealed large variations for all the characters. The variance estimates, GCA and SCA were highly significant for most of the traits emphasizing the importance of additive and non-additive gene actions in inheritance of fruit yield and its contributing traits. Among the female parents, PR-5 and PLR-1, whereas, among male parents, BCB-464, BCB-71-1, Swarna Mani and CO-2 were effective general combiners for fruit yield and its influencing characteristics. According to the action of the impacts of specific combining ability, the cross combinations, viz. PR-5 × BCB-71-1, PR-5 × BCB-464, PLR-1 × BCB-71-1 and PLR-1 × Swarna Mani exhibited desirable effects in all three environments (seasons) as well as over pooled environment.*

***Keywords*:** Brinjal, environments, GCA, Line × Tester, SCA and yield

Eggplant (*Solanum melongena* L.) is a self-pollinating perennial crop that produces year round fruits and is an important as well as popular vegetable crop suitable for many agro-climatic regions. Across the country, different kinds of vegetables are grown in different climatic zones, in which brinjal the major vegetable grown in India (Amit *et al*., 2023). India is the country where brinjal was first cultivated and the top states for brinjal production are Maharashtra, Andhra Pradesh, Karnataka, Orissa, Uttar Pradesh, Bihar, Gujarat, Rajasthan and West Bengal. Vegetables are a good source of vitamins, minerals, vegetable fibre and a moderate quantity of protein and carbohydrates (Nayak *et al*., 2020). The brinjal fruit is a popular ingredient in many dishes and is a great source of nutrients that are protective. There is a necessity for higher levels of productivity and production of brinjal due to rise up population. Brinjal crops are very crucial in ensuring nutritional security through veggies (Parida *et al*., 2020). Unfortunately, the current yield and production of brinjal are sparse to ensure the growing population's nutritional security. Any breeding program's effectiveness demands knowledge of parental selection and the types of gene action regulating various traits. In the instance of eggplant, is practically impossible to have a common variety suitable at particular regions as well as regional preferences, as preferences for the color and shape of the fruit vary from region to region. Therefore, it is very important to develop cultivars or hybrids with preferred shapes, colors, high yields and adaptability to different agricultural climatic conditions. Currently, these characteristics of the fruit make it the most desirable target for eggplant breeders not only in our country but all over the world. The general and specific combination effects and variations obtained from the $F_1$ sets allow breeders to select ideal parents and crosses for every quantitative component. A design *i.e.* Line × Tester is a crossbreeding pattern that predicts parent combination ability by crossing selected parents in a specific order and finds out the working nature of genes participate in trait inheritance (Abhinav and Nandan, 2010).

## MATERIALS AND METHODS

The investigation was undertaken at Instructional Farm, College of Agriculture, Mandor, Jodhpur, (Rajasthan), during 2020 – 2021. Four females (Lines) and eight males (Testers) were crossed during Rabi 2019 to produce $F_1$ seeds by manual pollination using Line × Tester mating scheme. The experiment components included twelve parents, their 32 $F_1$s and one commercial check (Pusa Uttam). The experimental materials were sown under 3 environments (seasons). The details of three environments (Transplanting season) were $E_1$: *Summer* Season; $E_2$: *Kharif* Season and $E_3$: *Early Winter* Season. Three replications of a complete randomized block design were used for the trials in three

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environments (season). Transplanting was done in 6 m long single row at 60 × 60 cm spacing between rows and plants, respectively for all the treatments. The combining ability analysis for various characters was calculated using Kempthorne's (1957) L×T model. To maintain a quality crop, the entire suggested package of practices and plant safety precautions were implemented.

## RESULTS AND DISCUSSION

In the current study, lines × tester interaction and mean sum of square were found to be significant in all 3 environments (seasons) as well as in pooled over environments for all the attributes except number of fruits per plant in $E_1$ and $E_2$, average fruit length in $E_1$, $E_2$ and $E_3$, average fruit weight in $E_1$ and total fruit yield (Tables 1 to 3). The variance estimates, GCA and SCA were highly significant for most of the traits (except SCA variance for average fruit length, average fruit weight in $E_1$, fruit yield per plant and total fruit yield in $E_1$, $E_2$ and $E_3$, number of fruits per plant in $E_1$, $E_2$ and pooled over environments) emphasizing the importance of additive and non-additive gene actions in inheritance of these traits. Both variances significance for attributes related to yield was likewise confirmed by Das and Barua (2001), Suneetha *et al.* (2005), Bisht *et al.* (2006) and Rajan *et al.* (2022). Further, it was observed that variance due to GCA was higher in magnitude than SCA for all the traits studied. Thus, it supports predominance of additive gene effects on governing the expression of most of the characters, indicating early generation testing of genotypes becomes more fruitful due to chance of fixing superior genes would be greater. However, perusal of GCA:SCA variance ratio revealed less than unity was observed for all the characters except fruit yield per plant and total fruit yield in $E_1$ and pooled over environments revealing greater than one. The results validated the findings of Rajan *et al.* (2022) reported GCA:SCA ratio less than unity for average fruit length, average fruit diameter and number of fruits per plant suggesting the importance of dominance gene action in controlling the inheritance of the characters. While Reddy and Patel (2014) observed GCA:SCA ratio more than unity for average fruit weight suggesting the existence of over dominance gene action.

### General combining ability

The data in Tables 4 and 5 show the estimated GCA impacts of the male and females for six traits in individual and pooled environments. For various traits in most of the environments (seasons), including pooled over environments, female parents had desirable substantial GCA estimates, including PLR-1 for number of fruits per plant (except $E_2$, $E_3$), fruit yield per plant with average fruit weight and total fruit yield whereas, the another female parent PR-5 showed good GCA for average fruit weight, average fruit diameter together with fruit yield per plant and total fruit yield as well as the line VR-2 for number of fruits per plant (except $E_1$, pooled), average fruit length and average fruit diameter. The line IIHR-563 was a poor combiner for all the characters. Among the males CHBR-2 exhibited good effects for average fruit weight and fruit diameter (except in $E_3$), whereas, RCMBL-49 for average fruit length along with number of fruits per plant. The tester CO-2 exhibited good GCA for average fruit weight coupled with average fruit length (except in $E_1$, $E_2$), as well as JB-64 manifested good GCA for number of fruits per plant (except in $E_1$). Another tester PB-6 displayed significantly positive effects for number of fruits per plant (except in $E_1$) and average fruit length. The testers BCB-464 and BCB-71-1 exhibited significantly desirable effects in all three environments (seasons) as well as environments that were pooled over environments for all the traits except average fruit length and number of fruits per plant. The another tester Swarna Mani also manifested significant effects for average fruit weight including fruit yield per plant, and total fruit yield. The same outcomes were also reported by Biradar *et al.* (2005), Kamalakkannan *et al.* (2007), Vora *et al.* (2020) and Rajan *et al.* (2022). In order to increase fruit yield and yield qualities, as might be beneficial to utilize these parental lines in interbreeding programmes as a good source of favourable genes. This may be explained by the fact that additive and additive-additive gene activity predominately controls the offering of these attributes.

### Specific combining ability

In accordance with SCA effect estimate, none of cross was superior for any of the traits in none of the environments (seasons) including pooled environment. Tables 4 and 5 showed the estimates of GCA for all the traits. The crossover combinations that were significantly good in $E_1$ for two or more characters were PLR-1 × Swarna Mani for fruit yield per plant, total fruit yield and number of fruits per plant whereas, the crosses PR-5 × BCB-464 and VR-2 × CO-2 manifested significantly positive effects for average fruit length and average fruit diameter. The cross combination VR-2 × CHBR-2 had significant effects of SCA for average fruit length as well as average fruit diameter. Another hybrid IIHR- 563 × PB-6 had significance for yield attributing traits like average fruit diameter and average fruit weight. As well as only 4 crosses out of 32 exhibited positive favourable effect in $E_2$ for two and more than two characters were PLR-1 × CO-2, PR-5 × BCB-71-1 and PR-5 × BCB-464 for average fruit weight, fruit yield

**Table 1: ANOVA for combining ability for average fruit length (cm) and average fruit diameter (cm) in each environment and pooled over environments**

| Source of variance | | Average fruit length (cm) | | | | Average fruit diameter (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | d.f. | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled |
| Environment | 2 | | | | 371.296** | | | | 252.421** |
| Replication | 2 | 0.060 | 0.413 | 0.241 | 0.408 | 0.162 | 0.431 | 0.233 | 0.045 |
| Hybrids | 31 | 3.564** | 6.663** | 6.411** | 14.242** | 3.021** | 3.618** | 3.294** | 8.412** |
| Female (F) | 3 | 8.726** | 7.668** | 4.026* | 16.695** | 5.041* | 13.667** | 14.055** | 27.737** |
| Male (M) | 7 | 9.167** | 23.909** | 23.604** | 52.304** | 7.801** | 7.130** | 5.076** | 18.631** |
| Females × Males (F × M) | 21 | 0.960 | 0.771 | 1.021 | 1.204* | 1.140** | 1.012** | 1.162** | 2.246** |
| Hybrids × Environments | 62 | | | | 1.198** | | | | 0.760** |
| Female × Environment | 6 | | | | 1.862* | | | | 2.513** |
| Male × Environment | 14 | | | | 2.188** | | | | 0.688 |
| (F × M) × Environments | 42 | | | | 0.774 | | | | 0.534* |
| Pooled Error | 186 | | | | 0.696 | | | | 0.320 |
| **Estimates** | | | | | | | | | |
| σ2 Environment | | | | | 2.808** | | | | 1.910** |
| σ2 Females | | 0.338** | 0.290** | 0.134* | 0.222** | 0.199* | 0.551** | 0.571** | 0.381** |
| σ2 Males | | 0.712** | 1.933** | 1.900** | 1.434** | 0.628** | 0.557** | 0.393** | 0.509** |
| σ2 gca | | 0.462** | 0.838** | 0.723** | 0.626* | 0.342** | 0.553** | 0.512** | 0.423** |
| σ2 sca | | 0.112 | 0.021 | 0.073 | 0.056 | 0.290** | 0.190** | 0.268** | 0.214** |
| σ2 gca/ ó2 sca | | 0.511 | 0.031 | 0.010 | 0.046 | 0.031 | 0.829 | 0.655 | 0.450 |
| σ2 Females × Environments | | | | | 0.049* | | | | 0.091** |
| σ2 Males × Environments | | | | | 0.124** | | | | 0.031 |
| σ2 gca × Environments | | | | | 0.074* | | | | 0.071* |
| σ2 sca × Environments | | | | | 0.026 | | | | 0.071* |

*$E_1$, $E_2$ and $E_3$ are different environments (seasons) viz., Summer Season, Kharif Season and Early Winter Season, respectively.*

**, ** Significant at 5 and 1 per cent probability levels, respectively.*

**Table 2: ANOVA for combining ability for average fruit weight (g) and fruit yield per plant (kg) in each environment and pooled over environments.**

| **Source of variance** | | **Average fruit weight (g)** | | | | **Fruit yield per plant (kg)** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **d.f.** | **$E_1$** | **$E_2$** | **$E_3$** | **Pooled** | **$E_1$** | **$E_2$** | **$E_3$** | **Pooled** |
| Environment | 2 | | | | 16040.010** | | | | 15.291** |
| Replication | 2 | 1.018 | 0.818 | 0.645 | 0.135 | 0.001 | 0.001 | 0.003 | 0.002 |
| Hybrids | 31 | 105.725** | 254.766** | 265.042** | 558.189** | 0.011** | 0.017** | 0.014** | 0.039** |
| Female (F) | 3 | 249.544** | 469.174** | 374.579** | 1043.500** | 0.060** | 0.077** | 0.038** | 0.168** |
| Male (M) | 7 | 339.087** | 858.393** | 911.524** | 1922.297** | 0.023** | 0.034** | 0.036** | 0.088** |
| Females × Males (F × M) | 21 | 7.392 | 22.927** | 33.901** | 34.156** | 0.001 | 0.003 | 0.003 | 0.004 |
| Hybrids × Environments | 62 | | | | 33.672** | | | | 0.002 |
| Female × Environment | 6 | | | | 24.898 | | | | 0.003 |
| Male × Environment | 14 | | | | 93.353** | | | | 0.002 |
| (F × M) × Environments | 42 | | | | 15.032** | | | | 0.002 |
| Pooled Error | 186 | | | | 5.114 | | | | 0.003 |
| **Estimates** | | | | | | | | | |
| σ2 Environment | | | | | 121.477** | | | | |
| σ2 Females | | 10.149** | 19.329** | 15.370** | 14.422** | 0.002** | 0.003** | 0.001** | 0.002** |
| σ2 Males | | 27.759** | 71.094** | 75.485** | 53.255** | 0.002** | 0.002** | 0.003** | 0.002** |
| σ2 gca | | 16.019** | 36.584** | 35.408** | 27.366** | 0.002** | 0.003** | 0.002** | 0.002** |
| σ2 sca | | 0.473 | 5.885** | 9.399** | 3.227* | -0.0003 | -0.0002 | -0.0001 | 0.0001* |
| σ2 gca/ ó2 sca | | 0.381 | 0.128 | 0.062 | 0.243 | 1.944 | 0.735 | 0.688 | 3.311 |
| σ2 Females × Environments | | | | | 0.824 | | | | 0.0001 |
| σ2 Males × Environments | | | | | 7.353** | | | | 0.0001 |
| σ2 gca × Environments | | | | | 3.001** | | | | 0.0001 |
| σ2 sca × Environments | | | | | 3.306** | | | | -0.0004 |

*$E_1$, $E_2$ and $E_3$ are different environments (seasons) viz., Summer Season, Kharif Season and Early Winter Season, respectively.*
**, ** Significant at 5 and 1 per cent probability levels, respectively.*

**Table 3: ANOVA for combining ability for number of fruits per plant and total fruit yield (q/ha) in each environment and pooled over environments.**

| Source of variance | d.f. | Number of fruits per plant | | | | Total fruit yield (q/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled |
| Environment | 2 | | | | 1465.385** | | | | 1180957.000** |
| Replication | 2 | 0.376 | 0.223 | 0.324 | 0.501 | 59.996 | 99.149 | 221.745 | 188.157 |
| Hybrids | 31 | 1.076** | 3.763** | 4.087** | 5.021** | 887.215** | 1342.701** | 1045.590** | 2993.937** |
| Female (F) | 3 | 6.197** | 2.287* | 4.189* | 2.435* | 4748.961** | 5896.697** | 2904.218** | 13056.410** |
| Male (M) | 7 | 1.254** | 13.845** | 13.575** | 18.879** | 1806.959** | 2600.119** | 2750.624** | 6817.146** |
| Females × Males (F × M) | 21 | 0.285 | 0.614 | 0.911** | 0.772** | 28.956 | 272.991 | 211.727 | 282.038 |
| Hybrids × Environments | 62 | | | | 1.953** | | | | 140.784 |
| Female × Environment | 6 | | | | 5.119** | | | | 246.731 |
| Male × Environment | 14 | | | | 4.897** | | | | 170.277 |
| (F × M) × Environments | 42 | | | | 0.519* | | | | 115.818 |
| Pooled Error | 186 | | | | 0.327 | | | | 197.656 |
| **Estimates** | | | | | | | | | |
| σ2 Environment | | | | | 11.099** | | | | 8945.146** |
| σ2 Females | | 0.244** | 0.073* | 0.163* | 0.029 | 194.057** | 231.94** | 111.627** | 178.594** |
| σ2 Males | | 0.076** | 1.109** | 1.108** | 0.515* | 142.947** | 189.16** | 210.455** | 183.875** |
| σ2 gca | | 0.188** | 0.418** | 0.478** | 0.191* | 177.020** | 217.68** | 144.570** | 180.354** |
| σ2 sca | | -0.019 | 0.026 | 0.211** | 0.049 | -20.881 | -19.04 | -4.479 | 9.376** |
| σ2 gca/ σ2 sca | | 0.400 | 0.046 | 0.017 | 0.080 | 1.922 | 0.730 | 0.698 | 3.226 |
| σ2 Females × Environments | | | | | 0.200** | | | | 2.045 |
| σ2 Males × Environments | | | | | 0.381** | | | | -2.282 |
| σ2 gca × Environments | | | | | 0.260** | | | | |
| σ2 sca × Environments | | | | | 0.060* | | | | |

*$E_1$, $E_2$ and $E_3$ are different environments (seasons) viz., Summer Season, Kharif Season and Early Winter Season, respectively.*
**, ** Significant at 5 and 1 per cent probability levels, respectively.*

**Table 4: Estimates of general combining ability and specific combining ability effects in each environment and pooled over environments for average fruit length (cm), average fruit diameter (cm) and average fruit weight (g).**

| Genotypes | Average fruit length (cm) | | | | Average fruit diameter (cm) | | | | Average fruit weight (g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled |
| **Females** | | | | | | | | | | | | |
| PLR-1 | 0.57** | -0.14 | 0.03 | 0.15 | -0.29** | -1.04** | -1.08** | -0.80** | 2.14** | 1.95** | 2.40** | 2.17** |
| PR-5 | -0.45** | -0.53** | -0.31 | -0.43** | 0.43** | 0.73** | 0.66** | 0.61** | 2.69** | 3.58** | 1.83** | 2.70** |
| VR-2 | 0.46** | 0.80** | 0.56** | 0.61** | 0.34** | 0.29* | 0.36** | 0.33** | -4.37** | -6.41** | -5.90** | -5.56** |
| IIHR- 563 | -0.58** | -0.12 | -0.28 | -0.33** | -0.48** | 0.01 | 0.05 | -0.13* | -0.47 | 0.87 | 1.66** | 0.68* |
| **Males** | | | | | | | | | | | | |
| CHBR-2 | -0.28 | -0.87** | -1.05** | -0.73** | 1.43** | 0.82** | 0.72** | 0.99** | 2.57** | 5.23** | -0.02 | 2.59** |
| RCMBL-49 | 0.84** | 1.76** | 1.80** | 1.47** | -0.07 | -0.32 | -0.08 | -0.15 | -8.06** | -13.30** | -11.57** | -10.98** |
| CO-2 | 1.41** | 1.26** | 1.34** | 1.34** | -0.29 | -0.53** | -0.50** | -0.44** | -0.45 | -0.83 | 6.86** | 1.85** |
| JB-64 | -0.44 | -1.00** | -0.70** | -0.71** | -0.56** | -0.63** | -0.45* | -0.55** | -4.12** | -7.07** | -8.03** | -6.41** |
| PB-6 | 0.72** | 2.01** | 1.86** | 1.53** | -1.34** | -1.11** | -1.00** | -1.15** | -4.76** | -7.32** | -10.29** | -7.46** |
| BCB-71-1 | -0.95** | -0.96** | -1.01** | -0.98** | 0.19 | 0.84** | 0.58** | 0.53** | 6.77** | 7.93** | 8.45** | 7.72** |
| BCB-464 | -0.82** | -1.00** | -0.88** | -0.90** | 0.43** | 0.80** | 0.70** | 0.69** | 6.01** | 9.97** | 8.28** | 8.09** |
| Swarna Mani | -0.46* | -1.20** | -1.34** | -1.00** | 0.22 | 0.09 | -0.06 | 0.08 | 2.04** | 5.40** | 6.32** | 4.59** |
| **S.E.(gi)** | 0.16 | 0.17 | 0.18 | 0.09 | 0.10 | 0.13 | 0.12 | 0.06 | 0.49 | 0.46 | 0.48 | 0.26 |
| **S.E.(gj)** | 0.22 | 0.24 | 0.25 | 0.13 | 0.15 | 0.19 | 0.17 | 0.09 | 0.70 | 0.66 | 0.68 | 0.37 |
| **SCA effects** | | | | | | | | | | | | |
| PLR-1 × CHBR-2 | 0.10 | 0.01 | 0.03 | 0.04 | -0.57 | 0.11 | 0.17 | -0.09 | 2.38** | 1.19 | 1.00 | 1.52* |
| PLR-1 × RCMBL-49 | 0.04 | 0.20 | 0.18 | 0.14 | 0.14 | -0.34 | 0.56 | 0.12 | -0.25 | 0.26 | -2.52 | -0.83 |
| PLR-1 × CO-2 | -0.46 | -0.39 | -0.76* | -0.54* | -1.13** | -0.50 | -0.86* | -0.83** | -0.31 | 2.28* | 3.86** | 1.94* |
| PLR-1 × JB-64 | -0.08 | 0.03 | -0.19 | -0.09 | 0.17 | 0.59 | -0.12 | 0.21 | 1.65* | 0.29 | 0.35 | 0.76 |
| PLR-1 × PB-6 | 0.48 | 0.24 | -0.56 | 0.05 | -0.15 | -0.40 | -0.42 | -0.32 | -1.40 | -2.57 | 0.91 | -1.02 |
| PLR-1 × BCB-71-1 | 0.00 | -0.43 | 0.36 | -0.02 | 0.83** | 0.44 | 0.18 | 0.48* | -0.69 | -2.71* | 3.30* | -0.03 |
| PLR-1 × BCB-464 | -0.32 | -0.06 | 0.35 | -0.01 | 0.67* | 0.36 | 0.66* | 0.56** | -0.90 | 2.67* | 0.79 | 0.85 |
| PLR-1 × Swarna Mani | 0.23 | 0.44 | 0.58* | 0.42* | 0.03 | -0.27 | -0.16 | -0.13 | -0.46 | -1.42 | -7.70** | -3.20** |
| PR-5 × CHBR-2 | -0.78* | 0.71* | 0.71* | 0.21 | 0.23 | -0.23 | 0.10 | 0.03 | -0.20 | 2.09* | 1.89 | 1.26* |
| PR-5 × RCMBL-49 | 0.68* | -0.42 | -0.67* | -0.14 | 0.48 | -0.38 | -0.86* | -0.25 | 0.86 | -0.45 | -0.61 | -0.06 |
| PR-5 × CO-2 | -0.33 | -0.36 | -0.19 | -0.29 | -0.08 | 0.17 | 0.21 | 0.10 | -0.60 | -2.68* | -3.39* | -2.22** |
| PR-5 × JB-64 | -0.38 | 0.23 | 0.17 | 0.008 | -0.34 | 0.37 | 0.55 | 0.19 | 0.17 | -1.86 | -2.43 | -1.37* |
| PR-5 × PB-6 | 0.16 | -0.65 | -0.45 | -0.31 | -0.50 | -0.50 | -0.49 | -0.50** | 0.03 | -0.39 | -1.26 | -0.55 |
| PR-5 × BCB-71-1 | -0.34 | 0.46 | 0.09 | 0.07 | -0.25 | -0.09 | 0.06 | -0.09 | 0.34 | 2.25* | 1.56 | 1.38* |
| PR-5 × BCB-464 | 0.64* | 0.26 | 0.44 | 0.45* | 0.27 | 0.32 | -0.31 | 0.09 | 1.59* | 1.97* | 2.66* | 2.07** |

**Contd…**

**Table 4: Contd…**

| Genotypes | Average fruit length (cm) | | | | Average fruit diameter (cm) | | | | Average fruit weight (g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled |
| PR-5 × Swarna Mani | 0.35 | -0.23 | -0.11 | 0.006 | 0.18 | 0.35 | 0.74* | 0.42* | -2.17* | -0.92 | 1.56 | -0.50 |
| VR-2 × CHBR-2 | 1.06** | -0.69* | -0.35 | 0.005 | 0.69* | 0.11 | -0.10 | 0.23 | -0.18 | -3.82** | -0.01 | -1.34* |
| VR-2 × RCMBL-49 | -0.92* | 0.24 | 0.34 | -0.11 | -0.52 | 0.45 | 0.23 | 0.05 | 1.61* | 0.93 | -1.34 | 0.40 |
| VR-2 × CO-2 | 0.83* | 1.08** | 0.93* | 0.95** | 1.22** | 0.49 | 0.69* | 0.80** | -0.68 | -0.35 | -1.36 | -0.80 |
| VR-2 × JB-64 | 0.47 | -0.39 | -0.17 | -0.03 | -0.07 | -0.85* | -1.05** | -0.66** | -2.28** | 1.03 | 1.26 | 0.00 |
| VR-2 × PB-6 | -0.59 | 0.72* | 1.14** | 0.42* | 0.02 | 0.80* | 0.74* | 0.52** | -0.18 | 4.35** | 3.08* | 2.41** |
| VR-2 × BCB-71-1 | 0.05 | -0.38 | -0.50 | -0.27 | -0.70* | 0.05 | 0.02 | -0.20 | 0.05 | -2.06* | -4.53** | -2.18** |
| VR-2 × BCB-464 | -0.51 | -0.20 | -0.57 | -0.43* | -0.17 | 0.02 | 0.37 | 0.07 | -1.02 | -4.97** | -2.35 | -2.78** |
| VR-2 × Swarna Mani | -0.39 | -0.36 | -0.81* | -0.52* | -0.47 | -1.10** | -0.91* | -0.82** | 2.70** | 4.90** | 5.26** | 4.29** |
| IIHR- 563 × CHBR-2 | -0.38 | -0.01 | -0.39 | -0.26 | -0.35 | -0.003 | -0.17 | -0.17 | -1.99* | 0.53 | -2.88* | -1.44* |
| IIHR- 563 × RCMBL-49 | 0.19 | -0.02 | 0.15 | 0.10 | -0.11 | 0.27 | 0.06 | 0.07 | -2.22** | -0.75 | 4.48** | 0.50 |
| IIHR- 563 × CO-2 | -0.02 | -0.33 | 0.01 | -0.11 | -0.01 | -0.16 | -0.04 | -0.07 | 1.59* | 0.76 | 0.90 | 1.08* |
| IIHR- 563 × JB-64 | -0.01 | 0.15 | 0.19 | 0.11 | 0.24 | -0.10 | 0.61* | 0.25 | 0.46 | 0.53 | 0.81 | 0.60 |
| IIHR- 563 × PB-6 | -0.06 | -0.30 | -0.12 | -0.16 | 0.63* | 0.09 | 0.18 | 0.30 | 1.58* | -1.37 | -2.73* | -0.84 |
| IIHR- 563 × BCB-71-1 | 0.28 | 0.35 | 0.03 | 0.22 | 0.12 | -0.41 | -0.26 | -0.18 | 0.30 | 2.52* | -0.33 | 0.82 |
| IIHR- 563 × BCB-464 | 0.19 | 0.01 | -0.21 | -0.006 | -0.78* | -0.71 | -0.71* | -0.73** | 0.33 | 0.32 | -1.11 | -0.15 |
| IIHR- 563 × Swarna Mani | -0.20 | 0.15 | 0.33 | 0.09 | 0.25 | 1.02** | 0.33 | 0.53** | -0.06 | -2.55* | 0.87 | -0.58 |
| **S.E. (Sij)** | 0.45 | 0.48 | 0.51 | 0.27 | 0.30 | 0.38 | 0.34 | 0.18 | 1.41 | 1.32 | 1.37 | 0.75 |

*$E_1$, $E_2$ and $E_3$ are different environments (seasons) viz., Summer Season, Kharif Season and Early Winter Season, respectively.*
**, ** Significant at 5 and 1 per cent probability levels, respectively*

**Table 5: Estimates of general combining ability and specific combining ability effects in each environment and pooled over environments for fruit yield per plant (kg), number of fruits per plant and total fruit yield (q/ha).**

| Genotypes | Fruit yield per plant (kg) | | | | Number of fruits per plant | | | | Total fruit yield (q/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled |
| **Females** | | | | | | | | | | | | |
| PLR-1 | 0.04** | 0.04** | 0.03** | 0.04** | 0.47** | 0.18 | 0.05 | 0.22** | 11.98** | 12.75** | 9.74** | 11.49** |
| PR-5 | 0.02** | 0.04** | 0.02* | 0.03** | 0.06 | -0.17 | -0.03 | -0.04 | 6.86** | 11.55** | 7.89* | 8.76** |
| VR-2 | 0.07** | -0.07** | -0.05** | -0.06** | -0.71** | 0.33* | 0.51** | 0.04 | -20.03** | -20.68** | -13.83** | -18.18** |
| IIHR- 563 | 0.005 | -0.01 | -0.01 | -0.007 | 0.17 | -0.33* | -0.51** | -0.22** | 1.19 | -3.62 | -3.79 | -2.07 |
| **Males** | | | | | | | | | | | | |
| CHBR-2 | -0.003 | 0.02 | -0.01 | 0.001 | -0.44* | -0.72** | -0.35* | -0.50** | -0.86 | 6.79 | -5.14 | 0.26 |
| RCMBL-49 | -0.04** | -0.06** | -0.06** | -0.05** | 0.44* | 1.99** | 1.60** | 1.35** | -12.75** | -19.06** | -17.19** | -16.34** |
| CO-2 | -0.006 | 0.01 | 0.03* | 0.01 | -0.06 | 0.23 | -0.87** | -0.23* | -1.60 | 3.60 | 9.93* | 3.97 |
| JB-64 | -0.04** | -0.05** | -0.04** | -0.05** | -0.25 | 0.66** | 0.91** | 0.44** | -13.16** | -15.10** | -13.29** | -13.85** |
| PB-6 | -0.03** | -0.06** | -0.06** | -0.05** | -0.02 | 0.60** | 1.20** | 0.59** | -11.24** | -16.95** | -17.53** | -15.24** |
| BCB-71-1 | 0.03** | 0.04* | 0.04** | 0.04** | -0.27 | -1.04** | -1.03** | -0.78** | 10.96** | 11.57* | 12.44** | 11.66** |
| BCB-464 | 0.07** | 0.06** | 0.07** | 0.07** | 0.34* | -1.11** | -0.64** | -0.47** | 19.68** | 17.69** | 21.33** | 19.56** |
| Swarna Mani | 0.03** | 0.04* | 0.03* | 0.03** | 0.26 | -0.61** | -0.81** | -0.38** | 8.98** | 11.45* | 9.46* | 9.96** |
| **S.E.(gi)** | 0.007 | 0.01 | 0.01 | 0.006 | 0.11 | 0.14 | 0.10 | 0.06 | 1.95 | 3.70 | 3.06 | 1.65 |
| **S.E.(gj)** | 0.01 | 0.01 | 0.01 | 0.008 | 0.16 | 0.21 | 0.15 | 0.09 | 2.76 | 5.24 | 4.33 | 2.34 |
| **SCA effects** | | | | | | | | | | | | |
| PLR-1 × CHBR-2 | -0.001 | 0.001 | -0.01 | -0.006 | -0.32 | -0.22 | -0.42 | -0.32* | 0.24 | 0.24 | -4.97 | -1.49 |
| PLR-1 × RCMBL-49 | 0.006 | -0.02 | -0.008 | -0.008 | 0.17 | -0.40 | 0.38 | 0.05 | 0.74 | -5.82 | -2.16 | -2.41 |
| PLR-1 × CO-2 | -0.001 | 0.03* | -0.006 | 0.01 | 0.07 | 0.01 | -0.68* | -0.19 | 0.05 | 10.23* | -1.62 | 2.88 |
| PLR-1 × JB-64 | -0.01 | -0.005 | -0.01 | -0.01 | -0.44* | -0.14 | -0.27 | -0.28* | -3.07 | -1.44 | -2.64 | -2.38 |
| PLR-1 × PB-6 | -0.008 | -0.02 | 0.01 | -0.009 | 0.08 | 0.24 | -0.04 | 0.09 | -2.91 | -7.07 | 3.98 | -2.00 |
| PLR-1 × BCB-71-1 | -0.01 | 0.01 | 0.02 | 0.01 | -0.16 | 0.56* | -0.19 | 0.07 | -3.60 | 1.80 | 7.99 | 2.06 |
| PLR-1 × BCB-464 | 0.01 | 0.01 | 0.01 | 0.01 | 0.20 | -0.23 | -0.00 | -0.01 | 2.45 | 4.68 | 2.61 | 3.24 |
| PLR-1 × Swarna Mani | 0.02* | -0.01 | -0.01 | 0.001 | 0.39* | 0.17 | 1.24** | 0.60** | 6.09* | -2.60 | -3.19 | 0.10 |
| PR-5 × CHBR-2 | 0.006 | -0.03* | 0.001 | -0.01 | 0.10 | -0.76* | -0.32 | -0.32* | 1.26 | -10.53* | 0.32 | -2.98 |
| PR-5 × RCMBL-49 | 0.007 | 0.003 | -0.01 | 0.001 | -0.01 | -0.00 | -0.06 | -0.02 | 2.29 | 0.94 | -2.45 | 0.26 |
| PR-5 × CO-2 | 0.002 | -0.03* | -0.03* | -0.02 | 0.17 | 0.04 | 0.13 | 0.12 | 0.90 | -9.94 | -10.03* | -6.36 |
| PR-5 × JB-64 | -0.01 | -0.03* | -0.03* | -0.02 | -0.28 | -0.05 | 0.01 | -0.11 | -3.88 | -8.51 | -9.74 | -7.38 |
| PR-5 × PB-6 | 0.006 | -0.02 | -0.01 | -0.01 | 0.11 | -0.29 | 0.01 | -0.05 | 1.70 | -6.53 | -4.95 | -3.26 |
| PR-5 × BCB-71-1 | -0.002 | 0.03* | 0.03* | 0.02 | -0.05 | 0.10 | 0.13 | 0.06 | -0.22 | 9.93* | 9.05 | 6.25 |
| PR-5 × BCB-464 | 0.006 | 0.06** | 0.03* | 0.03* | -0.16 | 0.42 | 0.01 | 0.09 | 1.18 | 16.85** | 10.18* | 9.40* |

**Contd…**

**Table: 5 Contd…**

| Genotypes | Fruit yield per plant (kg) | | | | Number of fruits per plant | | | | Total fruit yield (q/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled | $E_1$ | $E_2$ | $E_3$ | Pooled |
| PR-5 × Swarna Mani | -0.01 | 0.02 | 0.02 | 0.01 | 0.11 | 0.54* | 0.06 | 0.24* | -3.23 | 7.80 | 7.62 | 4.06 |
| VR-2 × CHBR-2 | -0.007 | 0.01 | -0.004 | 0.002 | -0.11 | 0.90* | -0.08 | 0.23 | -2.33 | 5.10 | -1.21 | 0.51 |
| VR-2 × RCMBL-49 | 0.001 | 0.02 | -0.01 | 0.004 | -0.44* | 0.37 | 0.47* | 0.13 | -0.52 | 5.82 | -2.71 | 0.86 |
| VR-2 × CO-2 | -0.007 | -0.001 | 0.01 | 0.002 | -0.12 | 0.10 | 0.33 | 0.10 | -2.81 | -0.25 | 4.39 | 0.44 |
| VR-2 × JB-64 | 0.008 | 0.02 | 0.03* | 0.02 | 0.47* | 0.22 | 0.38 | 0.36* | 2.40 | 7.09 | 9.73* | 6.41 |
| VR-2 × PB-6 | 0.01 | 0.03* | -0.004 | 0.01 | 0.25 | -0.44 | -0.66* | -0.28* | 3.72 | 9.10 | -1.04 | 3.92 |
| VR-2 × BCB-71-1 | 0.007 | -0.05* | -0.02 | -0.02 | 0.21 | -0.48 | 0.22 | -0.01 | 2.51 | -16.21** | -10.20 | -7.97 |
| VR-2 × BCB-464 | -0.01 | -0.05* | -0.02 | -0.03* | 0.12 | 0.08 | -0.11 | 0.03 | -2.08 | -15.18* | -9.69 | -8.98 |
| VR-2 × Swarna Mani | -0.003 | 0.01 | 0.03* | 0.01 | -0.38* | -0.76* | -0.56* | -0.57** | -0.87 | 4.52 | 10.73* | 4.79 |
| IIHR- 563 × CHBR-2 | 0.003 | 0.01 | 0.02 | 0.01 | 0.33* | 0.09 | 0.82** | 0.41* | 0.83 | 5.18 | 5.86 | 3.96 |
| IIHR- 563 × RCMBL-49 | -0.01 | -0.004 | 0.02 | 0.003 | 0.28 | 0.02 | -0.79* | -0.16 | -2.52 | -0.94 | 7.33 | 1.28 |
| IIHR- 563 × CO-2 | 0.006 | 0.001 | 0.02 | 0.01 | -0.11 | -0.17 | 0.20 | -0.02 | 1.86 | -0.03 | 7.26 | 3.03 |
| IIHR- 563 × JB-64 | 0.01 | 0.01 | 0.01 | 0.01 | 0.25 | -0.02 | -0.12 | 0.03 | 4.55* | 2.86 | 2.65 | 3.35 |
| IIHR- 563 × PB-6 | -0.01 | 0.01 | 0.008 | 0.004 | -0.46* | 0.49 | 0.68* | 0.24* | -2.51 | 4.51 | 2.00 | 1.33 |
| IIHR- 563 × BCB-71-1 | 0.008 | 0.01 | -0.02 | 0.001 | 0.03 | -0.19 | -0.17 | -0.12 | 1.32 | 4.48 | -6.84 | -0.34 |
| IIHR- 563 × BCB-464 | -0.004 | -0.02 | -0.01 | -0.01 | -0.17 | -0.27 | 0.11 | -0.11 | -1.54 | -6.34 | -3.10 | -3.66 |
| IIHR- 563 × Swarna Mani | -0.005 | -0.03* | -0.05* | -0.02 | -0.12 | 0.05 | -0.74* | -0.27 | -1.98 | -9.72 | -15.17* | -8.96 |
| **S.E. (Sij)** | 0.01 | 0.03 | 0.03 | 0.01 | 0.33 | 0.42 | 0.30 | 0.19 | 5.52 | 10.49 | 8.66 | 4.68 |

*$E_1$, $E_2$ and $E_3$ are different environments (seasons) viz., Summer Season, Kharif Season and Early Winter Season, respectively.*

**, ** Significant at 5 and 1 per cent probability levels, respectively.*

per plant followed by total fruit yield. The cross VR-2 × PB-6 manifested good effect regarding average fruit diameter, average fruit weight and fruit yield per plant.

Whereas, in $E_3$, 5 crosses showed good SCA effects *viz.*, PLR-1 × Swarna Mani for average fruit length with number of fruits per plant, PR-5 × BCB-464 for average fruit weight, total fruit yield and fruit yield per plant while, cross combination VR-2 × CO-2 manifested good effect for two yield traits namely, average fruit length and diameter. VR-2 × PB-6 also manifested significant effects for three yield traits *viz.*, average fruit length, fruit diameter and average fruit weight and the cross,

VR-2 × Swarna Mani showed positive effects for average fruit weight with fruit yield per plant and total fruit yield. The hybrids which were significantly good in the pooled over environments only for two and more characters were PLR-1 × BCB-464 for number of fruits per plant with average fruit length. Hybrid PR-5 × BCB-464 exhibited well for all the characters except average fruit diameter and number of fruits per plants whereas, the cross combination VR-2 × CO-2 showed good SCA for average fruit length together with average fruit diameter, as well as the cross VR-2 × PB-6 manifested good SCA for average fruit length, average fruit diameter along with average fruit weight.

A summary of cross fusing with desirable significantly high SCA effects in the majority of environments as well as pooled over environments was considered the best specific combiners for a specific character or characters. The crosses *viz.*, PLR-1 × Swarna Mani (except in $E_2$) and IIHR- 563 × CHBR-2 (except in $E_2$) for number of fruits per plant. Furthermore, the hybrids VR-2 × PB-6 (except in $E_1$) and VR-2 × CO-2 exhibited good effects for average fruit length whereas the another crosses, PLR-1 × BCB-71-1 (except $E_2$, $E_3$), PLR-1 × BCB-464 and VR-2 × CO-2 found good for average fruit diameter. Crosses, PLR-1 × CO-2 (except in $E_1$), VR-2 × PB-6 (except in $E_1$) and VR-2 × Swarna Mani recorded significant effects for average fruit weight, in addition to another cross namely PR-5 × BCB-464 which manifested positively significant result for fruit yield per plant with total fruit yield. The current study's findings are consistent with previous findings Bhakta *et al*. (2009), Singh *et al*. (2013), Dubey *et al*. (2014), Reddy and Patel (2014), Suneetha and Kathiria (2006), Mishra *et al*. (2013), Patel *et al.* (2013) Ramani *et al*. (2017) and Kumar *et al*. (2018).

## CONCLUSION

The variance estimates, GCA and SCA were highly significant for most of the traits emphasizing the importance of additive and non-additive gene actions in inheritance of fruit yield and its contributing traits but additive gene action was more prominent. Over all, among female parents, PR-5 and PLR-1 and among male parents, BCB-464, BCB-71-1, Swarna Mani and CO-2 were effective general combiners for traits that contributed to fruit yield, as shown by significant and favourable GCA effects. These parents are anticipated to produce attractive transgressive segregants in subsequent generations and could be chosen in breeding programmes. Some prospective crosses with strong SCA outcomes in the right conduct for fruit yield and associated attributes have been found. These crosses were PR-5 × BCB-71-1, PR-5 × BCB-464, PLR-1 × BCB-71-1 and PLR-1 × Swarna Mani, offers better potential for the brinjal enhancement programme because of their desired effects. In addition, research indicates that variance due to GCA was higher in magnitude than SCA for all the traits studied. Thus, it supports predominance of additive gene effects on governing the expression of most of the characters, indicating early generation testing of genotypes becomes more fruitful due to chance of fixing superior genes would be greater.

Include the charaters with high GCA or SCA variances and how it could be exploited in breeding programme

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