



## Heterosis Exploitation in Brinjal against Fruit Borer Infestation under Semi-arid Climates of Gujarat

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**Abstract:** Brinjal (*Solanum melongena* L.) suffers severe losses due to devastating and multi-insecticide resistant pest known as shoot and fruit borer (*Leucinodes orbonalis* Guenee). Breeding varieties against pest resistance is imperative. Hence, hybrids were developed for insect resistance. These insect-resistant hybrids were evaluated at multiple locations in Gujarat during late rabi 2021-22 in RBD, in order to analyse the heterosis of eight lines, six testers, their resulting 48 hybrids, and two standard checks for fruit borer infestation. Significant differences due to environment, genotypes, parents, hybrids, parents *vs* hybrids suggested the existence of genetic variation and overall heterosis. Overall, ABSR-2 × GAB-6 hybrid showed better performance against shoot and fruit borer resistance and was high in fruit yield in Gujarat's semi-arid regions. It showed desirable heterobeltiosis and standard heterosis at multi-locations for fruit yield plant<sup>-1</sup> compared to the standard checks.

**Key words:** Brinjal, heterosis, *Leucinodes orbonalis*, line × tester, multi-location.

Brinjal (*Solanum melongena* L.) one of the most common and well-liked vegetables cultivated all over the world is also known as melongene, garden egg, guinea squash and aubergine. It belongs to the family 'Solanaceae' and is challenged by fruit and shoot borer (*Leucinodes orbonalis* Guenee) affecting the fruit yield significantly. This insect harms the plant by feeding into tender shoots, flower buds, and fruit, making the fruits unsuitable for human consumption, and decreasing both productivity and profit. The population growth of *L. orbonalis* is triggered by high humidity and moderate temperature (Rahman, 2013), the damage caused by the pest varies from location to location and season to season (Gautam *et al.*, 2019). According to Jagginavar *et al.* (2009) the percentage of fruit damage caused by *L. orbonalis* can go up to 90%. Brinjal crop is sensitive to *L. orbonalis* infestation from the seedling stage until maturity, which makes its management extremely challenging.

Management options rest with pesticides application which are often used excessively as preventive option or as curative means. The use of pesticide dramatically raises the cost of cultivation; creates problems with residue levels

Table 1. Details of parents and standard checks selected

| Parents/standard check | Shape of the fruit | Color of the fruit | Presence of spines/prickles                     |                                  |
|------------------------|--------------------|--------------------|---|----------------------------------|
| Arka Komal             | Lines              | Long               | Dark Purple                                     | --                               |
| Ph-6                   | Lines              | Oval               | Dark Purple                                     | --                               |
| Ph-9                   | Lines              | Round              | Purple  | --                               |
| PPL                    | Lines              | Long               | Greenish Purple                                 | Yes                              |
| JDNB-16-1              | Lines              | Oval               | Purple  | --                               |
| ISD-006                | Lines              | Oblong             | Dark purple                                     | --                               |
| CO2                    | Lines              | Slightly oblong    | dark purple streaks under pale green background | --                               |
| ABSR-2                 | Lines              | Round              | Dark purple                                     | Spiny                            |
| GOB-1                  | Testers            | Oblong             | Dark purple                                     | --                               |
| GAOB-2                 | Testers            | Obovate            | Pinkish Purple                                  | Prickles on pedicel              |
| GAB-6                  | Testers            | Club shaped        | Dark pink                                       | --                               |
| GRB-5                  | Testers            | Round              | Light green with purple shadow                  | --                               |
| Arka Harshita          | Testers            | long               | Green   | --                               |
| P. Anupam              | Testers            | long               | purple  | --                               |
| GJBH-4                 | Standard checks    | Oblong             | Deep yellow                                     | --                               |
| GABH-3                 | Standard checks    | Long               | Dark Purple                                     | Medium spine on leaves and calyx |

in fruits, develops resistance to multiple classes of insecticide and harms the natural enemies (Alengebawy *et al.*, 2021). The host plant resistance technique works well when combined with other methods because it has many advantages over other measures. Developing resistant hybrids in brinjal is the most efficient and economical strategy to control the issue of insect infestation. In brinjal developing hybrids is cost effective as the fruit contains a large number of seeds (Sahil *et al.*, 2021). Additionally, testing of hybrids in multiple locations helps to select stable hybrids, the present study was undertaken under three semi-arid climates of Gujarat to identify the resistant brinjal hybrids against brinjal fruit borer.

## Materials and Methods

### Experimental site and material

The experimental material shown in Table 1 consists of 8 lines [Arka Komal, Ph-6, Ph-9, PPL, JDNB-16-1, ISD-006, CO2 and ABSR 2] 6 testers [GOB 1, GAOB 2, GAB 6, GRB 5, Arka Harshita and P. Anupam] and standard checks [GJBH 4 and GABH 3]. A total of 48 F<sub>1</sub> hybrids were developed by crossing fourteen parents in line × tester fashion. The experiment was conducted during late rabi 2021-22.

Plant spacing was 45 cm × 10 cm. Sixty-four treatments were grown in randomized block design with three replications at three different locations, *viz.* (i) Horticulture Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, (Environment E<sub>1</sub>) (ii) Seed Spices Research Station, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, (Environment E<sub>2</sub>) (iii) Maize Research Station, Sardarkrushinagar Dantiwada Agricultural University, Bhiloda, (Environment E<sub>3</sub>).

### Experimental details

The mode of action of brinjal shoot and fruit borer were noticed on shoots, flowers and fruits (Fig. 1). The fruit infestation was considered for analysis in this experiment since, fruits are the economical parts. The observation was recorded at timely intervals on five randomly selected plants from each entry in each replication. The total number of fruits and number of fruits infested per plant by shoot and fruit borer were counted at every picking for each entry. The weight of brinjal fruits was recorded to determine fruit yield plant<sup>-1</sup>.

### Statistical analysis

The following equation was applied to find out fruit borer infestation.

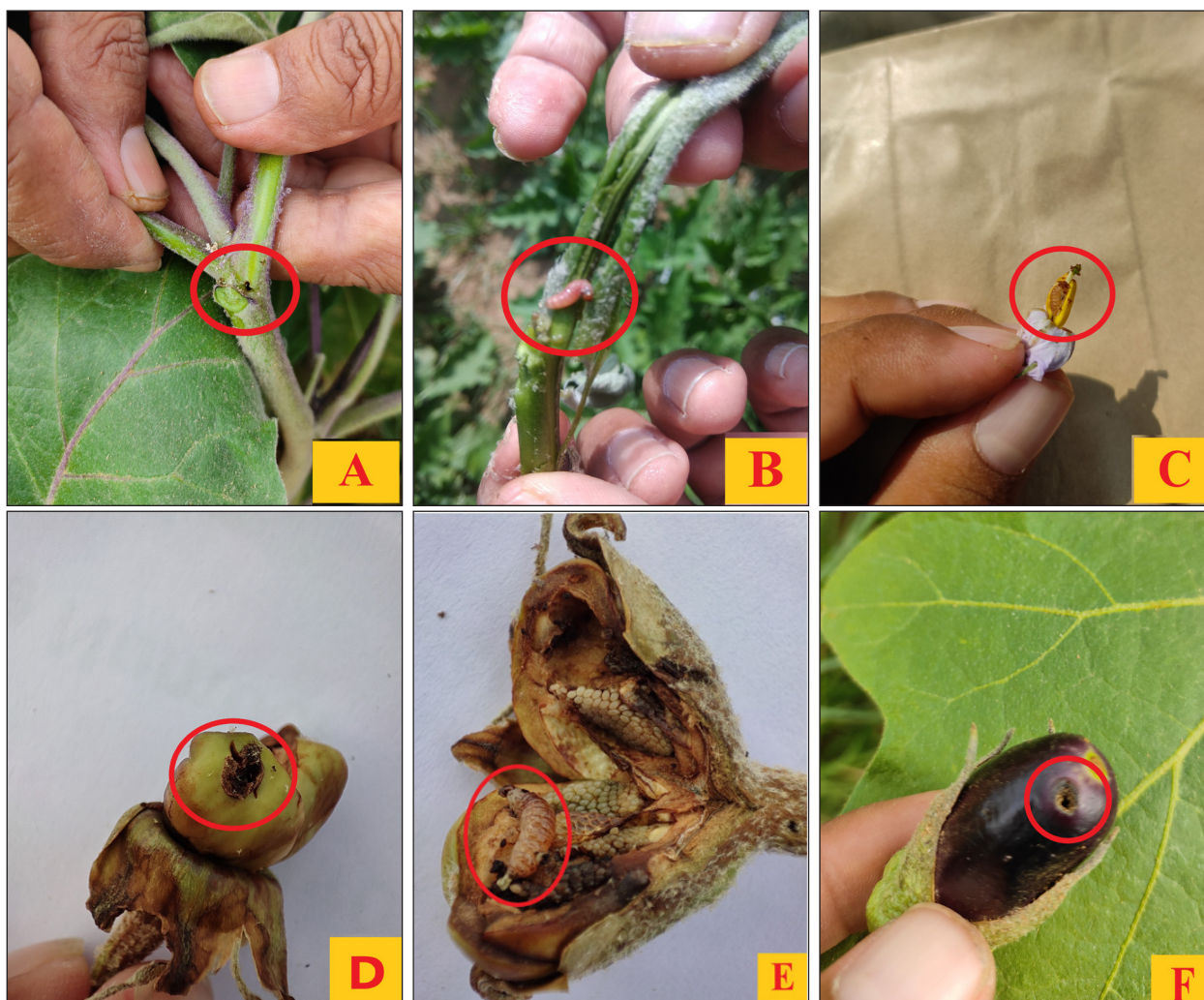
$$\text{Fruit borer infestation (\%)} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits}} \times 100$$

The overall mean values of five randomly selected plants in each replication and every picking for fruit yield and borer infestation at 3 locations were used for statistical analysis. Data analyses was carried out through computer facilities available in the department. The characters studied were analysed separately by using the analysis of variance technique for the individual environments as per the procedure outlined by Cochran and Cox (1963). Pooled analysis of variance over the three environments was done as per the method of Comstock and Robinson (1952). Heterosis was estimated as the per cent increase (+) or decrease (-) of

F<sub>1</sub> hybrid mean over the better parent (BP), standard check 1 (SH1) and standard check 2 (SH2) as per standard procedure (Fonseca and Patterson, 1968). Genotypic correlation coefficient was estimated as per the method of Al-Jibouri *et al.* (1958).

## Results and Discussion

Analysis of variance for 64 genotypes depicting mean squares for two traits under individual environments as well as pooled over environments are presented in Table 2. Significant differences were observed among genotypes for both the traits under individual environments but for fruit yield it was significant for over the environments. This indicated the presence of substantial amount of genetic variability



A: Entry hole of *L. orbonalis* in tender shoots; B: Transsection of damaged shoots and presence of *L. orbonalis* ; C: Damaged flower and presence of *L. orbonalis* in flower ; D: Entry hole of *L. orbonalis* on premature fruit; E: Transsection of damaged premature fruit and presence of *L. orbonalis* F: Hole caused by *L. orbonalis* on fruit

Fig. 1. Mode of brinjal fruit and shoot borer observed on the plant during experiment

Table 2. Analysis of variance (mean squares) for individual and pooled over the environments for fruit borer infestation and fruit yield per plant in brinjal

| Source of variation                | d.f. | Fruit borer infestation |                |                |           | Fruit yield per plant |                |                |                |
|------------------------------------|------|-------------------------|----------------|----------------|-----------|-----------------------|----------------|----------------|----------------|
|                                    |      | E <sub>1</sub>          | E <sub>2</sub> | E <sub>3</sub> | Pooled    | E <sub>1</sub>        | E <sub>2</sub> | E <sub>3</sub> | Pooled         |
| Replications                       | 2    | 1.87                    | 0.26           | 0.05           | --        | 333900.48             | 86551.16       | 804268.23      | --             |
| Genotypes (G)                      | 63   | 39.76**                 | 10.08**        | 1.98**         | 21.19     | 2384185.33**          | 351203.11**    | 1712831.29**   | 2453331.67**   |
| Replications<br>(within locations) | 6    |                         |                |                | 0.73**    |                       |                |                | 408709.33**    |
| Environments (E)                   | 2    |                         |                |                | 1143.99** |                       |                |                | 218663324.12** |
| G × E                              | 126  |                         |                |                | 15.32**   |                       |                |                | 997444.03**    |
| Parents (P)                        | 13   | 41.41**                 | 1.87**         | 0.61**         | 1.41*     | 1166820.00**          | 175118.85**    | 822623.08**    | 434016.54      |
| Lines (L)                          | 7    | 45.26**                 | 1.67**         | 0.45**         | 3.01*     | 538028.57**           | 151713.71**    | 633481.14*     | 432725.86      |
| Testers (T)                        | 5    | 44.15**                 | 2.54**         | 0.96**         | 3.60      | 2034052.00**          | 146397.34**    | 1241446.40**   | 494937.60      |
| L vs. T                            | 1    | 0.82                    | 0.01           | 0.002          | 0.38      | 1232216.00**          | 482564.00**    | 52480.00       | 138432.00      |
| Hybrids (H)                        | 47   | 34.09**                 | 11.96**        | 2.43**         | 0.46**    | 2264102.13**          | 378554.26**    | 1882769.15**   | 2537404.26**   |
| Parents vs. Hybrids                | 1    | 337.20**                | 8.94**         | 0.12**         | 75.21     | 28004320.00**         | 1731124.00**   | 6846080.00**   | 28360930.00    |
| Between checks                     | 1    | 17.34**                 | 35.53**        | 0.11*          | 0.72      | 278641.50             | 247067.28*     | 629.97         | 367515.94      |
| Checks vs. Hybrids                 | 1    | 1.86                    | 2.98**         | 2.85**         | 0.59      | 5861.43               | 163961.29*     | 1245589.18*    | 206822.89      |
| Error                              | 126  | 0.61                    | 0.09           | 0.02           | --        | 113580.43             | 41640.44       | 262827.09      | --             |
| P × E                              | 26   |                         |                |                | 0.49**    |                       |                |                | 865186.54**    |
| L × E                              | 14   |                         |                |                | 0.94**    |                       |                |                | 445096.79**    |
| T × E                              | 10   |                         |                |                | 1.48**    |                       |                |                | 1463479.00**   |
| (L vs. T) × E                      | 2    |                         |                |                | 0.11      |                       |                |                | 814349.00**    |
| H × E                              | 94   |                         |                |                | 0.14      |                       |                |                | 994024.36**    |
| (P vs. H) × E                      | 2    |                         |                |                | 67.76**   |                       |                |                | 4111328.00**   |
| (Between checks) × E               | 2    |                         |                |                | 26.13**   |                       |                |                | 79411.40       |
| (Checks vs. Hybrids)<br>× E        | 2    |                         |                |                | 3.55**    |                       |                |                | 604294.51*     |
| Pooled error                       | 378  |                         |                |                | 0.24      |                       |                |                | 139349.32      |

E<sub>1</sub>, E<sub>2</sub> and E<sub>3</sub> are different environments viz., Sardarkrushinagar, Jagudan and Bhiloda, respectively

\*, \*\* Significant at 5 and 1% level of significance, respectively; L: Lines; T: Testers; E: environments

among the genotypes. Significant differences among parents were observed for both the traits (except pooled for fruit yield plant<sup>-1</sup>), which indicated that parents were distinct for these traits. The variance due to parents was further partitioned into variance due to lines, testers and lines vs. testers. The lines performed same as parents in individual and pooled over the environments. Testers were found significant in individual environments only. Lines vs. testers showed varied behavior in terms of significance for these traits. The hybrids also significantly differed among themselves. The performance of crosses differed significantly than that of parents in individual environments, suggesting the presence of average heterosis, which was evident from the significance of parents vs. hybrids comparison for these traits. ANOVA over environments revealed significant differences among the environments, which indicated variable environmental conditions.

Significant mean squares due to genotypes × environments and parents × environments were observed. This emphasized that genotypes and parents interacted differently to different environments. In case of check, comparison between check and check vs. hybrids were non-significant for both the traits for three locations and over the locations.

#### Heterobeltiosis

The percentage heterosis over better parent and standard checks for fruit borer infestation are presented in Table 2 and 3. Since less borer infestation is desirable, negative heterosis was considered useful for identifying resistant hybrids. The distinctiveness in heterobeltiosis for this trait varied from -83.92 to 138.3, -72.32 to 2950, -63.91 to 742.45 and -74.33 to 143.27% in E<sub>1</sub>, E<sub>2</sub>, E<sub>3</sub> and pooled over the environments, respectively. Total 24 hybrids had showed

Table 3. Per cent heterobeltiosis and standard heterosis in individual and pooled over the environments for fruit borer infestation

| Sr. No. | Hybrids                    | Sardarkrushinagar (E <sub>1</sub> ) |          |          | Jagudan (E <sub>2</sub> ) |           |          | Bhiloda (E <sub>3</sub> ) |           |           | Pooled over environments |          |          |
|---------|----------------------------|-------------------------------------|----------|----------|---------------------------|-----------|----------|---------------------------|-----------|-----------|--------------------------|----------|----------|
|         |                            | BP                                  | SHI      | SH2      | BP                        | SHI       | SH2      | BP                        | SHI       | SH2       | BP                       | SHI      | SH2      |
| 1       | Arka Komal × GOB-1         | -54.55**                            | -25.00*  | 73.08**  | -43.68**                  | 311.96**  | -75.58** | -38.55**                  | 80.53**   | 518.18**  | -54.65                   | -3.74    | -18.27   |
| 2       | Arka Komal × GAOB-2        | -48.46**                            | -18.39   | 88.33**  | -50.82**                  | 259.78**  | -78.67** | 27.04                     | 161.95**  | 796.97**  | -44.74                   | 4.48     | -11.29   |
| 3       | Arka Komal × GAB-6         | 21.43                               | 13.33    | 161.54** | -10.78                    | -1.09     | -94.14** | -24.14                    | -22.12    | 166.67    | 16.75                    | 10.46    | -6.22    |
| 4       | Arka Komal × GRB-5         | -83.92**                            | -61.67** | -11.54   | 11.69                     | 408.70**  | -69.85** | 33.96                     | 88.50**   | 545.45**  | -71.84*                  | -31.69   | -42.01   |
| 5       | Arka Komal × Arka Harshita | 14.71                               | -35.00** | 50.00*   | -46.98**                  | 263.04**  | -78.48** | -10.84                    | 161.95**  | 796.97**  | -9.77                    | -10.31   | -23.86   |
| 6       | Arka Komal × P. Anupam     | -61.76**                            | -56.67** | 0.00     | 170.13**                  | 352.17**  | -73.20** | -43.96*                   | -9.73     | 209.09*   | -45.33                   | -35.28   | -45.05   |
| 7       | Ph-6 × GOB-1               | -19.15                              | -36.67** | 46.15    | 644.01**                  | 2803.26** | 72.10**  | 2.42                      | 311.50**  | 1309.09** | 92.31                    | 113.00   | 80.84    |
| 8       | Ph-6 × GAOB-2              | 55.25**                             | 21.61    | 180.64** | 86.07**                   | 626.09**  | -56.96** | 63.09**                   | 236.28**  | 1051.52** | 45.75                    | 61.43    | 37.06    |
| 9       | Ph-6 × GAB-6               | -42.48**                            | -54.94** | 3.97     | 523.53**                  | 591.30**  | -59.02** | 370.69**                  | 383.19**  | 1554.55** | 4.90                     | -0.75    | -15.74   |
| 10      | Ph-6 × GRB-5               | 138.30**                            | 86.67**  | 330.77** | 0.28                      | 291.30**  | -76.80** | 143.40**                  | 242.48**  | 1072.73** | 84.75                    | 104.63   | 73.73    |
| 11      | Ph-6 × Arka Harshita       | 120.69**                            | 25.06*   | 188.59** | 161.84**                  | 921.74**  | -39.43** | -36.92**                  | 92.04**   | 557.58**  | 70.68                    | 69.66    | 44.04    |
| 12      | Ph-6 × P. Anupam           | -25.53                              | -41.67** | 34.62    | 220.13**                  | 435.87**  | -68.23** | -8.24                     | 47.79     | 406.06**  | -23.08                   | -14.80   | -27.66   |
| 13      | Ph-9 × GOB-1               | 104.01**                            | 236.61** | 676.79** | 147.52**                  | 1417.39** | -10.05*  | 742.45**                  | 1480.53** | 5312.12** | 116.90**                 | 360.39** | 290.86** |
| 14      | Ph-9 × GAOB-2              | -48.42**                            | -18.33   | 88.46**  | -35.82**                  | 293.48**  | -76.68** | 1.89                      | 91.15**   | 554.55**  | -46.01                   | 2.09     | -13.32   |
| 15      | Ph-9 × GAB-6               | -78.57**                            | -80.00** | -53.85*  | 2950.00**                 | 3281.52** | 100.45** | 134.48**                  | 140.71**  | 724.24**  | 97.16                    | 86.55    | 58.38    |
| 16      | Ph-9 × GRB-5               | -56.15**                            | -5.00    | 119.23** | 114.08**                  | 875.00**  | -42.20** | 94.97**                   | 174.34**  | 839.39**  | -37.65                   | 45.29    | 23.35    |
| 17      | Ph-9 × Arka Harshita       | -32.35                              | -61.67** | -11.54   | 119.86**                  | 1247.83** | -20.10** | 83.96**                   | 245.13**  | 1081.82** | 16.24                    | 15.55    | -1.90    |
| 18      | Ph-9 × P. Anupam           | -54.41**                            | -48.33** | 19.23    | 37.01                     | 129.35    | -86.40** | -17.58                    | 32.74     | 354.55**  | -45.71                   | -35.72   | -45.43   |
| 19      | PPL × GOB-1                | -75.36**                            | -71.67** | -34.62   | 1.79                      | 331.52**  | -74.42** | 8.93                      | 61.95*    | 454.55**  | -58.56                   | -45.74   | -53.93   |
| 20      | PPL × GAOB-2               | -1.45                               | 13.33    | 161.54** | -70.51**                  | 25.00     | -92.59** | -22.02                    | 15.93     | 296.97**  | -13.01                   | 13.90    | -3.30    |
| 21      | PPL × GAB-6                | -48.21**                            | -51.67** | 11.54    | 275.49**                  | 316.30**  | -75.32** | 52.59                     | 56.64*    | 436.36**  | -24.64                   | -28.70   | -39.47   |
| 22      | PPL × GRB-5                | -68.12**                            | -63.33** | -15.38   | 160.77**                  | 1005.43** | -34.47** | 82.39**                   | 156.64**  | 778.79**  | -25.11                   | -1.94    | -16.75   |
| 23      | PPL × Arka Harshita        | -5.98                               | -46.72** | 22.95    | 8.21                      | 358.70**  | -72.81** | 92.86**                   | 186.73**  | 881.82**  | -14.44                   | -14.95   | -27.79   |
| 24      | PPL × P. Anupam            | -64.71**                            | -60.00** | -7.69    | 187.01**                  | 380.43**  | -71.52** | -4.17                     | 42.48     | 387.88**  | -44.32                   | -34.08   | -44.04   |
| 25      | JDNB-16-1 × GOB-1          | 28.02                               | -11.67   | 103.85** | 106.63**                  | 679.35**  | -53.80** | 67.84**                   | 153.98**  | 769.70**  | 47.36                    | 29.30    | 9.77     |
| 26      | JDNB-16-1 × GAOB-2         | 3.86                                | -28.33*  | 65.38*   | 128.82**                  | 763.04**  | -48.84** | 150.88**                  | 279.65**  | 1200.00** | 42.76                    | 25.26    | 6.35     |
| 27      | JDNB-16-1 × GAB-6          | 32.85*                              | -8.33    | 111.54** | 177.45*                   | 207.61**  | -81.77** | 68.97*                    | 73.45**   | 493.94**  | 20.78                    | 5.98     | -10.03   |
| 28      | JDNB-16-1 × GRB-5          | 136.71**                            | 63.33**  | 276.92** | 147.26**                  | 832.61**  | -44.72** | 205.66**                  | 330.09**  | 1372.73** | 143.27                   | 113.45   | 81.22    |

Contd...

Table 3. *Contid...*

| Sr. No.                    | Hybrids                   | Sardarkrushinagar (E <sub>1</sub> ) |          |          | Jagudan (E <sub>2</sub> ) |           |          | Bhiloda (E <sub>3</sub> ) |          |           | Pooled over environments |         |        |
|----------------------------|---------------------------|-------------------------------------|----------|----------|---------------------------|-----------|----------|---------------------------|----------|-----------|--------------------------|---------|--------|
|                            |                           | BP                                  | SH1      | SH2      | BP                        | SH1       | SH2      | BP                        | SH1      | SH2       | BP                       | SH1     | SH2    |
| 29                         | JDNB-16-1 × Arka Harshita | 111.76**                            | 20.00    | 176.92** | 47.55*                    | 456.52**  | -67.01** | -5.85                     | 42.48    | 387.88**  | 60.99                    | 41.26   | 19.92  |
| 30                         | JDNB-16-1 × P. Anupam     | 40.10**                             | -3.33    | 123.08** | 20.78                     | 102.17    | -88.02** | -2.92                     | 46.90    | 403.03**  | 18.74                    | 4.19    | -11.55 |
| 31                         | ISD-006 × GOB-1           | -79.39**                            | -66.67** | -23.08   | 142.94**                  | 1788.04** | 11.92*   | 1.49                      | 262.83** | 1142.42** | -33.58                   | 36.92   | 16.24  |
| 32                         | ISD-006 × GAOB-2          | 37.89**                             | 118.33** | 403.85** | 31.50**                   | 916.30**  | -39.76** | 68.67**                   | 247.79** | 1090.91** | 38.58                    | 162.03* | 122.46 |
| 33                         | ISD-006 × GAB-6           | -33.93**                            | -38.33** | 42.31    | 403.92**                  | 458.70**  | -66.88** | 141.38**                  | 147.79** | 748.48**  | 0.16                     | -5.23   | -19.54 |
| 34                         | ISD-006 × GRB-5           | -73.21**                            | -56.67** | 0.00     | -72.32**                  | 26.09     | -92.53** | 3.77                      | 46.02    | 400.00**  | -74.33                   | -47.09  | -55.08 |
| 35                         | ISD-006 × Arka Harshita   | 46.96*                              | -16.72   | 92.18**  | 1.59                      | 595.65**  | -58.76** | 170.06**                  | 722.12** | 2715.15** | 53.83                    | 52.91   | 29.82  |
| 36                         | ISD-006 × P. Anupam       | -8.82                               | 3.33     | 138.46** | 137.66**                  | 297.83**  | -76.42** | -18.13                    | 31.86    | 351.52**  | 0.00                     | 18.39   | 0.51   |
| 37                         | CO2 × GOB-1               | -35.59**                            | -36.67** | 46.15    | 14.46                     | 106.52    | -87.76** | 10.55                     | 94.69**  | 566.67**  | -27.43                   | -22.87  | -34.52 |
| 38                         | CO2 × GAOB-2              | -54.24**                            | -55.00** | 3.85     | 297.59**                  | 617.39**  | -57.47** | -20.60                    | 39.82    | 378.79**  | -23.63                   | -18.83  | -31.09 |
| 39                         | CO2 × GAB-6               | -57.14**                            | -60.00** | -7.69    | 30.39                     | 44.57     | -91.43** | 21.55                     | 24.78    | 327.27**  | -47.71                   | -50.52  | -57.99 |
| 40                         | CO2 × GRB-5               | -15.31                              | -16.72   | 92.18**  | -6.63                     | 68.48     | -90.01** | 21.38                     | 70.80*   | 484.85**  | -13.36                   | -7.92   | -21.83 |
| 41                         | CO2 × Arka Harshita       | 120.59**                            | 25.00*   | 188.46** | -35.54                    | 16.30     | -93.11** | -35.18*                   | 14.16    | 290.91**  | 24.66                    | 23.92   | 5.20   |
| 42                         | CO2 × P. Anupam           | -32.20**                            | -33.33** | 53.85*   | 44.81                     | 142.39    | -85.63** | -45.05*                   | -11.50   | 203.03*   | -28.69                   | -24.22  | -35.66 |
| 43                         | ABSR-2 × GOB-1            | -24.95*                             | -35.00** | 50.00*   | 130.64**                  | 489.13**  | -65.08** | -63.91**                  | -46.02   | 84.85     | -9.63                    | -11.66  | -25.00 |
| 44                         | ABSR-2 × GAOB-2           | -44.19**                            | -51.67** | 11.54    | 6.81                      | 172.83*   | -83.83** | -20.12                    | 19.47    | 309.09**  | -35.93                   | -37.37  | -46.83 |
| 45                         | ABSR-2 × GAB-6            | -80.76**                            | -83.33** | -61.54*  | 46.08                     | 61.96     | -90.40** | -50.86                    | -49.56   | 72.73     | -73.30                   | -74.74  | -78.55 |
| 46                         | ABSR-2 × GRB-5            | -1.86                               | -15.00   | 96.15**  | 36.17                     | 247.83**  | -79.38** | 40.25*                    | 97.35**  | 575.76**  | 5.66                     | 3.29    | -12.31 |
| 47                         | ABSR-2 × Arka Harshita    | 58.92**                             | -9.94    | 107.82** | -24.68                    | 92.39     | -88.60** | -47.34*                   | -21.24   | 169.70    | -3.82                    | -5.98   | -20.18 |
| 48                         | ABSR-2 × P. Anupam        | -63.44**                            | -68.33** | -26.92   | 394.81**                  | 728.26**  | -50.90** | 93.49**                   | 189.38** | 890.91**  | -15.44                   | -17.34  | -29.82 |
| Range                      | Min.                      | -83.92                              | -83.33   | -61.54   | -72.32                    | -1.09     | -94.14   | -63.91                    | -49.56   | 72.73     | -74.33                   | -74.74  | -78.55 |
|                            | Max.                      | 138.30                              | 236.61   | 676.79   | 2,950.00                  | 3,281.52  | 100.45   | 742.45                    | 1,480.53 | 5,312.12  | 143.27                   | 360.39  | 290.86 |
|                            | S.Em±                     | 0.64                                |          |          | 0.24                      |           |          | 0.11                      |          |           |                          |         |        |
| No. of significant crosses | Positive                  | 12                                  | 6        | 26       | 25                        | 36        | 3        | 18                        | 30       | 44        | 1                        | 2       | 1      |
|                            | Negative                  | 24                                  | 27       | 2        | 6                         | 0         | 45       | 7                         | 0        | 0         | 1                        | 0       | 0      |

\*, \*\* Significant at 5 and 1% level of significance, respectively; S.Em.: Standard error of mean; BP = Heterobeltiosis; SH1 = Standard heterosis over GJBH-4; SH2 = Standard heterosis over GABH-3

Table 4. Genotypic correlation coefficient between fruit borer infestation at each location with fruit yield per plant at respective location

| Fruit borer infestation      | Genotypic correlation coefficient | Fruit yield per plant           |
|------------------------------|-----------------------------------|---------------------------------|
| Sardarkrushinagar (5.56 %)   | -0.430**                          | Sardarkrushinagar (2496.46 g)   |
| Jagudan (1.93 %)             | 0.109 <sup>NS</sup>               | Jagudan (1364.05 g)             |
| Bhiloda (0.91 %)             | -0.180*                           | Bhiloda (3497.05 g)             |
| Pooled environments (2.80 %) | -0.594**                          | Pooled environments (2452.52 g) |

\*, \*\* Significant at 5 and 1% level of significance, respectively; NS = Non-significant  
Data in '( )' showing overall mean of respective trait at respective location

significant negative heterosis in E<sub>1</sub>; 06 in E<sub>2</sub>; 07 in E<sub>3</sub> and 01 in pooled environments, respectively. Out of 48 crosses studied, the top three crosses exhibiting the lowest heterosis over better parent were Arka Komal × GRB-5 (-83.92%), ABR-2 × GAB-6 (-80.76%) and ISD-006 × GOB-1 (-79.39%) in Sardarkrushinagar (E<sub>1</sub>); ISD-006 × GRB-5 (-72.32%).

PPL × GAOB-2 (-70.51%) and Arka Komal × GAOB-2 (-50.82%) at Jagudan (E<sub>2</sub>) and ABR-2 × GOB-1 (-63.91%), ABR-2 × Arka Harshita (-47.34%) and CO2 × P. Anupam (-45.05%) at Bhiloda (E<sub>3</sub>). Over pooled environments Arka Komal × GRB-5 (-71.84%) exhibited the lowest heterosis over better parent. In contrast to this, Ph-6 × GRB-5, Ph-9 × GAB-6, Ph-9 × GOB-1 and Ph-9 × GOB-1 showed significantly higher borer infestation than the better parent and ranked the highest magnitude of heterobeltiosis to the tune of 138.30, 2950.00, 742.45 and 116.90% at Sardarkrushinagar (E<sub>1</sub>), Jagudan (E<sub>2</sub>), Bhiloda (E<sub>3</sub>) and pooled over the environments, respectively.

*Standard heterosis*

The commercial usefulness of hybrids would primarily depend on their performance in comparison with the best existing hybrids of the crop. In case of heterosis over the standard check GJBH-4, the standard heterosis ranged from -83.33 to 236.61, -1.09 to 3281.52, -49.56 to 1480.53 and -74.74 to 360.39% in E<sub>1</sub>, E<sub>2</sub>, E<sub>3</sub> and pooled over the environments, respectively. Total 27 hybrids had shown significant negative heterosis in E<sub>1</sub>. Rest environments were non-significant for negative heterosis. ABR-2 × GAB-6 (-83.33%), Ph-9 × GAB-6 (-80.00%) and PPL × GOB-1 (-71.67%) exhibited the lowest degree of heterosis over standard check GJBH-4 at Sardarkrushinagar (E<sub>1</sub>). In contrast to this, Ph-9 × GOB-1, Ph-9 × GAB-6, Ph-9 × GOB-1 and Ph-9 × GOB-1 showed significantly higher borer infestation than the standard check

GJBH-4 and ranked the highest magnitude of standard heterosis to the tune of 236.61, 3281.52, 1480.53 and 360.39% at Sardarkrushinagar (E<sub>1</sub>), Jagudan (E<sub>2</sub>), Bhiloda (E<sub>3</sub>) and pooled over the environments, respectively.

In case of heterosis over the standard check GABH-3, the standard heterosis ranged from -61.54 to 676.79, -94.14 to 100.45, 72.73 to 5312.12 and -78.55 to 290.86% in E<sub>1</sub>, E<sub>2</sub>, E<sub>3</sub> and pooled over the environments, respectively. Total two hybrids had showed significant negative heterosis in E<sub>1</sub> and forty-five in E<sub>2</sub>. Out of forty-eight crosses studied, the top crosses *viz.*, ABR-2 × GAB-6 (-61.54%) and Ph-9 × GAB-6 (-53.85%) exhibited the lowest degree of heterosis over standard check GABH-3 at Sardarkrushinagar (E<sub>1</sub>), while, Arka Komal × GAB-6 (-94.14%), CO2 × Arka Harshita (-93.11%) and PPL × GAOB-2 (-92.59%) at Jagudan (E<sub>2</sub>). In contrast to this, Ph-9 × GOB-1, Ph-9 × GAB-6, Ph-9 × GOB-1 and Ph-9 × GOB-1 showed significantly higher borer infestation than the standard check GABH-3 and ranked the highest magnitude of standard heterosis to the tune of 676.79, 100.45, 5312.12 and 290.86% at Sardarkrushinagar (E<sub>1</sub>), Jagudan (E<sub>2</sub>), Bhiloda (E<sub>3</sub>) and pooled over the environments, respectively. In the present study, both positive and negative heterobeltiosis and standard heterosis was recorded. These results are in line with the earlier finding of Praneetha *et al.* (2013), Ramani *et al.* (2015), Sujin and Karuppaiah (2018) and Solanki *et al.* (2022).

*Correlation between fruit borer infestation at each location with fruit yield per plant at respective location*

Genotypic correlation coefficient between fruit borer infestation at each location with fruit yield per plant at respective location were computed for 64 brinjal genotypes and are presented in Table 4. Estimated results of the present study revealed that significantly negative genotypic correlation coefficient was observed between

fruit borer infestation and fruit yield per plant at Sardarkrushinagar ( $r = -0.430$ ), Bhiloda ( $r = -0.180$ ) and pooled over environments ( $-0.594$ ). While, the performance at Jagudan location showed non-significant relationship of these two traits. Negative correlation obtained here suggested that increment in the fruit borer infestation leads to decrease in the fruit yield per plant. Hence, hybrids with fruit borer resistance characteristics will certainly increase the production of the fruits per plant in brinjal. Koundinya *et al.* (2018) found similar type of correlation in their studies in brinjal.

The degree of heterosis in the current study varied from cross to cross. Considerable high heterotic effects were observed in certain crosses, which revealed that nature of gene action varied with the genetic architecture of the parents. Several crosses exhibited noticeable heterotic response over better parent (heterobeltiosis) and over standard checks (standard heterosis) across environments. Combining all the aspects, hybrid ABSR-2  $\times$  GAB-6 was found better for the resistance for fruit and shoot borer in Gujarat's semi-arid regions and it has demonstrated higher fruit yield than standard checks; desirable heterobeltiosis and standard heterosis for fruit borer infestation at Sardarkrushinagar; desirable standard heterosis over GABH 3 at Jagudan.

This hybrid can be identified for cultivar development to strengthen strategies for designing eco-friendly pest management module.

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