International Journal of Research in Agronomy 2024; SP-7(10): 263-267


**E-ISSN:** 2618-0618
**P-ISSN:** 2618-060X

www.agronomyjournals.com
2024; SP-7(10): 263-267
Received: 15-08-2024
Accepted: 23-09-2024

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# Advances of genetic engineering in crop improvement

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**DOI:** https://doi.org/10.33545/2618060X.2024.v7.i10Sd.1766

**Abstract**
The investigation was done to study the heterosis and stability of different genetic parameters of bottle gourd. The experimental material consists of genotypes from a line × tester having 3 tester and 8 lines and their 24 $F_1$s which were grown in Randomized Block Design with three replications at College Farm, College of Horticulture, Jagudan (Dist-Mehsana) and Horticulture Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during the summer and *kharif* season of 2022. In the present investigation, significant and positive standard heterosis for yield per vine was obtained over the environments. The range of standard heterosis for yield per vine was from -58.60% to 58.20, $L_1 \times T_1$ gave consistency in performance and recorded highest significant and positive estimates of standard heterosis for yield per vine. The analysis of variance of phenotypic stability indicated that genotypes differed significantly for yield characters studied across the environments which indicated presence of substantial variation in the material studied when tested against both pooled error and pooled deviations.

**Keywords:** Heterosis, bottle gourd, line, tester and stability

## Introduction
The name bottle gourd is due to bottle like shape of fruit and its use as a container in the past. Fruits at tender stage are used as a cooked vegetable and for preparation of sweets and pickles. Hard shells of mature fruits are used as water jugs, domestic utensils, floats for fishing nets, *etc*. As a vegetable it is easily digestible. It has cooling effect and has diuretic and cardiotonic properties. Fruit pulp is used as an antidote against certain poisons and is good for controlling constipation, night blindness and cough. Bottle gourd is rich in vitamin 'B' and source of minerals *viz.*, P, Ca and Fe. It is also important for medicinal use as urines trouble and jaundice. Bottle gourd production has been increased considerably to meet the increasing domestic demands as well as to open the export market abroad.

There are several techniques for evaluating the varieties or lines in terms of their combining ability and genetic makeup. Among these, line × tester analysis as proposed by Kempthorne (1957) [4] has been extensively used to assess the combining ability of parent and crosses of different quantitative characters as well as to study the extent and magnitude of heterosis for yield and its contributing characters and gene action involved in the inheritance of characters.

Hybrid is one of the greatest practical contributions of genetics and has its most significant expression in bottle gourd. The breeding strategy for exploitation of heterosis in bottle gourd through the cultivation of hybrids is primarily dependent on the development and identification of high *per se* performing diverse, vigorous and productive inbred lines and their subsequent evaluation for combining ability in cross combinations to identify crosses with high heterotic effects. To exploit the heterosis of potential yield components, knowledge of genetic architecture of fruit yield and its attributes is important in crop improvement. Exploitation of heterosis in bottle gourd has been recognized as a practical tool in providing the breeders a means of improving yield and other important traits (Sprague and Tatum 1942) [13].

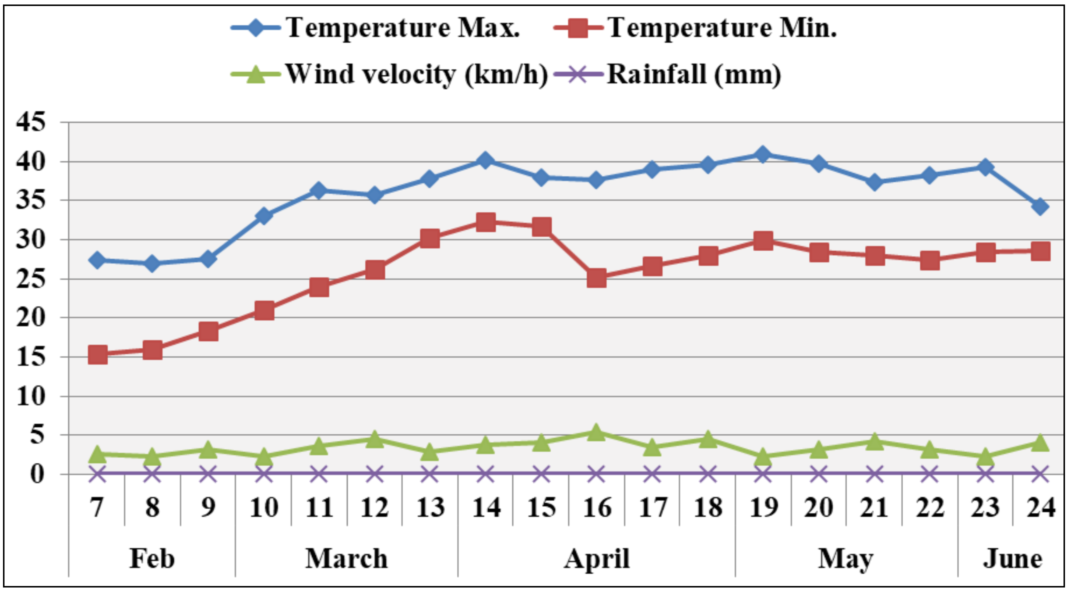
## Material and Methods

| | |
|---|---|
| Crossing Programme | *Kharif* 2021<br>Crosses has made from selected lines and tester in Line × Tester fashion at College Farm, College of Horticulture, SDAU, Jagudan<br>No. of line: 8<br>No. of tester: 3 |
| Evaluation Location | $E_1$ - Summer 2022 (Jagudan)<br>$E_2$ - Summer 2022 (Sardarkrushinagar)<br>$E_3$ - *Kharif* 2022 (Jagudan)<br>$E_4$ - *Kharif* 2022 (Sardarkrushinagar) |
| No. of Genotype | 24 $F_1$ + 11 Parents + 1 Checks = 36 |
| Spacing | 1.5 m × 1.5 m |
| Seed rate | 3 kg/ha |
| Manure and fertilizers (kg/ha) | 20 t/ha FYM<br>N:P:K = 100:50:50 kg/ha |

**Tester:** Arka Bahar ($T_1$), Anand Bottle Gourd 1($T_2$), Pusa Naveen ($T_3$)

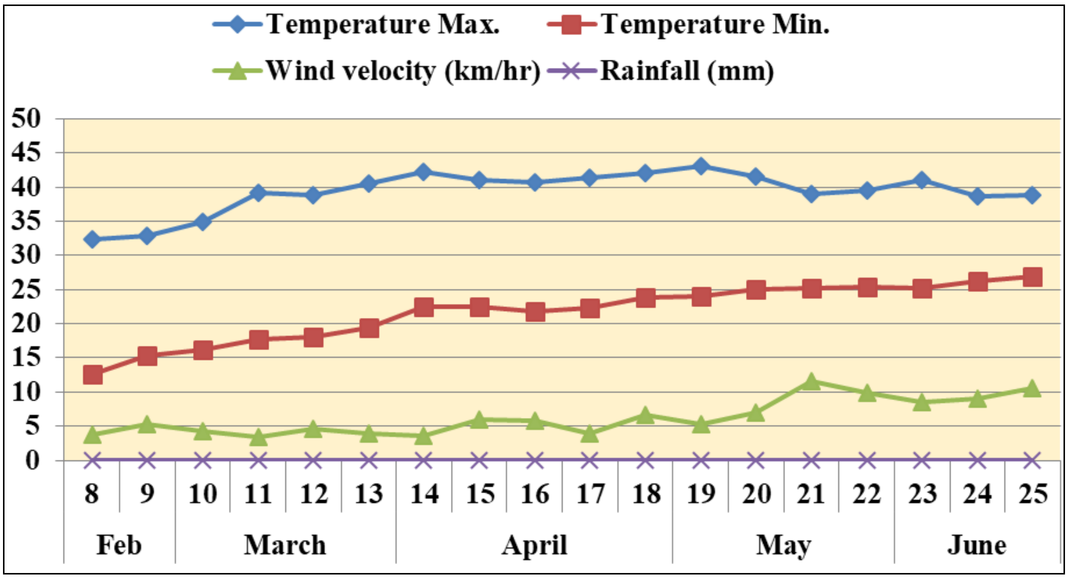
**Line:** Mokhasan Local Long ($L_1$), JBOGR-01-04 ($L_2$), JBOGL-01-28 ($L_3$), JBOGL-01-41 ($L_4$), JBOGL-01-43 ($L_5$), JBOGL-01-51 ($L_6$), JBOGL-01-61 ($L_7$), JBOGL-01-62 ($L_8$)

**Check:** Pusa Hybrid-3 ($C_1$)

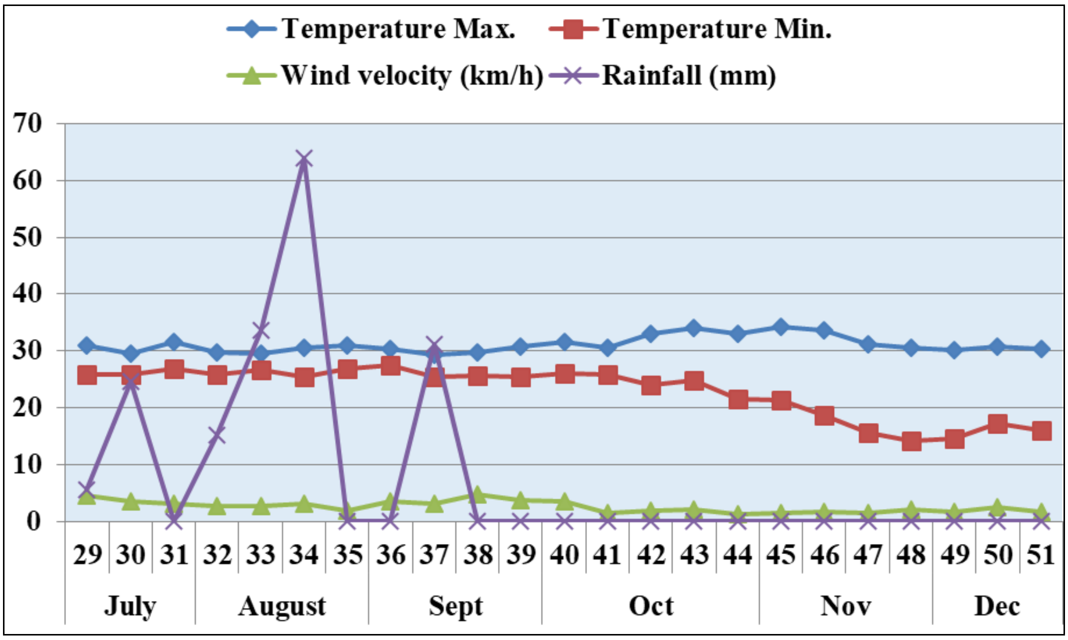



(a) Environment 1

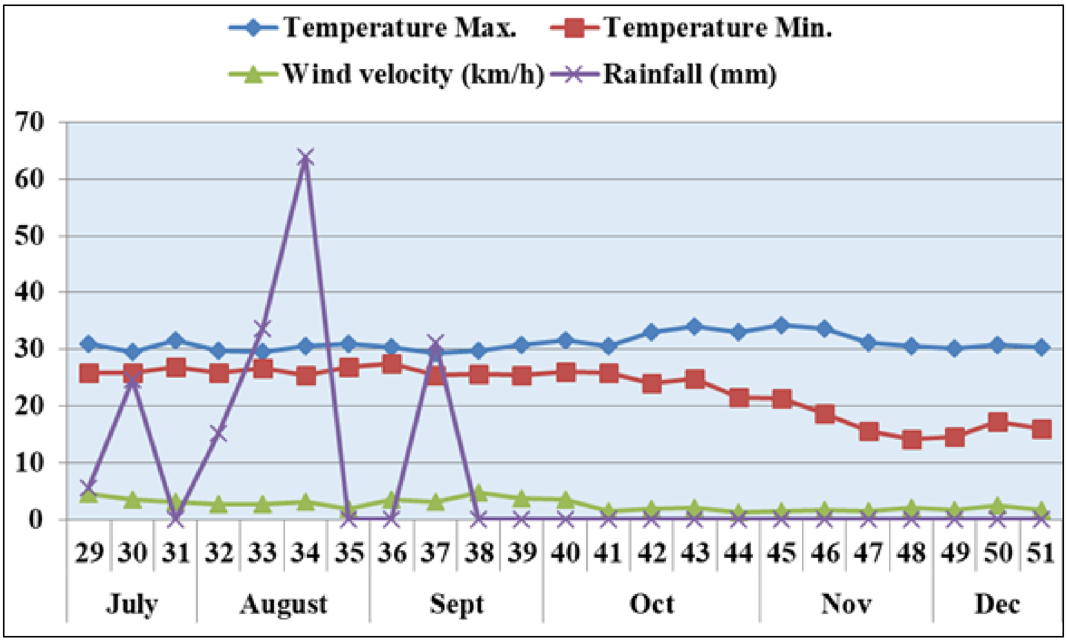
**Fig 1:** Mean weakly weather parameters recorded for different environment




(b) Environment 2




(c) Environment 3




(d) Environment 4

**Fig 2:** Indicate mean weakly weather parameters recorded at four different locations where research has been conducted for evaluation of hybrids

## Results and Discussion

**Table 1:** Standard heterosis of all parameter of bottle gourd

| Sr. No. | Hybrids | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | $L_1 \times T_1$ | 17.4* | 12.1* | 9.2** | -11.7 | -11.8** | 17.2** | -0.5 | 6.3* | 6.1* | 4.0 | -1.4 | 7.8 | -13.8* | 83.7** | 58.2** | 56.2** | 53.5** | 45.1** | -10.5** | 1.6 |
| 2. | $L_1 \times T_2$ | 9.7 | 2.8 | 12.2** | -13.2* | 9.1* | -17.7** | -0.9 | 7.4* | 7.8** | -8.7* | -14.0** | 14.6 | -24.9** | 59.7** | 26.1* | 26.1* | 26.1* | 36.9** | 1.4 | -5.2* |
| 3. | $L_1 \times T_3$ | 1.7 | 0.2 | 21.0** | -20.6** | 0.8 | 9.8** | 4.4** | 4.7 | 7.3** | 0.9 | -9.4* | 50.7** | -25.9** | 85.2** | 37.0** | 37.0** | 37.0** | 50.0** | -13.9** | -1.4 |
| 4. | $L_2 \times T_1$ | -21.2** | -20.4** | 17.5** | -11.0 | 3.6 | 13.8** | 7.7** | 25.5** | 21.6** | -41.6** | -38.4** | 1.0 | -46.0** | -12.2* | -48.8** | -48.8** | -48.8** | -12.6** | 9.1* | 5.0* |
| 5. | $L_2 \times T_2$ | 6.2 | 6.2 | 4.9 | -13.2* | -10.8** | 14.1** | -1.1 | 7.1* | 6.0* | -16.9** | -5.9 | -7.4 | -14.4* | -3.5 | -17.7 | -17.7 | -17.7 | -22.2** | 20.8** | -0.4 |
| 6. | $L_2 \times T_3$ | 7.5 | 4.9 | 1.6 | -14.8* | -3.2 | 17.5** | 5.0** | -4.5 | -5.1* | 3.3 | 8.2* | -2.4 | -10.7 | 3.8 | -8.4 | -8.4 | -8.4 | -21.1** | 12.7** | 4.7 |
| 7. | $L_3 \times T_1$ | 16.0* | 6.3 | 0.2 | -9.1 | -6.7 | 12.6** | 0.9 | 0.6 | -1.1 | -3.3 | -4.6 | 1.7 | -10.7 | -1.3 | -8.9 | -8.9 | -8.9 | 2.9 | 1.1 | -4.0 |
| 8. | $L_3 \times T_2$ | 6.8 | 5.9 | 3.5 | -16.1* | -6.5 | 13.8** | 1.4 | 3.6 | 1.1 | -1.3 | -3.6 | 4.9 | -17.9* | -0.5 | -18.4 | -18.4 | -18.4 | 3.7 | 7.2 | -3.2 |
| 9. | $L_3 \times T_3$ | 5.9 | 1.8 | 2.9 | -21.9** | -6.8 | 12.7** | 0.8 | -3.6 | -2.9 | 5.3 | 11.0* | -5.3 | -12.8 | 18.1** | 3.9 | 3.9 | 3.9 | 6.2* | 3.9 | 4.6 |
| 10. | $L_4 \times T_1$ | 9.9 | 7.4 | 0.9 | 1.6 | 1.0 | 16.7** | 7.2** | 1.0 | -0.1 | -3.1 | -10.1* | 17.7 | -5.0 | 16.7* | 12.8 | 12.8 | 12.8 | 4.1 | 3.6 | -0.8 |
| 11. | $L_4 \times T_2$ | 5.1 | 1.3 | 6.2* | 7.3 | 2.0 | 14.5** | 7.0** | 12.8** | 11.6** | -9.6** | -8.6* | 8.8 | 0.9 | 26.5** | 33.1** | 33.1** | 33.1** | 1.3 | 2.4 | -2.5 |
| 12. | $L_4 \times T_3$ | 23.9** | 18.1** | 6.7* | -8.2 | 0.0 | 17.3** | 6.8** | -4.2 | -6.0* | 9.3* | 15.4** | -4.8 | 9.2 | 14.2* | 26.1* | 26.1* | 25.3* | 6.2* | 1.1 | 2.3 |
| 13. | $L_5 \times T_1$ | -6.4 | -8.2 | 6.6* | -15.8* | -1.2 | 0.5 | -0.3 | 2.1 | 1.7 | -9.9** | -13.1** | 11.3 | -24.8** | 15.1* | -13.8 | -13.8 | -13.8 | -4.9 | 0.2 | -4.2 |
| 14. | $L_5 \times T_2$ | -5.9 | -9.1 | 5.1 | -10.1 | -4.5 | 9.0** | 0.9 | 1.0 | 0.1 | -2.1 | -5.2 | 13.7 | -13.9* | 2.5 | -10.2 | -10.2 | -10.2 | -3.5 | -1.2 | -6.6* |

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15. | $L_5 \times T_3$ | 8.2 | 9.5 | 4.5 | -11.6 | 3.3 | -0.3 | 2.2 | 6.8* | 6.5** | -1.0 | 0.5 | 0.7 | -11.8 | 20.9** | 7.7 | 7.7 | 7.7 | 2.4 | -2.1 | 3.2 |
| 16. | $L_6 \times T_1$ | -22.0** | -25.5** | 0.3 | -18.7** | 1.0 | -7.1** | -1.9 | 36.5** | 30.3** | -34.9** | -34.1** | 14.2 | -47.0** | -21.1** | -58.6** | -58.6** | -58.6** | -6.7* | -4.5 | 0.6 |
| 17. | $L_6 \times T_2$ | 3.3 | -6.3 | 6.0* | -1.5 | -2.1 | 10.1** | 2.8 | 4.2 | 3.5 | -10.9** | -12.7** | 18.8 | -11.6 | -1.8 | -10.0 | -10.0 | -10.0 | -0.3 | -2.9 | -6.1* |
| 18. | $L_6 \times T_3$ | 2.8 | 2.1 | 14.3** | -10.2 | 1.7 | 13.4** | 6.4** | 4.3 | 4.4 | -6.5 | -9.5* | 4.0 | -17.7* | 10.1 | -9.5 | -9.5 | -9.5 | -1.7 | -2.4 | 2.6 |
| 19. | $L_7 \times T_1$ | -7.4 | -14.1** | 8.3** | -12.0 | 3.6 | -10.7** | -1.7 | 3.4 | 2.6 | -16.5** | -17.9** | 8.0 | -26.2** | 12.6* | -15.2 | -15.2 | -15.2 | -0.3 | 2.9 | -5.7* |
| 20. | $L_7 \times T_2$ | 4.4 | 1.4 | 7.8* | -10.1 | -3.3 | 19.8** | 5.7** | 7.4* | 6.7** | -10.3** | -10.7* | 7.0 | -20.6** | 3.3 | -18.2 | -18.2 | -18.2 | 2.8 | 2.0 | -2.9 |
| 21. | $L_7 \times T_3$ | 19.6** | 14.2** | 5.3 | -10.2 | 2.6 | 8.3** | 5.1** | 2.5 | 2.0 | 0.0 | 1.0 | 3.1 | -8.6 | 20.1** | 10.1 | 10.1 | 10.1 | -2.2 | 0.5 | 2.9 |
| 22. | $L_8 \times T_1$ | -17.8* | -18.7** | 20.4** | -15.3* | 6.0 | -9.1** | 0.4 | 18.1** | 18.6** | -41.5** | -33.2** | -10.0 | -41.7** | -11.4 | -47.5** | -47.5** | -47.5** | -3.1 | -2.9 | -3.6 |
| 23. | $L_8 \times T_2$ | -18.9** | -14.5** | 16.8** | -13.2* | -9.2* | 24.9** | 4.0* | -1.1 | -0.7 | -13.9** | -10.3* | 3.0 | -21.5** | 1.1 | -20.3* | -20.3* | -20.3* | -1.2 | -3.3 | -4.7 |
| 24. | $L_8 \times T_3$ | 2.4 | 8.8 | 13.2** | 5.2 | 5.1 | 14.2** | 8.8** | 0.9 | 1.7 | -5.1 | -3.7 | -1.4 | 1.7 | 16.4* | 18.6 | 18.6 | 18.6 | -5.5 | -0.8 | -0.5 |
| | S.Ed ± | 10.35 | 10.30 | 0.34 | 2.43 | 3.57 | 1.34 | 2.30 | 1.52 | 1.54 | 2.53 | 1.12 | 0.35 | 0.55 | 33.09 | 0.38 | 1.16 | 17.23 | 1.06 | 0.23 | 0.12 |
| | CD @ 5% | 17.20 | 17.12 | 0.56 | 4.04 | 5.94 | 2.23 | 5.83 | 2.52 | 2.57 | 4.20 | 1.86 | 0.59 | 0.92 | 54.99 | 0.64 | 1.93 | 28.64 | 1.76 | 0.39 | 0.21 |
| | CD @ 1% | 24.52 | 24.41 | 0.80 | 5.76 | 8.47 | 3.18 | 5.46 | 3.60 | 3.66 | 6.00 | 2.66 | 0.84 | 1.31 | 78.39 | 0.91 | 2.75 | 40.83 | 2.52 | 0.55 | 0.30 |

| **Whereas…** | |
|---|---|
| 1 | Length of main vine (cm) at 60 DAS |
| 2 | Length of main vine (cm) at 90 DAS |
| 3 | Days taken from fruit set to edible maturity |
| 4 | Fruit set (%) |
| 5 | Chlorophyll a |
| 6 | Chlorophyll b |
| 7 | Total chlorophyll content |
| 8 | Days to first male flower |
| 9 | Days to first female flower |
| 10 | Number of male flowers |
| 11 | Number of female flowers |
| 12 | Sex ratio (Male: female) |
| 13 | Number of fruits per vine |
| 14 | Fruit weight (g) |
| 15 | Fruit yield per vine (kg) |
| 16 | Fruit yield per plot (kg) |
| 17 | Fruit yield per hectare (q/ha) |
| 18 | Length of fruit (cm) |
| 19 | Diameter of fruit (cm) |
| 20 | Total Soluble Solid (˚Brix) |

The highest estimate of significant economic heterosis on pooled basis are mentioned in table 1. Data presented in table 1 is pooled data of four different locations which is mentioned in material and methods.

The significant and desired heterosis effect in combination traits were also reported by Singh *et al.* (2012) [12], Yadav and Kumar (2012) [15], Janaranjani *et al.* (2016) [3] and Mishra *et al.* (2019) [8] for days to first male and female flower; Janaranjani *et al.* (2016) [3], Mishra *et al.* (2019) [8] for fruit length, Mishra *et al.* (2019) [8], Odedara *et al.* (2021) [9] for average fruit weight and number of fruit per plant; Thakur (2017) [14], Doloi *et al.* (2018) [2], Mishra *et al.* (2019) [8], Odedara *et al.* (2021) [9], Lal *et al.* (2021) [7] for fruit yield per plant.

Results revealed that the selection of parents has an important bearing on the performance of any hybrid. $L_1 \times T_1$, $L_1 \times T_3$ and $L_4 \times T_3$, these top ranking three hybrids were found significant standard heterosis for yield component.

**Table 2:** Stability parameter for fruit yield per vine (kg)

| Sr. No. | Genotypes | $\mu_i$ | $b_i$ | $S^2d_i$ |
|---|---|---|---|---|
| 1. | Arka Bahar | 3.07 | 0.48 | -0.18 |
| 2. | ABG-1 | 4.29 | -0.50++ | 0.08 |
| 3. | Pusa Naveen | 3.63 | 0.96** | -0.19 |
| 4. | Mokhasan Local Long | 3.37 | 1.22 | 0.66** |
| 5. | JBOGR-01-04 | 3.12 | 1.39** | 0.08 |
| 6. | JBOGL-01-28 | 1.90 | -0.30 | 0.65** |
| 7. | JBOGL-01-41 | 2.86 | 0.30 | 0.11 |
| 8. | JBOGL-01-43 | 2.40 | 0.47 | 0.47** |
| 9. | JBOGL-01-51 | 2.79 | 1.51* | 0.25* |
| 10. | JBOGL-01-61 | 3.61 | 0.75 | 0.62** |
| 11. | JBOGL-01-62 | 3.25 | 0.53*+ | -0.23 |
| 12. | Mokhasan Local Long × Arka Bahar | 5.17 | 1.19 | 3.59** |
| 13. | JBOGR-01-04 × Arka Bahar | 1.67 | 0.36 | -0.01 |
| 14. | JBOGL-01-28 × Arka Bahar | 2.97 | 1.65**+ | -0.15 |
| 15. | JBOGL-01-41 × Arka Bahar | 3.68 | 2.24**++ | -0.05 |
| 16. | JBOGL-01-43 × Arka Bahar | 2.81 | 1.21** | -0.04 |
| 17. | JBOGL-01-51 × Arka Bahar | 1.35 | 0.47**++ | -0.28 |
| 18. | JBOGL-01-61 × Arka Bahar | 2.77 | 0.92 | 0.53** |
| 19. | JBOGL-01-62 × Arka Bahar | 1.71 | 0.53 | -0.16 |
| 20. | Mokhasan Local Long × ABG-1 | 4.12 | 3.07**+ | 1.13** |

| | | | | |
|---|---|---|---|---|
| 21. | JBOGR-01-04 × ABG-1 | 2.69 | 1.61** | -0.13 |
| 22. | JBOGL-01-28 × ABG-1 | 2.66 | 0.61 | 0.55** |
| 23. | JBOGL-01-41 × ABG-1 | 4.35 | 2.60** | 1.19** |
| 24. | JBOGL-01-43 × ABG-1 | 2.93 | 1.47** | -0.12 |
| 25. | JBOGL-01-51 × ABG-1 | 2.94 | 0.99 | 0.72** |
| 26. | JBOGL-01-61 × ABG-1 | 2.67 | 0.62**++ | -0.28 |
| 27. | JBOGL-01-62 × ABG-1 | 2.60 | 1.27** | -0.02 |
| 28. | Mokhasan Local Long × Pusa Naveen | 4.47 | 1.59* | 0.31* |
| 29. | JBOGR-01-04 × Pusa Naveen | 2.99 | -0.16++ | -0.23 |
| 30. | JBOGL-01-28 × Pusa Naveen | 3.39 | 0.90** | -0.20 |
| 31. | JBOGL-01-41 × Pusa Naveen | 4.12 | 1.97** | 0.26* |
| 32. | JBOGL-01-43 × Pusa Naveen | 3.52 | 0.89** | -0.12 |
| 33. | JBOGL-01-51 × Pusa Naveen | 2.95 | 0.55 | 0.45** |
| 34. | JBOGL-01-61 × Pusa Naveen | 3.59 | 0.57* | -0.22 |
| 35. | JBOGL-01-62 × Pusa Naveen | 3.87 | 1.06** | -0.19 |
| 36. | Ph-3 (check) | 3.26 | 0.92 | 0.43** |
| | General Mean | 3.15 | 0.64 | |

*, ** indicates significance at 5 and 1 percent levels, respectively as tested as bi/SE(bi)

+, ++ Significant deviation of bi from unity at 5 and 1 percent levels, respectively as tested as 1-bi/SE(bi)

Data presented in table 2 which used to calculate stability of that particular hybrids performance in four different locations. Parent ($T_3$) indicated its suitability and stability of performance under unfavorable environments. Two hybrids ($L_4 \times T_1$ and $L_8 \times T_3$) indicated its suitability and stability under favorable environments and two hybrids ($L_3 \times T_3$ and $L_5 \times T_3$) indicated its suitability and stability of performance under unfavorable environments.

Similar findings for identification of genotypes for their yield stability under varying environmental conditions were also reported by Krishna Prasad and Singh (1990) [6], Rajput *et al*. (1994) [11] in bitter gourd for yield and its component, Prasad and Singh (1985) [10] in bottle gourd and in watermelon by Dia *et al.* (2016) [1].

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