*Original Research Article*

# Studies on ~~Heterosis~~ heterosis breeding in ~~Brinjal~~ brinjal germplasmfor growth and yield traits,~~(~~*Solanummelongena* L.~~)~~




## ABSTRACT

Brinjal,~~(~~*Solanum melongena* L.~~)~~, is one of the commercial vegetable annual grown all over India for its edible fruits. Heterosis in vegetable crops helps to exploit the superior hybrids based on its phenotypic superiority over their parents and indicates non-additive genetic effects. This research was carried out~~The present experimental was conducted~~ at Department of Vegetable Science, Horticultural College and Research Institute, Periyakulam. The study involves six parents and thirty hybrids laid out in Randomised Block Design with two replications. The cross CO2 ×Kothampattikathiri(16.53%) obtained significant positive heterosis for plant height over better parent. Significant amount of heterosis over mid parent was observed for number of branches in Kothampattikathiri×Odavaipachaikathiri(33.33%), fruit width in Dharmapuri oodhakathiri×Poiyur purple kathiri(25.54%), fruit length in Kothampattikathiri× Gobi pachaikathiri(24.33%). Significant negative heterosis over better parent for number of days to 50% flowering in the cross Odavaipachaikathiri× Gobi pachaikathiri(-9.25%). Significant amount of heterosis over standard check was obtained for number of fruit per plant(35.42%) in the cross Dharmapuri oodhakathiri× CO2 and fruit yield per plant in Dharmapuri oodhakathiri×Odavaipachaikathiri(21.54%). Heterosis exploited could be utilized in further crop improvement program in the development of a superior hybrid.


**KEYWORDS:**brinjal, heterosis, hybrids, parents, superiority, yield

## INTRODUCTION

Brinjal,~~(~~*Solanum melongena* L~~)~~,also known as eggplant or baingan, belongs to the family Solanaceae with a diploid chromosome number of 2n=2x=24. It is a perennial versatile crop grown commercially as an annual crop. It is one of the most common and popular vegetable grown almost in all parts of India and can be grown throughout the year. Brinjal is originated in its wild form in Indo-Burma region and is considered to be native to India where the major domestication of large-fruited cultivars occurred. The fruits have medicinal propertiesparticularly in white brinjal, which is found to be good for diabetic patients [1]. Botanically, there exist three different types based on fruit shape and colour under the species *S. melongena*. Large or egg-shaped fruited types were grouped under *S. melongena var. esculentum*. Long and slender types were grouped under *S. melongena var. serpentinum*while dwarf plants were categorised under *S.melongena var. depressum*.The consumer preference for brinjal varies from region to region and locality to locality. Hence it is necessary to characterize the genotypes as having better acceptance and wide adaptability. Brinjal has a huge genetic divergence in our country which offers much scope for improvement through heterosis breeding. The objective of increasing productivity can be achieved only through heterosis breeding, which is feasible in brinjal [2]. Heterosis plays an important role in enchancing yield and improving the quality of crops and can be measured in terms of relative heterosis, heterobeltiosis and standard heterosis. The estimation of heterosis for yield and its component traits would be useful to identify the best hybrid combination for exploitation of superior hybrids. Selection of the parents is an important step in heterosis breeding for developing hybrids which exhibits commercially exploitable heterosis. The exploitation of hybrid vigour has become a potential tool for crop improvement in eggplant [3]. Hetetosis in brinjal can be exploited because of its ease in crossing and presence of large number of seeds. The present study was carried out to estimate the nature and magnitude of heterosis in yield and yield attributing traits in different crosses for further utilization in future crop improvement programmes.



## MATERIAL AND METHODS

~~The present investigation~~This research was carried out in the Department of Vegetable Crops, Horticultural College and Research Institute, Periyakulam. The experimental site is situated between 10°12'N~~Latitude~~ and 77°58'N~~ Longitude~~.Thesite receives an average annual rainfall of 791.20 mm under both Southwest and Northeast monsoon. The beneficial monsoon is North-East monsoon, which accounts for 47 per cent,~~(~~375.50 mm~~)~~, of total annual rainfall. The South-West monsoon contributes 22 per cent,(172.70 mm).The experimental material consisted of six parents (Table 1) collected from various geographical locations across Tamil Nadu. Crossing was carried out during Kharif season in full diallel mating design. Six parents and resulting thirty hybrids were raised under Randomised block design with two replications. The heterosis was calculated for seven characters *viz*., plant height, number of branches, days to 50% flowering, fruit width, fruit length, number of fruits per plant and fruit yield per plant studied in the thirty hybrid combinations and expressed in percentage over mid parent (relative heterosis) (di), better parent (heterobeltiosis) (dii) and standard check (standard heterosis) (diii).Brinjal variety called Annamalai developed by Annamalai University was taken as the check for the estimation of standard heterosis.please remove all parentheses

$$\text{Relative heterosis (di)} = \frac{F_1\text{-Mid parent}}{\text{Mid parent}} \times 100$$

$$\text{Heterobeltiosis (dii)} = \frac{F_1\text{-Better parent}}{\text{Better parent}} \times 100$$

$$\text{Standard heterosis (diii)} = \frac{F_1\text{-Standard check}}{\text{Standard check}} \times 100$$

Where,

Mid parent refers to the mid value of the parents mean

Better parent refers to mean of the better parent

Standard check refers to the mean of the standard variety which is used as check

The significance at both 5% and 1% levels were tested statistically for all traits by using TNAUSTAT software package and mean was calculated accordingly [4].

## RESULTS AND DISCUSSION

Heterosis occurs where the progeny of different varieties of a species or crosses between species exhibit greater biomass, speed of development and fertility than both parents [5]. Heterosis also simply refers to the superiority of hybrids over the parents and became an important tool in determining the advantage of hybrids. **Table 1** depicts the six parents collected from the diverse regions of Tamil Nadu. The expression of heterosis was greater when the parents are of diverse origin than the parents from the same origin [6]. **Table 2** depicts the relative heterosis while **Table 3** depicts the heterobeltiosis and **Table 4** depicts the standard heterosis for different traits in thirty hybrids.

Plant height is an important trait by which growth and vigour of the plants are determined. The relative heterosis was positive and significant in four out of thirty hybrids registered over mid parental value. The maximum heterotic expression of 4.31 per cent for plant height was observed in combination (Kothampatti Kathiri × CO 2) followed by Kothampatti Kathiri ×Odavai Pachai Kathiri (1.91). The relative heterosis was positive and non-significant for six out of thirty hybrids. Heterosis over better parent varied from -15.41 (CO 2 ×Gobhi Pachai Kathiri) to 16.53 per cent (CO 2 ×Kothampatti Kathiri).The heterobeltiosisexhibitedsignificantly highest for plant height in the hybrid CO 2 ×Kothampatti Kathiri (16.53%).Similar findings were reported by Suneetha *et al.[7]*, Das *et al.[8]*, Sane *et al*. [9]and Rai and Asati (2011).

Among the thirty hybrids studied for heterosis over mid parent, number of branches per plant exhibited positive and significant in hybrids of Kothampatti Kathiri ×Odavai Pachai Kathiri (33.33) followed by Dharmapuri Oodha Kathiri ×Odavai Pachai Kathiri (30.40) and Kothampatti Kathiri ×Gobhi Pachai Kathiri (28.77). The heterobeltiosis was positive and significant for five out of thirty hybrids ranged from 2.89 per cent (Gobhi Pachai Kathiri ×Poiyur Purple Kathiri) to 9.40 per cent (Dharmapuri Oodha Kathiri ×Odavai Pachai Kathiri). The standard heterosis was positive and significant for twenty-three hybrids out of thirty hybrids. The range was from 7.92 per cent (Odavai Pachai Kathiri ×Gobhi Pachai Kathiri) to 69.31 per cent (Kothampatti Kathiri ×Gobhi Pachai Kathiri).The results were in accordance with the findings of Shafeeq *et al*. [11], Vaddoria*et al*. [12], Bhakta *et al*. [13] and Sao and Mehta [14].please remove all parentheses

Earliness is one of the important components influencing the duration of the crop, which is measured in terms of days to 50 % flowering. The relative heterosis for the number of days to 50% flowering exhibited significant positive heterosis for two hybrids *viz*., Gobhi Pachai Kathiri × CO 2 (1.86%) and CO 2 ×Gobhi Pachai Kathiri (1.69%) whilenone of the hybrids exhibited significant negative heterosis. Heterobeltiosis was positive and significant for seven hybrid combination ranged from 0.62 per cent (CO 2 ×Kothampatti Kathiri) to 1.87 per cent (Gobhi Pachai Kathiri ×Poiyur Purple Kathiri). Significant negative heterosis over better parent were observed in seventeen hybrids and ranged maximum in the cross Odavai Pachai Kathiri ×Gobhi Pachai Kathiri (-9.25%).The standard heterosis was positive and significant for twenty five hybrids out of thirty. The range of standard heterosis is from 1.17 per cent (Odavai Pachai Kathiri × Dharmapuri Oodha Kathiri) to 12.21 per cent (CO 2 ×Poiyur Purple Kathiri). Negative standard heterosis was observed in only one hybrid *viz*., Odavai Pachai Kathiri ×Gobhi Pachai Kathiri (-0.39%). Negative heterosis was preferred for the trait among the breeders owing to the earliness. The results were in accordance with the findings of Vaddoria*et al*. [12] and Chowdhury *et al*. [15].please remove all parentheses

Fruit yield in brinjal is determined by fruit width, fruit length and number of fruits per plant [16]. In respect to fruit width, the relative heterosis was maximum in Dharmapuri Oodha Kathiri ×Poiyur Purple Kathiri (25.54%) followed by Gobhi Pachai Kathiri ×Poiyur Purple Kathiri (23.94%) and Kothampatti Kathiri × Dharmapuri Oodha Kathiri (22.11%).The heterobeltiosis for this trait was positive and significant for three hybrids *viz*., Odavai Pachai Kathiri × CO 2 (4.51%), Gobhi Pachai Kathiri × CO 2 (1.06%) and Kothampatti Kathiri ×Gobhi Pachai Kathiri (0.11%). The highest standard heterosis was observed inDharmapuri Oodha Kathiri ×Gobhi Pachai Kathiri (16.17%) followed by Dharmapuri Oodha Kathiri ×Odavai Pachai Kathiri (16.04%) and Dharmapuri Oodha Kathiri ×Kothampatti Kathiri (15.04%). (Table 5).

Among the thirty hybrids the relative heterosis for fruit length is positive and significant for six hybrids. The highest was 24.33 per cent (Kothampatti Kathiri ×Gobhi Pachai Kathiri) followed by 12.00 per cent (Kothampatti Kathiri ×Odavai Pachai Kathiri) and 9.27 per cent (Poiyur Purple Kathiri × CO 2). The relative heterosis is positive and non-significant for thirteen hybrids. Significant positive heterobeltiosis was observed in four hybrids*viz*.,Kothampatti Kathiri × Dharmapuri Oodha Kathiri (9.60%), Dharmapuri Oodha Kathiri ×Kothampatti Kathiri (1.60%), Dharmapuri Oodha Kathiri ×Poiyur Purple Kathiri (0.40%) and CO 2 ×Gobhi Pachai Kathiri (2.54%). Standard heterosis for fruit length was positive and significant for Kothampatti Kathiri × Dharmapuri Oodha Kathiri (15.04%) and it was negative and significant for twenty nine hybrids ranges from -59.77 per cent (Gobhi Pachai Kathiri × Dharmapuri Oodha Kathiri) to -1.13 (Odavai Pachai Kathiri × Poiyur Purple Kathiri) respectively (Table 6). Angadi *et al*.[17] reported that there was a positive association between the fruit length and fruit yield.please remove all parentheses

Number of fruits per plant is an important trait since it reflects the yield per plant. Positive and significant relative heterosis for number of fruits per plant was three hybrids out of thirty, Poiyur Purple Kathiri × CO 2 (7.91) followed by Poiyur Purple Kathiri ×Kothampatti Kathiri (6.65) and Poiyur Purple Kathiri ×Gobhi Pachai Kathiri (3.93). The positive and non-significant relative heterosis was exhibited in eleven hybrids out of thirty hybrids. The highest positive non-significant heterosis was 17.31 per cent Dharmapuri Oodha Kathiri ×Kothampatti Kathiri followed by 14.54 per cent Dharmapuri Oodha Kathiri ×Gobhi Pachai Kathiri.Heterobeltiosis was positive and significant for two hybrids, Gobhi Pachai Kathiri ×Kothampatti Kathiri (2.33) and Poiyur Purple Kathiri × CO 2 (1.49). (Table 7). Positive and significant standard heterosis was in seventeen hybrids out of thirty, the highest was 35.42 per cent (Dharmapuri Oodha Kathiri × CO 2) followed by 34.95 per cent (Dharmapuri Oodha Kathiri ×Gobhi Pachai Kathiri) and 34.72 per cent (Dharmapuri Oodha Kathiri ×Odavai Pachai Kathiri). The findings of Makani *et al*. [18] and Patel *et al*. [19] were in concordance with the present experimental results on number of fruits per plant.

Fruit yield per plant is an important objective to be achieved in any breeding program.More the number of fruits per plant coupled with maximum fruit weight provides maximum yield.The relative heterosis was significant and positive for two hybrids, 1.00 per cent Odavai Pachai Kathiri ×Gobhi Pachai Kathiri (1%) and Kothampatti Kathiri × Dharmapuri Oodha Kathiri (2.87%). Heterobeltiosisfor fruit yield per plant observed significant and positive in Kothampatti Kathiri ×Odavai Pachai Kathiri (12.82), while significantly negative for fourteen cross combinationranging from -21.79 per cent (Gobhi Pachai Kathiri ×Odavai Pachai Kathiri) to -2.56 per cent (Odavai Pachai Kathiri ×Poiyur Purple Kathiri).Significantly Positive standard heterosis wereobserved in fourteen hybrids, ranging from 2.56 per cent (Odavaipachai Kathiri ×Poiyur Purple Kathiri) to 21.54 per cent (Dharmapuri Oodha Kathiri ×Odavai Pachai Kathiri). The highest was Dharmapuri Oodha Kathiri ×Odavai Pachai Kathiri (21.54) followed by Dharmapuri Oodha Kathiri ×Kothampatti Kathiri (18.72) (Table8).Similar results were reported by Sao and Mehta [14], Nalini [20]and Jansirani[21].

## CONCLUSION

Heterosis is an important criterion in developing superior hybrids with good yield. The present results clearly depicts that all the growth and yield characters showed higher heterosis value which indicates the non-additive genetic effects in their expression. In order to enhance yield characters, studies should be focused on suitable breeding programmes to produce hybrids of high heterosis and combining ability which in turn results in yield improvement. The best performing hybrids for fruit yield contributing parameters *viz*., $P_4 \times P_1$, $P_4 \times P_6$, $P_3 \times P_4$ might be studied for specific combining ability in the further research for commercially exploiting the hybrid vigour of the above hybrids.

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**Table 1**. Source and Plant characters of parents.

| **Sl.No** | **Code No.** | **Variety/ Genotypes** | **Source** |
|---|---|---|---|
| 1 | $P_1$ | Odavai Pachai Kathiri | Dindigul |
| 2 | $P_2$ | Gobhi Pachai Kathiri | Erode |
| 3 | $P_3$ | Kothampatti Kathiri | Salem |
| 4 | $P_4$ | Dharmapuri oodha Kathiri | Dharmapuri |
| 5 | $P_5$ | Poiyur purple Kathiri | Nagapattinam |
| 6 | $P_6$ | CO2 | Horticultural College and Research Institute, Coimbatore |

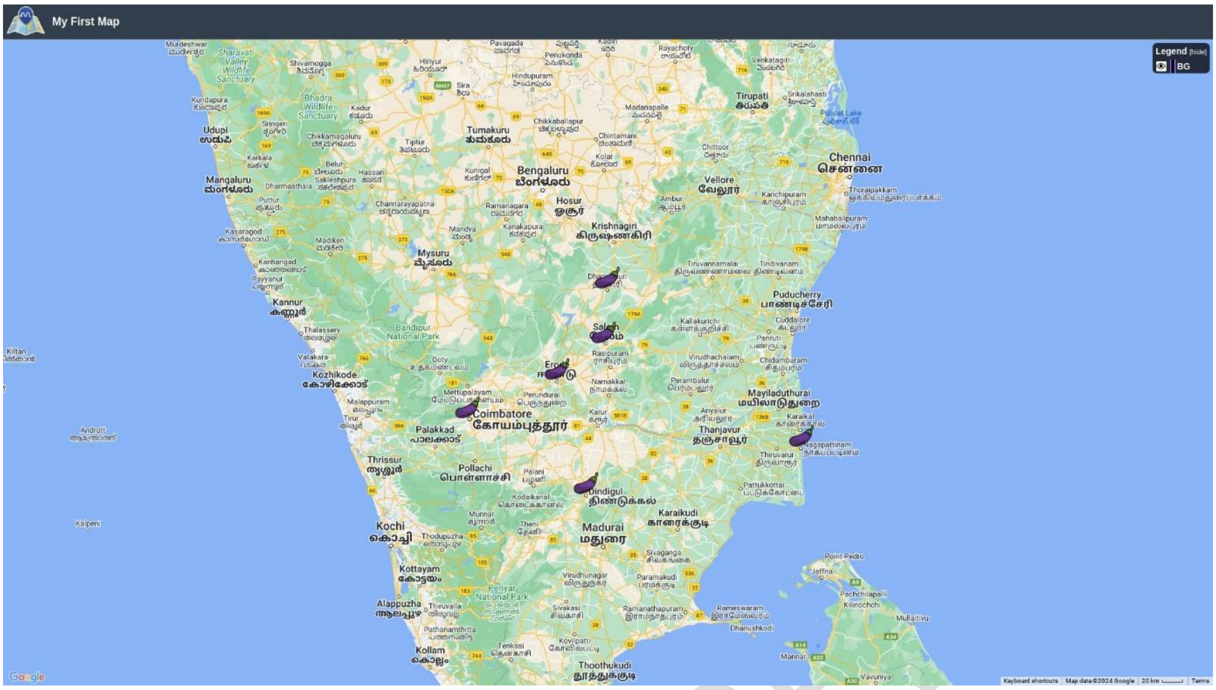


**Figure 1. Geographical location of brinjal genotypes**

**Table 2**. Relative heterosis for various traits in thirty hybrids

| Crosses | Plant height | Number of branches | Days to 50% flowering | Fruit width | Fruit length | Number of fruits per plant | Fruit yield per plant |
|---|---|---|---|---|---|---|---|
| $P_1$× $P_2$ | -3.51 | -0.27 | -5.03 | -5.90 * | 36.29 | 1.16 | 1.00 * |
| $P_1$× $P_3$ | -4.83 * | -7.63 ** | -1.24 | -12.13 ** | 1.20 ** | 4.12 | -3.38 * |
| $P_1$× $P_4$ | -1.43 | -10.40 * | -1.15 | -10.72 ** | 1.55 | -17.45 | 3.70 |
| $P_1$× $P_5$ | -2.86 | 26.70 | -0.67 | 22.46 | 6.26 | -12.16 | 9.51 |
| $P_1$× $P_6$ | 1.86 ** | -7.76 | -3.44 | -3.91 ** | 8.75 | -5.74 | -1.97 * |
| $P_2$× $P_1$ | 1.46 | 7.96 | 4.56 | 2.86 * | -42.04 | -0.23 | -12.48 * |
| $P_2$× $P_3$ | -1.52 | -4.37 ** | 3.64 | -2.58 | -37.32 ** | 6.80 | -4.57 |
| $P_2$× $P_4$ | -0.56 * | -14.48 | 3.83 | -3.83 | -41.69 | -12.97 | -0.48 |
| $P_2$× $P_5$ | -2.52 ** | 16.57 | 4.95 | 23.94 ** | -32.95 | -12.60 ** | 0.49 |
| $P_2$× $P_6$ | 6.86 | -5.96 | 1.86 * | 4.71 | -27.28 | -3.54 | -3.02 |
| $P_3$× $P_1$ | 1.91 * | 33.33 ** | 0.48 | 5.54 ** | 12.00 ** | -6.54 | -7.98 * |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $P_3 \times P_2$ | -0.15 | 28.77 ** | -5.10 | 3.15 | 24.22 ** | -7.52 | 0.00 |
| $P_3 \times P_4$ | 0.13 ** | 6.40 | 0.28 | -0.49 | 6.61 | -19.96 | 2.87 |
| $P_3 \times P_5$ | -0.01 | 32.77 | -0.75 | 22.11 ** | 1.08 | -14.16 ** | 3.83 |
| $P_3 \times P_6$ | 4.31 ** | 10.96 | -2.82 | 2.96 ** | 1.64 | -7.37 | 2.53 |
| $P_4 \times P_1$ | 0.20 | 30.40 * | 1.15 | 7.36 ** | -3.88 | 14.12 | -12.82 |
| $P_4 \times P_2$ | -2.83 * | 18.53 | -3.46 | 4.51 | 36.24 | 14.54 | 4.04 |
| $P_4 \times P_3$ | -4.70 ** | 3.70 | 0.56 | 0.49 | 4.96 | 17.31 | -4.08 |
| $P_4 \times P_5$ | -2.63 * | 33.05 | 1.88 | 25.54 ** | 4.80 | -0.53 ** | 2.92 |
| $P_4 \times P_6$ | 4.62 | 9.22 | -2.36 | 5.66 ** | 9.94 | 10.17 | 0.95 |
| $P_5 \times P_1$ | 0.86 | -14.14 | -0.77 | -23.08 | -10.30 | 8.87 | -11.82 |
| $P_5 \times P_2$ | -1.57 ** | -18.11 | -4.49 | -30.17 ** | 30.64 | 3.93 ** | 0.82 |
| $P_5 \times P_3$ | -0.01 | -29.41 | -2.07 | -34.38 ** | -0.65 | 6.65 ** | -4.44 |
| $P_5 \times P_4$ | -0.03 * | -28.87 | -0.94 | -34.22 ** | -2.30 | -9.24 ** | 0.97 |
| $P_5 \times P_6$ | 4.55 | -26.50 | -4.48 | -27.44 ** | 9.27 ** | 7.91 * | -1.60 |
| $P_6 \times P_1$ | -6.06 ** | 15.92 | 5.85 | -2.52 ** | -11.21 | 1.10 | -8.15 * |
| $P_6 \times P_2$ | -8.70 | 13.15 | 1.69 * | -6.06 | 30.52 | 2.43 | 5.56 |
| $P_6 \times P_3$ | -9.14 ** | 0.68 | 3.27 | -11.37 ** | -3.37 | 8.99 | -1.94 |
| $P_6 \times P_4$ | -5.36 | 3.07 | 3.54 | -15.45 ** | -5.45 | -8.29 | 6.94 |
| $P_6 \times P_5$ | -6.40 | 20.51 | 5.03 | 16.28 ** | 0.97 ** | -2.37 * | 2.56 |

* Significant at 5 per cent level

** Significant at 1 per cent level

**Table 3**. Heterobeltiosis for various traits in thirty hybrids

| Crosses | Plant height | Number of branches | Days to 50% flowering | Fruit width | Fruit length | Number of fruits per plant | Fruit yield per plant |
|---|---|---|---|---|---|---|---|
| $P_1 \times P_2$ | -6.37** | -7.31 | -9.25 ** | -8.62 ** | -1.88 ** | 0.93 | -9.74 ** |
| $P_1 \times P_3$ | 8.47 ** | -22.3 | -3.45 * | -17.11 ** | -4.89 ** | -0.46 ** | -8.46 ** |
| $P_1 \times P_4$ | -2.32 | -24.83 * | -3.36 * | -16.94 ** | -1.50 | -28.40 ** | -6.67 ** |
| $P_1 \times P_5$ | -5.76** | 19.80 | -2.27 * | -0.25 ** | -1.13 ** | -20.82 ** | -2.56 ** |
| $P_1 \times P_6$ | -2.89** | -21.53 ** | -7.96 ** | 4.51 ** | -3.76 ** | -9.92 ** | -10.51 ** |
| $P_2 \times P_1$ | -1.54** | 0.34 | -0.09 ** | -0.12 ** | -58.27 ** | -0.46 | -21.79 ** |
| $P_2 \times P_3$ | -2.42 * | -14.19 | 1.25 ** | -5.44 ** | -52.99 ** | 2.33 ** | -10.32 ** |
| $P_2 \times P_4$ | -2.65** | -23.49 * | 1.42 * | -7.98 ** | -57.20 ** | -24.66 ** | -1.28 |
| $P_2 \times P_5$ | -2.55** | 2.89 ** | 1.87 ** | -1.30 ** | -49.34 ** | -21.38 ** | 0.00 |
| $P_2 \times P_6$ | -0.99** | -14.58 | 1.59 | 1.06 ** | -42.87 ** | -8.02 ** | -5.28 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $P_3 \times P_1$ | -1.99** | 12.16 | -1.77 * | -0.44 ** | -17.29 ** | -10.65 ** | 12.82 ** |
| $P_3 \times P_2$ | -1.06 * | 15.54 | -7.30 ** | 0.11 ** | -6.84 ** | -11.40 ** | -6.02 ** |
| $P_3 \times P_4$ | 2.86 ** | 6.04 | 0.28 | -1.94 * | 9.60 ** | -33.16 ** | 2.58 * |
| $P_3 \times P_5$ | -0.90 | 6.76 ** | -1.40 * | -4.89 ** | 0.00 | -25.65 ** | -2.87 * |
| $P_3 \times P_6$ | 4.17 ** | 9.46 | -5.31 * | -3.44 ** | -4.70 ** | -15.19 ** | -1.43 |
| $P_4 \times P_1$ | -0.69 | 9.40 * | -1.12 * | -0.11 ** | -6.77 ** | -1.02 ** | -21.54 ** |
| $P_4 \times P_2$ | 4.87 ** | 6.04 * | -5.69 * | 0.00 | 0.00 | -0.85 ** | 3.21 |
| $P_4 \times P_3$ | -7.54** | 3.36 | 0.56 | -0.97 * | 1.60 ** | -2.04 ** | -9.17 * |
| $P_4 \times P_5$ | -4.71** | 6.71 ** | 1.21 | -3.24 ** | 0.40 * | -4.76 ** | 1.60 |
| $P_4 \times P_6$ | 1.10 ** | 7.38 | -4.87 * | -2.27 ** | -6.02 ** | -0.51 ** | -0.62 |
| $P_5 \times P_1$ | -2.16** | -18.81 | -2.36 * | -37.34 ** | -16.54 ** | -1.86 ** | -21.54 ** |
| $P_5 \times P_2$ | -1.61** | -27.72 ** | -7.30 ** | -44.39 ** | -1.31 ** | -6.51 ** | 0.33 |
| $P_5 \times P_3$ | -0.90 | -43.24 ** | -2.71 * | -48.89 ** | -1.71 | -7.62 ** | -10.60 * |
| $P_5 \times P_4$ | -2.16** | -42.95 ** | -1.59 | -49.30 ** | -6.40 * | -13.10 ** | -0.32 |
| $P_5 \times P_6$ | -3.16** | -40.28 ** | -7.52 ** | -40.61 ** | 3.49 | 1.49 * | -4.35 |
| $P_6 \times P_1$ | -10.44** | -1.39 ** | 0.88 ** | -3.13 ** | -21.43 ** | -3.38 | -16.15 ** |
| $P_6 \times P_2$ | -15.41** | 2.78 | 1.42 | -9.33 ** | 2.54 ** | -2.32 ** | 3.11 |
| $P_6 \times P_3$ | 16.53 ** | -0.68 | 0.62 * | -16.89 ** | -9.40 ** | -0.21 ** | -5.73 |
| $P_6 \times P_4$ | 10.54 ** | 1.34 | 0.88 * | -21.79 ** | -14.00 ** | -17.18 ** | 5.28 |
| $P_6 \times P_5$ | -13.30** | -2.08 ** | 1.68 ** | -4.82 ** | -4.37 | -8.18 * | -0.31 |

* Significant at 5 per cent level

** Significant at 1 per cent level

**Table 4**. Standard heterosis for various traits in thirty hybrids

| Crosses | Plant height | Number of branches | Days to 50% flowering | Fruit width | Fruit length | Number of fruits per plant | Fruit yield per plant |
|---|---|---|---|---|---|---|---|
| $P_1 \times P_2$ | -6.37** | 7.92 * | -0.39 ** | -3.01 * | -1.88 ** | 1.03 | 9.94 ** |
| $P_1 \times P_3$ | 8.47 ** | 13.86 ** | 1.07 | -6.52 ** | -5.89 ** | 0.76 ** | -6.46 ** |
| $P_1 \times P_4$ | -2.32 | 10.89 ** | 1.17 * | -3.51 ** | -2.50 ** | -2.55 ** | -4.67 ** |
| $P_1 \times P_5$ | -5.76** | 19.8 | 0.98 | -0.25 ** | -1.13 ** | -1.39 ** | 2.56 ** |
| $P_1 \times P_6$ | -2.89** | 11.88 ** | 1.56 ** | -4.51 ** | -1.76 ** | -1.16 | 11.51 ** |
| $P_2 \times P_1$ | 4.66 * | 16.83 * | 9.67 ** | 6.02 * | -58.27 ** | -0.46 | -21.79 ** |
| $P_2 \times P_3$ | 5.66 ** | 25.74 ** | 11.13 ** | 6.64 ** | -58.65 ** | 1.85 ** | -19.74 ** |
| $P_2 \times P_4$ | 3.48 ** | 12.87 ** | 11.33 ** | 6.89 ** | -59.77 ** | 2.55 ** | -21.03 ** |
| $P_2 \times P_5$ | 3.66 ** | 19.80 | 11.82 ** | 4.76 ** | -56.39 ** | -2.08 ** | -21.28 ** |
| $P_2 \times P_6$ | 5.25 ** | 21.78 ** | 12.11 ** | 7.27 * | -56.02 ** | 0.93 * | -21.79 ** |
| $P_3 \times P_1$ | 6.13 ** | 64.36 ** | 2.83 | 12.28 ** | -17.29 ** | -10.65 ** | 12.82 ** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $P_3$× $P_2$ | 7.13 ** | 69.31 ** | 1.76 ** | 12.91 ** | -18.05 ** | -11.81 ** | -15.90 ** |
| $P_3$× $P_4$ | 5.19 ** | 56.44 ** | 4.98 ** | 13.91 ** | 15.04 ** | -9.03 ** | 12.82 ** |
| $P_3$× $P_5$ | 7.31 ** | 56.44 ** | 3.22 * | 7.27 ** | -12.03 ** | -7.41 * | 13.08 ** |
| $P_3$× $P_6$ | 3.77 ** | 60.40 ** | 4.49 ** | 8.90 | -16.17 ** | -6.94 | 11.79 ** |
| $P_4$× $P_1$ | 1.12 | 61.39 ** | 3.52 * | 16.04 ** | -6.77 ** | 34.72 ** | 21.54 ** |
| $P_4$× $P_2$ | 1.12 ** | 56.44 ** | 3.52 ** | 16.17 ** | -6.02 ** | 34.95 ** | 17.44 ** |
| $P_4$× $P_3$ | 0.12 ** | 52.48 ** | 5.27 ** | 15.04 ** | -4.51 ** | 33.33 ** | 18.72 ** |
| $P_4$× $P_5$ | 1.36 ** | 57.43 ** | 5.96 ** | 12.41 ** | -5.64 ** | 29.63 ** | -18.72 ** |
| $P_4$× $P_6$ | 0.71 ** | 58.42 ** | 4.98 ** | 13.53 ** | -6.02 ** | 35.42 ** | 17.95 ** |
| $P_5$× $P_1$ | 4.07 ** | -18.81 | 0.88 | -37.34** | -16.54 ** | 22.22 ** | -24.13 ** |
| $P_5$× $P_2$ | 4.66 ** | -15.84 | 1.76 ** | -40.98** | -15.04 ** | 16.44 ** | -21.03 ** |
| $P_5$× $P_3$ | 7.31 ** | -16.83 ** | 1.86 * | -42.36** | -13.53 ** | 15.05 * | -20.00 ** |
| $P_5$× $P_4$ | 4.07 ** | -15.84 ** | 3.03 ** | -41.10** | -12.03 ** | 18.29 ** | -20.26 ** |
| $P_5$× $P_6$ | 3.01 ** | -14.85 * | 2.05 ** | -41.35** | -10.90** | 26.39 ** | -21.03 ** |
| $P_6$× $P_1$ | -10.44** | 40.59 ** | 11.33 ** | -3.13 ** | -21.43 ** | 6.02 | 16.15 ** |
| $P_6$× $P_2$ | -10.08** | 46.53 ** | 11.91 ** | -3.76 * | -21.05 ** | 7.18 * | -14.87 ** |
| $P_6$× $P_3$ | -9.61 ** | 45.54 ** | 11.04 ** | -6.27 | -20.30 ** | 9.49 | 15.64 ** |
| $P_6$× $P_4$ | -8.90 ** | 49.50 ** | 11.33 ** | -9.15 ** | -19.17 ** | 12.73 ** | -13.08 ** |
| $P_6$× $P_5$ | -7.78 ** | 39.60 * | 12.21 ** | -6.02 ** | -17.67 ** | 14.35 ** | 17.69 ** |

* Significant at 5 per cent level

** Significant at 1 per cent level