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RESEARCH ARTICLE

Analysis of gene action, combining ability and heterosis for fruit yield and yield components in brinjal (*Solanum melongena* L.)

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Abstract

Using a line x tester mating design involving seven lines, three testers and the resulting 21 hybrids, the combining ability, heterosis and nature of gene action governing fruit yield and its component traits in brinjal were evaluated. Analysis of variance revealed highly significant differences among genotypes including parents and hybrids, for most of the traits**,** indicating sufficient genetic variability for the ten traits under study. According to the general combining ability impact and per se performance, the lines L_4, L_1, L_7, L_2 and the tester T_3 were the best among the parents for most of the qualities under investigation. $L_2 \times T_3$, $L_7 \times T_3$, $L_4 \times T_3$ and $L_6 \times T_3$ are the hybrid crosses which exhibited high *per se* performance for fruit yield per plant. For traits like days to 50 % flowering, plant height, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit weight and fruit yield per plant, the combining ability variances showed that non-additive gene activity predominated. Therefore, heterosis breeding is a viable approach to exploit these traits. The high specific combining ability status of the hybrids indicated dominance and epistatic interaction. The hybrid $L_4 \times T_3$ was promising among all the hybrids studied, followed by $L_7 \times T_3$ which possessed desirable SCA (specific combining ability). Based on *per se* performance, SCA effect and standard heterosis the hybrid $L_4 \times T_3$ and $L_7 \times T_3$ can be recommended for hybrid breeding. It may be possible to simultaneously exploit the type of gene activities for improving fruit yield and its qualities in brinjal by using heterosis breeding, recurrent selection, or biparental mating followed by pedigree selection.

Keywords: brinjal; combining ability; gene action; heterosis; line × tester; *Solanum melongena*

Introduction

A member of the Solanaceae family, brinjal (*Solanum melongena* L.) is a highly significant vegetable crop in tropical and sub-tropical regions worldwide. Its diploid chromosome number is 2n = 2x = 24. Brinjal is frequently referred to be the "king of vegetables" because of its many uses in Indian cuisine. It is also called the "vegetable of masses" due to its popularity across all socio- economic groups (1). The genus *Solanum* includes about 2000 species comprising both herbaceous and shrubby species (2, 3). Three main botanical varieties under the species *melongena* namely, the *S. melangena* var. *depressum* consists of dwarf brinjal plant, the *S. melangena* var. *serpentinum* consists of long brinjal plant and the *S. melangena* var. *esculentum* consists of round or ovoid fruit varieties. A variety of nutrients can be found in abundance in brinjal fruits (4). Nutritional composition per 100 g of edible portion (fresh food) includes 1.4 g protein, 92.7 g moisture, 0.3 g minerals, 0.3 g fat, 1.3 g fibre and 4 g carbohydrates. Mineral composition includes 18 mg Ca, 16 mg Mg, 0.47 mg Riboflavin, 0.17 mg Cu, 44 mg S, 52 mg Cl, 0.9 mg Fe, 3 mg Na, 2.4 mg Mn and iodine (7 µg/kg). Vitamin A (124 IU), thiamine (0.4 mg), niacin (0.9 mg), vitamin C (12 mg) and choline (25 mg) are the vitamins included in a 100 g edible serving (4, 5).

Eggplants offer several health benefits. They help to protect against infections, cancer and heart disease, very good for people at higher risk of bone degradation and osteoporosis, delicious and useful snacks or dietary addition for pregnant women, regulator of glucose and insulin activity within the body, very good for people trying to lose weight and it bulk up your bowl movements so they pass more easily through the digestive system. Eggplants are rich in natural chemicals called phyto nutrients, which have been known to improve mental health. In addition, eggplants are a source of phenolic compound that act as antioxidant. In India, Andhra Pradesh, Maharashtra, Bihar, Odisha, Karnataka, Gujarat and West Bengal are the major brinjal growing states. In Tamil Nadu, brinjal cultivation covers an area of 0.15 million hectares including rainfed and irrigated conditions, resulting in a production of 1.96 million tons and a productivity of 13.29 tons per hectare (6).

To create better variations, eggplant breeders formerly received assistance from land races in both mass and pureline selection. It is true that choosing parents based solely on their performance does not always produce the intended outcome because any genetic gain that occurs in progenies originating from the selected parents were due to their phenotypic attributes and may be random and non-repeatable (7). Therefore, it is crucial to develop a systematic breeding plan to increase this crop's output. The only practical method of achieving the productivity goals through heterosis breeding in this crop (7, 8).

One approach that offers trustworthy data for researching genotypes' capacity for combining is the line × tester mating design (9). It aids in comprehending the genetic makeup of different traits, enabling the breeder to create a successful breeding strategy for the advancement of the available materials in the future. To find possible combinations that could result in exceptional hybrids with outstanding traits and large yields, the current study was carried out. According to this perspective, any plant breeding program that offers the information needed for cultivar development or the commercial exploitation of heterosis must include studies on heterosis and combining ability (10).

Materials and Methods

The line × tester experiment was conducted during two seasons: April-August 2021 and December 2021-April 2022 at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Chidambaram, Tamil Nadu, India.

The experimental materials comprised of ten genetically diversified brinjal genotypes, out of which seven genotypes used as lines such as Violet brinjal (L_1), Arka Keshav (L_2), Bhavani brinjal (L_3), Sevanthipatti brinjal (L_4), Kollampatti brinjal (L_5), Manaparai brinjal (L_6), Kulasai brinjal (L_7) and three genetically diversified genotypes used as testers such as White brinjal (T_1), Large Bhavani brinjal (T_2), Arka Harshitha (T_3) collected from Namakkal, Tamil Nadu and Indian Institute of Horticultural Research, Bangalore were used for this study. These seven lines and three testers were crossed to generate 21 F_1 hybrids using a randomized block design with three replications (Fig. 1, 2). The observation data was recorded on ten selected plants of each hybrid and parents for all ten traits studied. Traits such as days to 50 % flowering; plant height; number of branches per plant; number of flowers per cluster; number of fruits per cluster; number of fruits per plant; fruit length; fruit weight; fruit breadth and fruit yield per plant were recorded. The parents were evaluated based on mean performance as well as general combining ability for different traits (11). The parent Arka Harshitha (T_3) taken as a standard parent. The statistical package R studio software was used for the analysis.

Results and Discussion

Analysis of variance for experimental design

The line × tester analysis showed predominance of non-additive gene action for days to 50 % flowering, plant height, number of branches per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit weight and fruit yield per plant. The traits such as fruit length and fruit breadth showed predominance of additive gene action. Analysis of variance (ANOVA) revealed significant GCA differences among lines and testers for all traits evaluated. The significance of GCA variances thus reflected the importance of

Fig. 1. Emasculation of immature flower buds.

Fig. 2. Pollination of emasculated flower buds.

additive gene action for these traits were also reported earlier (12). For every trait in the F_1 generation, the variations in SCA between hybrids resulting from the interaction of lines and testers were also shown to be significant, highlighting the significance of non-additive gene activity. Gene action outcomes for traits such as days to 50 % flowering, plant height, number of branches per plant, number of flowers per cluster, number of fruits per cluster, number of fruits per plant, fruit length, fruit weight and fruit yield per plant were also revealed to be similar (13). For every attribute in the F_1 generation, non-additive gene action was found to play a major influence. Except for fruit length, almost all traits had general combining ability/specific combining ability (GCA/SCA) variance ratios smaller than unity, indicating that non-additive gene action predominates in the inheritance of these traits and that heterosis breeding is beneficial for increasing yield (Table 1).

Days to 50 % flowering

The crosses $L_1 \times T_2$ (62.84 days) followed by $L_1 \times T_3$ (63.85 days) and $L_1 \times T_1$ (65.17 days) recorded minimum mean value for days to 50 % flowering. Among the hybrids evaluated, the SCA effects for this trait varied from -0.67 to -7.58 and hybrid $L_5 \times T_3$ (-7.58) showed the maximum significant and negative SCA effect followed by $L_6 \times T_1$(-5.77) (Table 2). The crosses (Violet brinjal × Large Bhavani brinjal) $L_1 \times T_2$ recorded maximum negative standard heterosis (- 7.51 %) followed by (Violet brinjal × Arka Harshita) $L_1 \times T_3$ (-6.03 %) (Table 3).

Plant height

Among the 21 hybrids, twelve hybrids recorded the significant mean value for this trait. The crosses $L_5 \times T_2$ (57.36 cm) followed by $L_5 \times T_3$ (59.94 cm) recorded minimum plant height. The hybrids $L_4 \times T_1$ (-8.80) recorded maximum negative SCA effect followed by $L_5 \times T_2$ (-7.02). Fourteen out of twenty-one cross combinations recorded maximum negative significant standard heterosis for this trait. The crosses (Kollampatti brinjal × Large Bhavani brinjal) $L_5 \times T_2$ (Kollampatti brinjal × Large white brinjal) $L_5 \times T_3$ recorded maximum negative standard heterosis (Arka Harshitha).

Number of branches per plant: The hybrids $L_4 \times T_2$ (5.87) followed by $L_4 \times T_1$ (5.50) recorded maximum significant value for this trait. Five hybrids have exceeded the general mean value of 4.61 for this character. The hybrids $L_4 \times T_2$ (0.77) showed the maximum significant and positive SCA effect. The crosses of (Sevanthipatti brinjal × Large Bhavani brinjal) $L_4 \times T_2$ recorded maximum significant positive standard heterosis (29.31 %) than the better parent followed by (Sevabthipatti brinjal × White brinjal) $L_4 \times T_1$ (21.16 %) for this trait.

Number of flowers per cluster: The mean performance was ranged from 6.15 to 7.25 and the hybrid $L_2 \times T_3$ recorded maximum number of flowers per cluster followed by $L_1 \times T_3$ (6.48). The hybrid $L_5 \times T_1$ (0.71) showed the maximum significant and positive SCA effect of followed by the hybrid $L_4 \times T_3$ (0.61). The cross of $L_2 \times T_3$ (Arka Keshav × Arka Harshitha) recorded maximum significant positive standard heterosis (26.18 %) followed by (Manaparai brinjal × White binjal) $L_6 \times T_1$ (25.66 %) and (Violet brinjal × Arka Harshitha) $L_1 \times T_3$ (12.81 %) for this trait.

Number of fruits per cluster: In the case of hybrids, the maximum number of fruits per cluster was ranged from 4.64 to 5.53 and the hybrid $L_1 \times T_1$ (5.53) recorded maximum of fruits per cluster. The hybrid $L_2 \times T_3$ showed the maximum significant and positive SCA effect of (0.50) followed by the hybrids $L_3 \times T_2$ (0.47) for this character. For this characteristic, the $L_1 \times T_1$ cross had the highest significant positive standard heterosis (63.67 %), followed by the Kollampatti brinjal × White brinjal (52.94 %) and the Violet brinjal × Large Bhavani brinjal (50.78 %).

Number of fruits per plant: In case of hybrids, the hybrid $L_1 \times T_1$ (27.98) recorded the maximum number of fruits per plant followed by $L_2 \times T_1$ (26.66) and $L_1 \times T_3$ (25.85) respectively. Among the hybrids, the maximum significant and positive GCA effect was noticed in $L_5 \times T_2$ (4.33) followed by the hybrid $L_3 \times T_3$ (3.23) and $L_6 \times T_1$ (2.13) for this character. The cross of (Violet brinjal × White brinjal) recorded maximum significant positive standard heterosis (28.11 %) followed by (Arka Keshav × Violet brinjal) (22.07 %).

Fruit length: The cross $L_2 \times T_3$ recorded maximum fruit length (11.31 cm) followed by $L_4 \times T_3$ (11.10 cm) and $L_6 \times T_3$ (10.73 cm) respectively. Among the hybrid evaluated, $L_4 \times T_3$ (0.87) recorded significant SCA effect followed by $L_2 \times T_2$ (0.82). Among the 21 cross combinations, the hybrid Sevanthipatti brinjal × Arka Harshitha exhibited the highest significant positive standard heterosis (11.98 %) for fruit length.

Fruit weight: Among the 21 hybrids ten recorded significantly higher fruit weight than the general mean of 104.91 and it was ranging from 106.32 g to 142.38 g. The cross $L_4 \times T_3$ recorded the highest fruit weight (142.38 g) followed by $L_5 \times T_3$ (132.20 g) and $L_4 \times T_1$ (127.91 g). The lowest and highest SCA effects were noticed in the crosses $L_6 \times T_1$ (2.91) and $L_7 \times T_3$ (11.14) respectively. The hybrid $L_7 \times T_3$ (11.14) recorded maximum

Table 1. Analysis of variance for ten characters in brinjal

Source	Degrees of freedom (DF)	Days to 50 % flowering	Plant height	No. of branches per plant	No. of flowers per cluster	No. of fruits per cluster	No. of fruits per plant	Fruit length	Fruit weight	Fruit breath	Fruit yield per plant
Replication	2	0.91	0.05	0.11	0.07	0.03*	1.93	0.60	0.63	0.53	0.52
Lines	6	220.78*	138.10*	4.20*	4.85*	5.21**	158.7*	25.67**	1870.2*	13.03*	78658.97*
Testers	2	22.50**	115.06**	1.20**	0.20**	0.81**	110.77**	53.60**	2482.60*	4.78*	71719.45**
L X T	12	62.27**	130.77*	0.61*	0.47**	0.22**	16.95**	1.21**	221.07*	0.73**	8285.20**
Error	60	0.31	0.23	0.08	0.03	0.005	0.35	0.21	0.41	0.22	430.25**
GCA	-	0.91	0.78	0.01	0.02	0.01	1.32	0.46	20.11	0.10	615.84
SCA	-	20.65	43.48	0.15	0.13	0.04	5.51	0.32	73.51	0.15	2623.17
GCA/ SCA	-	0.042	0.017	0.12	0.20	0.47	0.23	1.41	0.26	0.66	0.22

*, ** - significant at 5 % and 1 % level respectively

significant SCA effect followed by $L_6 \times T_2$ (9.01) and $L_2 \times T_3$ (7.04) for this trait. The cross (Manaparai brinjal × Large Bhavani brinjal) $L_6 \times T_2$ recorded maximum significant positive Standard heterosis (36.87 %) followed by (Manaparai brinjal × White brinjal) $L_6 \times T_1$ (30.37 %) for this trait.

Fruit breadth: Out of 21 hybrids, five exceeded the general mean value of 5.54 cm, ranging from 6.92 cm to 7.41 cm. The cross $L_6 \times T_2$ recorded the maximum fruit breadth (7.41 cm). The crosses $L_4 \times T_3$ (0.58) recorded maximum significant positive SCA effect for this trait. The hybrid Manaparai brinjal × Large Bhavani brinjal recorded maximum significant positive standard heterosis (128.52 %) followed by Bhavani brinjal × Large Bhavani brinjal (127.71 %).

Fruit yield per plant: Among the 21 hybrids eight exceeded the general mean value of 730.98, ranging from 775.64 g to 955.81 g. The hybrid $L_4 \times T_3$ (955.81 g) recorded maximum fruit yield per plant followed by $L_5 \times T_3$ (853.25 g) and $L_7 \times T_3$ (850.24 g). Among the 21 hybrids seven crosses recorded positive SCA effect. The crosses $L_2 \times T_3$(71.97) recorded maximum significant positive SCA effect followed by $L_7 \times T_3$ (49.67). Standard heterosis ranged from 8.61 % (Kulasaibrinjal × Arka Harshitha) to 12.32 % (Sevanthipatti brinjal × Arka Harshitha) followed by 11.71 % (Arka Keshav × Large Bhavani brinjal) and 8.61 % (Kulasai brinjal × Arka Harshitha) for this trait.

For practically all the yield-contributing characteristics, including plant height, flower and fruit cluster counts, fruit production per plant, fruit length and fruit number per cluster, Kulasai and Sevanthipatti brinjal were good general combiners (Table 2). Arka Keshav shown high GCA for yield-contributing traits such fruit length, number of flowers per cluster and number of fruits per plant, as well as good earliness. Using these parental lines will be more fruitful for raising brinjal fruit yield because Kulasai and Sevanthipatti brinjal were shown to be good sources of favourable genes for enhancing fruit yield per plant through numerous yields contributing features. In

Fig. 3. Performance of best F1 brinjal hybrids.

Table 2. Estimates of specific combining ability effects of hybrids in brinjal

F1 hybrids	Days to 50 %	Plant height	No. of branches	No. of flowers per	No. of fruits per cluster	No. of fruits per plant	Fruit length	Fruit weight	Fruit breath	Fruit yield per plant
Violet brinjal x White brinjal	0.03	-6.06**	-0.28	0.07	0.43*	0.08	-0.16	6.12**	0.38	38.37 **
Violet brinjal x Large Bhavani brinjal	-0.42	5.17**	-0.37*	-0.18	-0.02	0.03	0.01	-1.45**	-0.06	20.93
Violet brinjal x Arka Harshita	0.38	0.88**	0.65**	0.11	-0.41*	-0.12	0.16	-4.66**	-0.31	-59.31**
Arka Keshav x White brinjal	-0.67**	0.83**	0.58**	-0.24	-0.18	0.92*	0.47	-7.48**	-0.56	-82.30**
Arka Keshav x Large Bhavani brinjal	-0.93**	2.71**	-0.27	-0.30*	-0.11	-1.35**	0.82**	0.43	0.40	10.31
Arka Keshav x Arka Harshita	1.62**	-3.57**	-0.31	0.55**	0.50**	0.45	-1.30**	7.04**	0.15	71.97 **
Bhavani brinjal x White brinjal	5.13**	5.60**	0.13	-0.31*	-0.02	-3.33**	0.60*	5.12**	-0.53	38.23**
Bhavani brinjal x Large Bhavani brinjal	-1.11**	-4.21**	-0.21	0.55**	0.47**	0.11	-0.55*	0.45	0.15	8.02
Bhavani brinjal x Arka Harshita	-4.02**	-1.37*	0.04	-0.23	0.07	3.23**	-0.04	-5.58**	0.37	-46.26**
Sevanthipatti brinjal x White brinjal	-0.10	-8.81**	-0.45*	0.03	-0.16	0.87*	-0.52	6.87**	-0.02	9.61
Sevanthipatti brinjal x Large Bhavani brinjal	-0.92**	6.71**	0.77**	-0.11	0.04	-0.05	-0.34	-10.68**	-0.56	-40.44**
Sevanthipatti brinjal x Arka Harshita	-1.03**	2.11**	-0.31	0.61**	0.45**	-0.81*	0.87**	3.80**	0.58*	30.84**
Kollampatti brinjal x White brinjal	1.36**	12.12**	0.13	0.71**	0.46**	-0.96*	-0.11	-3.07**	0.21	40.72**
Kollampatti brinjal x Large Bhavani brinjal	6.20**	-7.02**	-0.08	-0.31*	-0.23	4.32**	0.11	2.93**	-0.14	-25.22**
Kollampatti brinjal x Arka Harshita	-7.57**	-5.08**	-0.03	-0.41**	0.07	-3.35**	-0.01	0.13	-0.07	-15.51**
Manaparai brinjal x White brinjal	-5.76**	-1.65**	-0.27	-0.23	0.15	2.13**	-0.32	2.91**	0.55	-11.01**
Manaparai brinjal x Large Bhavani brinjal	-2.05**	-1.57**	0.32	0.31*	0.06	-1.61**	-0.12	9.01**	0.22	42.42**
Manaparai brinjal x Arka Harshita	7.85**	3.23**	-0.02	-0.08	-0.22	-0.51	0.43	-11.91**	-0.77**	-31.42**
Kulasai brinjal x White brinjal	0.02	-2.03**	0.15	-0.02	-0.35*	0.28	0.01	-10.44**	-0.03	-33.63**
Kulasai brinjal x Large Bhavani brinjal	-0.72*	-1.76**	-0.13	0.02	0.28	-1.42**	0.07	-0.68	-0.02	-16.03
Kulasai brinjal x Arka Harshita	-0.71**	3.82**	-0.01	0.11**	0.06	1.13**	-0.11	11.14**	0.04	49.67**

*, ** - significant at 5 % and 1 % level respectively

Table 3. Evaluation of 21 F1 brinjal hybrids based on the standard heterosis

Hybrids	Days to 50 % flowering	Plant height	No. of branches per plant	No. of flowers per cluster	No. of fruits per cluster	No. of fruits per plant	Fruit length	Fruit weight	Fruit breadth	Fruit yield per plant
	SH	SH	SH	SH	SH	SH	SH	SH	SH	SH
L_1 X T_1	-4.08**	-1.84**	14.42*	-6.21	63.67**	28.11**	-64.92**	-23.69*	117.91**	-32.68**
L_1 X T_2	-7.51**	0.76	-6.51	7.02*	50.78**	2.22	-54.63*	-40.02*	62.01**	-22.57**
L_1X T_3	-6.03**	-4.07**	19.04**	12.81**	24.52**	18.38**	-20.78*	-18.84*	4.21	-37.83**
L_2 X T_1	2.82**	10.61**	15.37**	-6.02	7.08	22.07**	-37.66*	-38.73*	52.31**	-37.07**
L_2 X T_2	-0.31	0.75	-22.72**	10.65**	9.64	-13.98*	-25.96*	-43.92*	-3.92	11.71**
L_2 X T_3	3.73**	-6.75**	-20.36**	26.18**	8.06	11.24**	-10.40*	-15.69*	88.35**	-16.63**
L_3 X T_1	17.48**	14.03**	5.34	-25.71*	6.88	-29.73*	-57.54*	-21.65*	127.71**	-29.07**
L_3 X T_2	5.56**	-11.36*	-21.11**	7.35*	7.08	-39.64*	-57.88*	-35.88*	85.98**	-16.17**
L_3 X T_3	1.52*	-6.72**	-12.81*	-6.21	-3.53	-8.34**	-21.34*	-16.74*	62.32**	-9.07**
L_4 X T_1	1.25	-6.44**	21.16*	-6.65*	30.01**	9.16**	-64.56*	-8.21**	63.33**	-23.66**
L_4 X T_2	-2.712*	1.82**	29.31**	8.74**	37.21**	-20.82*	-54.29*	-31.71*	50.87**	12.32**
L_4 X T_3	-1.77**	-3.45**	8.05	11.98**	24.91**	-7.32**	11.99*	2.19**	55.31**	-11.78**
L_5 X T_1	16.23**	14.07**	9.66	-8.91**	52.94**	-28.98*	-67.78*	-20.03*	61.58**	-28.06**
L_5 X T_2	20.62**	-23.72**	-14.35*	-8.56**	42.02**	-30.41**	-57.08*	-26.58*	15.43	-8.32**
L_5 X T_3	0.56	-20.30*	-10.41	-9.90**	37.31**	-48.65**	-25.71**	-5.13**	121.52**	-29.56**
L_6 X T_1	3.04**	-3.12**	10.03	25.66**	36.62**	10.90**	-62.32*	30.37**	128.51**	-33.01**
L_6 X T_2	5.72**	-15.34*	4.11	1.81	34.34**	-32.03*	-52.01*	36.87**	49.32**	-22.23**
L_6 X T_3	20.66**	-8.08**	-0.65	-4.86	11.51	-10.03*	-14.89**	28.38**	43.87**	-27.11**
L_7 X T_1	-0.21	1.97**	9.66	-6.02	5.82	6.97**	-61.05**	-36.50*	62.62**	-34.41**
L_7 X T_2	-4.01**	-10.00*	-15.74**	11.87**	25.38**	-26.57*	-51.62**	-40.39*	16.17	8.62**
7_7 X T_3	-1.67**	-1.72**	-10.41	12.33**	4.62	7.87**	-20.54**	8.42**	33.87**	-23.11**

*, ** - significant at 5 % and 1 % level respectively

brinjal, comparable outcomes have been documented (14-19). A high-producing cultivar was developed as a result of the general combining capacity for fruit yield and yield related features, which further highlighted parental lines that consistently produced better yielding progeny (Fig. 3). A key component of plant breeding techniques meant to improve plant health and agricultural yield is general combining ability. These results are consistent with earlier studies (20-24).

Three F_1 hybrids, $L_4 \times T_3$, $L_7 \times T_3$ and $L_2 \times T_3$, were shown to be potential combiners for fruit yield per plant and other characteristics based on the unique combining ability effect. An investigation of specific combining abilities showed that some cross combinations regularly produced tall offspring with lots of branches. The result provides important information for breeders choosing prospective hybrid combinations to improve desired traits in future generations.

The SCA estimates also revealed that some crosses resulted in early-fruiting progeny, which suggests that specific were gene interactions favour early fruiting, a characteristic that significantly contributes to fruit production and overall productivity (25-30). Furthermore, depending on the genetic combinations involved, the SCA of yield-related variables showed variation in hybrid performance, with some crosses creating genotypes with high yields and others with decreased productivity. These findings demonstrate how crossings with high SCA can be used to produce high-yielding hybrids, increasing small-scale farming's economic feasibility. As a result, SCA is used to find the best parental combinations and create cultivars that are suitable for growing. These results support those of related studies (31, 32).

Fruit yield per plant, the most significant characteristic, exhibited non-additive gene activity, as the GCA/SCA ratio was less than one. This indicates that heterosis breeding would be effective for improving such traits. For the trait that showed additive gene action, similar results in fruit yield per plant were also reported in brinjal (33). Because it is adaptable, simple selective would be preferred for improving these characteristics. It is recommended to use heterosis breeding for features with non-additive gene activity. Due to the inexpensive cost of producing F1 seeds and the low seed demand per unit area, this crop can be exploited commercially (34).

Information on GCA should be complemented with SCA and hybrid performance leverage heterosis. None of the F1 hybrids were consistently better for every characteristic, according to the estimations of SCA effects. This suggested that the GCA of the parents involved was not always a determining factor in the F1 hybrids' specific combining ability. These findings supported by previous studies (35-37), should be considered when utilising hybrid vigour in brinjal for vegetable traits. For the purpose of exploiting the hybrid vigour in brinjal

Table 4. Identification of best hybrid based on *Per se*, SCA and standard heterosis

S. No.	Traits	*Per se*		SCA effect		Standard heterosis	
		L_4 x T_3	L_4 x T_3	L_4 x T_3	L_4 x T_3	L_4 x T_3	L_4 x T_3
1	Days to 50 % flowering (days)	68.31**	66.81**	-1.04**	-0.72*	-1.77**	-1.67**
2	Plant height (cm)	72.61	73.91**	2.11**	3.82**	-3.45**	-1.72**
3	Number of branches per plant	4.91	4.07	-0.31	-0.01	8.05	-10.41
4	Number of flowers per cluster	6.43**	6.45**	0.61**	0.56**	11.98**	12.32**
5	Number of fruits per cluster	4.66**	3.53**	0.45**	0.06	24.91**	4.62
6	Number of fruits per plant	20.24	22.32**	-0.82*	1.13**	-7.32**	7.86**
7	Fruit length (cm)	11.12**	10.02**	0.87**	-0.11	11.98**	-20.52*
8	Fruit weight (g)	142.38**	127.62**	3.82**	11.14**	2.19**	8.42**
9	Fruit breadth (cm)	6.92**	3.75	0.58*	0.04	50.87**	16.16
10	Fruit yield (g)	955.81**	850.24**	30.84**	49.6**	2.32**	8.61**

*, ** - significant at 5 % and 1 % level respectively

for vegetable traits, the cross (Sevanthipatti brinjal × Arka Harshitha) should be taken into consideration (Table 4). Similar outcomes have been reported in earlier studies (38-40).

Conclusion

Through a variety of yield-contributing traits, Kulasai and Sevanthipatti brinjal were identified as effective donors of favourable alleles for raising fruit production per plant; using these parental lines would be more fruitful in improving brinjal yield. For traits such as days to 50 % flowering, plant height, number of flowers per cluster, number of fruits per plant, fruit weight and fruit output per plant, Kulasai brinjal × Arka Harshitha was a good specific combiner. For the number of flowers per cluster, the number of fruits per cluster, the weight of the fruits and the fruit output per plant, Arka Keshav × Arka Harshitha was a good specific combiner. By identifying the important genes involved in the above crosses, the key genes that control plant ideotypes can be characterized in future studies. The study of ideal plant architecture obtained through heterosis breeding that could paves path in achieving substantial gain in yield with other attributing traits.

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Authors' contributions

SRRR supervised the research work and prepared the manuscript. SV helped to shape of the final manuscript. SS and KRS provided the support for research activities during the study periods. RE carried out the experimental work and analysed the data. CK and VJ provided the digital and plant protection measures support. SRV provided critical feedback. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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