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Research Article

Elucidation of nature of gene action and estimation of combining ability effects for fruit yield and its component traits and resistance to fruit and shoot borer in brinjal (*Solanum melongena* (L.))

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Abstract
Combining ability assessment helps select parents and hybrids with high performance, which can lead to increased yield and effective crop improvement. The present study aimed to evaluate 24 diverse crosses for ten different quantitative traits using line x tester mating in the *kharif* season. The experiment involved the assessment of crosses, which included 4 females, 6 males, and 1 commercial cultivar (Nishant). The evaluation employed a randomized block design (RBD) with three replications. Major discrepancies were observed in the genotypes of both parents and hybrids for all traits, indicating a significant amount of variation in fruit yield and other characteristics that contribute to yield. JBR-20-05 was found the best general combiner for days to 50% flowering, fruit length and plant height. JBR-20-04 was found to be the best general combiner for average fruit weight, fruit girth and total fruit yield per plant. The genotype identified in the JBR-20-07 study, resistant to fruit and shoot borer infestation, held significant potential for use in breeding and selection programs to enhance the resistance of brinjal varieties. Estimation of Specific combining ability effect revealed that among the hybrids, the hybrids JBR-20-04 x JBR-20-05 recorded highly significant specific combining ability (SCA) effects for total fruit yield per plant. The cross JBR-20-03 x JBR-20-05 showed high desirable significance to SCA for fruit and shoot borer infestation. Variance due to general combining ability was less than the variance due to SCA, and the ratio of GCA to SCA variance was less than unity. When choosing hybrids to enhance yield in brinjal (*Solanum melongena* L.) through breeding, it is crucial to prioritize specific traits that directly contribute to increased production.

Keywords: Brinjal, Fruit borer, Genotypes, Gene action, General combining ability, Shoot borer , Specific combining ability

INTRODUCTION

Brinjal (*Solanum melongena* L.) is a highly significant and popular vegetable crop. It is often cross-pollinated, an annual herbaceous plant with versatility, well-suited to various agro-climatic regions, and can be cultivated throughout the year (Kumar *et al*., 2020) and (Ghosh *et al*., 2022). Brinjal is a popular vegetable in India and is acknowledged as one of the more successful crops. In India, brinjal hybrids are gaining popularity among farmers and consumers due to their early maturity, high yield potential, and superior qualities in terms of fruit colour, shape, and taste (Ginoya *et al*., 2021). Brinjal continues to be a favoured choice among breeders for improvement due to its resilient crop characteristics, particularly its large flower size, and the substantial seed abundance resulting from a single pollination event (Farooq and Delvadiya, 2023). The brinjal crop plays a pivotal role in attaining nutritional security through vegetables. The success of a breeding program hinges on the careful selection of parents and a comprehensive understanding of the genetic mechanisms influencing various traits (Siva *et al.,* 2020). Breeders can optimize cross-combinations in hybridization by carefully selecting parent generations based on their general combining ability (GCA) and specific combining ability (SCA) (Vamsi *et al*., 2022). This entails assessing the overall performance and compatibility of genotypes to optimize the success of hybridization. Various methods, such as diallel, partial diallel, and line x tester, provide diverse approaches for estimating the requisite breeding demands. The specific combining ability values for each cross and the general combining ability for lines and testers were determined using the line x tester mating design, as outlined by (Rajan *et al*., 2022). Quantifying gene action requires evaluating genetic variation components, combining ability variance and specific effects. In homozygous genotypes, genetic dissimilarity is exclusively attributable to both additive and non-additive factors, including epistasis. However, a combination of additive and non-additive genes is present in segregating populations. Due to eggplant's high susceptibility to the fruit and shoot borer (FSB), specifically Leucinodes orbonalis, our primary goal is to identify natural resistance hybrids that can effectively combat infestations (Harshita Thota *et al*., 2023). This is crucial for enhancing the resilience of eggplant varieties, as the brinjal shoot and fruit borer, a significant pest, has been documented to cause substantial crop yield reduction, reaching up to 70% and resulting in massive production losses (Haldhar *et al*., 2023). Although brinjal is widely cultivated, it is susceptible to insect-pest infestations, with the fruit and shoot borer posing a particularly challenging threat for farmers. Consequently, a pressing demand exists to bolster resistance against the fruit and shoot borer through efficient breeding methodologies (Thota and Delvadiya, 2024). The present study aimed to evaluate 24 diverse crosses for ten different quantitative traits using line x tester mating in the *kharif* season.

MATERIALS AND METHODS

Methodology

The present exploration was conducted at the Research Farm, School of Agriculture, Lovely Professional University, Punjab using 6 lines, 4 testers and one standard check. Testers (Females) JBR-21-04 (T1), JBR-20-05(T2), JBR-20-06 (T3), JBR-21-06 (T4), JBR-20-07(T5), JBR-21-14(T6), Lines (Males) JBR-20-01 (L1), JBR-20-02(L2), JBR-20-03 (L3), JBR-20-04 (L4) and Check Nishant, Total 24 crosses which made by line × tester mating design. The cross seed was obtained during the *Kharif* (May-October) 2023. The hybrids (24), along with parents (10) and 1 check, were grown and tested in RBD with three replications during *kharif* 2023. Observations recorded were days to 50% flowering (DFF), days to first picking (DFP), fruit length (FL) (cm), fruit girth (FG) (cm), average fruit weight (AFW)(g), number of primary branches per plant (NPB), number of fruits per plant (NFP), plant height (PH) (cm), fruit and shoot borer infestation (FBI) (%) and total fruit yield per plant (TFYP)(kg).

Statistical analysis

The analysis of combining ability in the line x tester design was conducted following Kempthrone's (1957) proposed method. Covariances between full-sibs and half-sibs were computed based on the expected mean squares. The data were analysed in R using the Agricola package, Version 1.3-5.

RESULTS AND DISCUSSION

The analysis of variance indicated significant variation among parents and hybrids for the evaluated characteristics (Table 1), These results were compatible with previous studies on brinjal (*Solanum melongena*), as reported by Subha Laxmi Mishra *et al*. (2023), which investigated 7 parents and 21 hybrids. The combining ability analysis revealed noteworthy distinctions in GCA and SCA variances across all examined traits. These results underscore the significance of both additive and non-additive gene effects in the genetic regulation of the studied characters. GCA/SCA showed a majority of non-additive gene action in inheritance for most of the characters. The genetic variance attributed to General Combining Ability (GCA) is lower than that attributed to Specific Combining Ability (SCA), and the ratio of GCA to SCA variance was less than unity. Therefore, all the traits studied showed a non-additive type of gene action. Corresponding results were observed previously by Kachouli *et al*. (2019) reported in 8 parents and 28 hybrids, and Nikhila *et al*. (2023) study involved 21 hybrids of brinjal (*Solanum melongena* (L.) for days to 50 % flowering, average fruit weight, days of first picking, number of fruits per plant, numbers of primary branches per plant and fruit yield per plant. Gangadhara *et al*. (2021) reported that their study involved 8 parents and 15 brinjal hybrids revealing total fruit yield per plant for fruit grith. Solanki *et al*. (2022) revealed same result for fruit borer infestation among 9 parents and 36 hybrids in brinjal (*S. melongena* (L.)). While Thota and Delvadiya (2024) also reported using half diallel mating design with 9 parents.

Significant GCA effects among females were observed in JBR-20-04 and JBR-20-01 for fruit length. JBR-20-05 was identified as a promising combiner for enhancing fruit length among all males. In terms of fruit girth, female lines JBR-20-04 and JBR-20-03, along with the

Table 1. ANOVA for the Line x Tester involving parents for yield and its contributing traits in brinjal

Source of variation	Df	Days to 50% Flowering	Days to First Picking	Fruit Length (cm)	Average fruit Weight (g)	Fruit girth(cm)
Replication	2	4.60	0.17	0.14	122.61	0.007
Crosses	23	73.94**	70.69**	8.71**	2363.87**	11.13**
Tester effect	5	102.30	98.02	6.87	1488.60	7.78
Line effect	3	38.79	25.27	25.27	8045.22*	29.55*
Line x Tester effect	15	71.52**	70.66**	6.01**	1519.36**	8.57**
Error	46	2.21	0.94	0.10	148.21	0.26
Source of variation	**Df**	**No. of fruit per Plant**	**No. of primary branches**	**Plant height (cm)**	**Total fruit yield per plant (kg)**	**Fruit borer Infestatio (%)**
Replication	2	0.16	0.06	0.48	0.005	0.05
Crosses	23	24.82**	1.92**	92.23**	0.256**	65.42**
Line effect	5	19.31	1.57	120.94	0.094	47.44
Tester effect	3	58.89	4.27	4.078	0.613	43.77
Line x Tester effect	15	19.85**	1.56**	100.29**	0.238**	75.74**
Error	46	0.20	0.04	1.44	0.007	0.17

*, **denotes significance at 5% and 1% respectively

tester JBR-20-05, displayed substantial and positive general combining ability. For the number of fruits per plant, the female lines JBR-20-01 and JBR-20-02 demonstrated notable combining ability. Conversely, among the male lines, JBR-21-06 and JBR-20-05 were identified as strong general combiners, displaying significant and positive General combining ability (GCA) effects. Regarding plant height, the female lines, particularly JBR-20-02, exhibited highly significant and positive general combining ability effects, establishing them as proficient combiners. Male lines JBR-20-05 and JBR -21-06 were the best combiner for plant height. Concerning the number of primary branches, JBR-20-04 demonstrated significant general combining ability effects among females, while JBR-21-06 exhibited considerable and positive effects among males. Achieving high yield is the primary objective in most varietal improvement programs, and the new variety is anticipated to possess a yield potential that is either equal to or higher than that of existing cultivars. JBR-20-04 among the female parents and JBR-20-05 among male parents were good combiners for Total fruit yield per plant. For fruit borer infestation, it was observed among female lines JBR-20-04 and JBR-20-03, whereas among testers, JBR-20-07 possessed the highest negative significant GCA effect, which is useful for less fruit borer infestation in the crop. General combining ability effects helps to pinpoint the good parent.

The GCA effect estimation indicated that JBR-20-04, JBR-20-05, and JBR-20-06 were strong general combiners, displaying highly significant GCA effects. It can be inferred that the female parent JBR-20-04 emerged as the most effective combiner for average fruit girth, fruit weight, and total fruit yield per plant.JBR-20-02 no. of fruit per plant Among the testers, JBR-20-05 was a

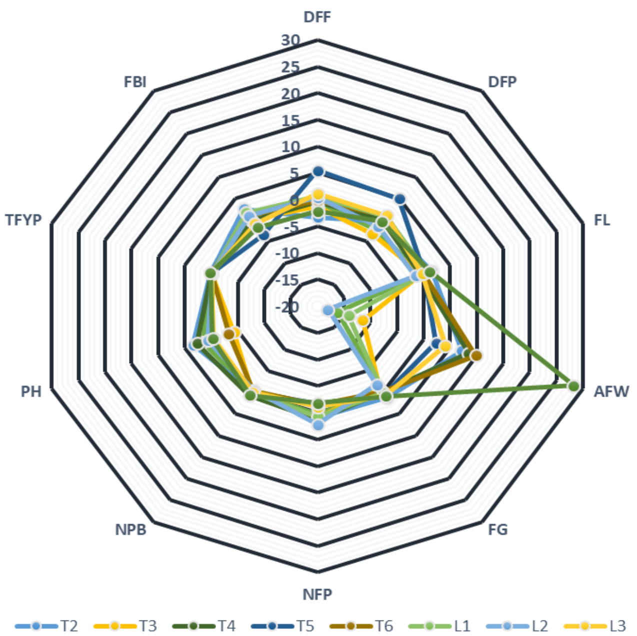

Fig. 1. *General Combining Ability (GCA) effects for 10 traits among parental lines in brinjal*

good combiner for days to 50% flowering, fruit length and plant height. JBR-21-06 was the best male parent for a number of primary branches, days to first picking. JBR-20-07 Fruit borer infestation. Parents with greater combining ability may be extensively employed in a hybridization programme targeted at increasing fruit yield. Manubhai (2017) reported that to make a dynamic population with most of the good genes, it will be necessary to use the above parents, who were strong general combiners for many traits, in a repeated crossing process. Specific combining ability reveals differences in the performance of offspring combinations compared to what would be expected based on the

Table 2. General combining ability (GCA) effects for 10 traits among parental lines in brinjal

SrNo	Genotypes	Days to50% Flowering	Days to First Picking	Fruit Length(cm)	Average fruit weight(g)	Fruit girth (cm)	No. of fruit per plant	No. of primary branches	Plant height (cm)	Total fruityield per plant(kg)	Fruit borer infestation(%)
	Tester										
T1	JBR-21-04	-0.31	-2.30**	-0.44**	-16.23**	-0.30*	0.16	0.7	1.70**	-0.11**	-0.176
T2	JBR-20-05	-3.30**	-0.20	1.46**	7.16*	1.21	0.89**	-0.05	3.39**	0.14**	2.52**
T3	JBR-20-06	-1.21**	-3.22**	-0.42**	-11.50**	-1.20**	0.58**	-0.08	-4.26**	-0.01	0.11
T4	JBR-21-06	-0.41	-0.09	-0.56**	8.46*	-0.05	1.23**	0.66**	2.67**	0.02	-0.07
T5	JBR-20-07	5.46**	4.92**	0.09	2.31	0.46**	-1.64**	-0.09	-0.27	-0.06	-3.48**
T6	JBR-21-14	-0.20	0.90**	-0.12	9.80**	-0.12	-1.50**	-0.44**	-3.24**	0.02	1.09**
	Lines										
L1	JBR-20-01	0.57	0.82**	0.69**	-14.17**	0.14	0.72**	0.03	-0.05	-0.12**	1.67**
L2	JBR-20-02	0.41	-1.50**	-1.54**	-18.07**	-1.85**	2.18**	-0.54**	-0.17	-0.17**	0.90**
L3	JBR-20-03	1.15**	1.06**	-0.26**	4.02	0.80**	-1.08**	-0.11	-0.41	0.05**	-0.87**
L4	JBR-20-04	-2.15**	-0.38	1.12**	28.23**	0.89**	-1.82**	0.63**	-0.21	0.23**	-1.70**
SE±(Lines)		0.42	0.28	0.09	3.51	0.14	0.13	0.058	0.34	0.025	0.12
CD@5%(Lines)		0.86	0.56	0.18	7.07	0.3	0.26	0.11	0.69	0.05	0.02
CD@1%(Lines)		1.15	0.75	0.24	9.44	0.4	0.34	0.15	0.93	0.06	0.03
SE± (Testers)		0.35	0.22	0.75	2.86	0.12	0.1	0.048	0.28	0.02	0.09
CD@5%(Testers)		0.7	0.46	0.15	5.77	0.24	0.21	0.09	0.57	0.041	0.19
CD@1%(Testers)		0.94	0.61	0.2	6.86	0.32	0.28	0.12	0.76	0.055	0.26

general combining abilities of the parents; it can be either negative or positive. Table 2 and Fig.1 represent estimates for Specific combining ability effects across various traits revealed advantageous and significant negative effects in 9 crosses for days to 50% flowering. The cross (JBR-20-04 x JBR-20-07) registered the highest value for significant negative Specific combining ability (SCA) effects. Significant estimates of SCA effects of crosses for days to 50% flowering in brinjal were also reported earlier by Siva *et al*. (2020) for 7 parents + 21 hybrids and Timma Reddy *et al.* (2021) for 10 parents + 28 hybrids. Deshmukh *et al*. (2020) reported that 10 parents + 24 hybrids among brinjal had significant negative SCA effects from days to the first fruit picking. For the trait of interest, nine crosses exhibited desirable and significant negative Specific Combining Ability (SCA) effects. Notably, the cross combination JBR-20-04 x JBR-21-06 recorded the highest negative SCA effects, surpassing other crosses.

Additionally, five crosses displayed positive Specific Combining Capability effects in the context of average fruit weight. The cross JBR-20-03 x JBR-21-14 was observed to be the best specific combiner for this character, followed by the other crosses. Nikhila *et al*. (2023) also found positive Specific combining ability effects for average fruit weight among 21 hybrids of brinjal (*S. melongena* (L.). The cross JBR-20-03 x JBR-21-14 showed the highest specific combining ability effect for fruit length among the nine crosses with significant and positive effects, followed by the remaining crosses. Gangadhara *et al*. (2021) previously reported significant specific combining ability (SCA) effects for fruit length in brinjal. Additionally, concerning fruit girth, among six cross-combinations, the highest SCA estimates were observed in the (JBR-20-01 x JBR-20-06) cross, followed by the remaining combinations among 8 parents +15 hybrids of eggplant S. melongena (L.). Mondal *et al*. (2021) conducted a study on six parents and 15 hybrids of brinjal (*Solanum melongena* (L.)), revealing noteworthy estimates for specific combining capability effects in crosses specifically designed for fruit diameter. The number of fruits per plant revealed that 07 crosses had significant advantageous specific combining ability effects. Rajan *et al*. (2020) explored 14 parents and found that the cross JBR-20-01 x JBR-20-06 exhibited the highest positive specific combining ability (SCA) effects, with similar trends observed in the remaining crosses in brinjal (*S. melongena* (L.). SCA effects showed 09 crosses as having significant, positive SCA estimates on plant height. The cross JBR-20-04 x JBR-20-07 showed maximum significant, positive SCA effects, followed by the other crosses. Subha Laxmi Mishra *et al*., (2023) among 7 parents + 21 hybrids reported Significant estimates for SCA effects of crosses for plant height in eggplant (*S. melongena* (L.). SCA effects on a number of primary branches revealed that

Table 3. Specific combining ability (SCA) effects for 10 traits among hybrids in brinjal

Sr.no.	Genotypes	Days to 50% Flowering	Days to First Picking	Fruit Length (cm)	Average fruit weight(g)	Fruit girth (cm)	No. of fruit per plant	No. of primary branches	Plant height (cm)	Total fruit yield per plant(kg)	Fruit borer infestation(%)
1	L1xT1	-3.32**	-1.00	-0.26	15.56 *	0.26	-0.71 **	-0.86 **	0.77	0.15 **	-2.22**
2	L1xT2	2.33**	0.49	-0.49*	-23.85 **	-0.35	-1.71 **	-0.01	3.29 **	-0.39**	-3.75 **
3	L1xT3	0.57	-1.55**	2.11**	21.02 **	3.25 **	-0.27	0.12	-7.82**	0.26 **	2.98 **
4	L1xT4	-0.89	1.34*	0.69**	10.51	0.47	-2.96 **	-0.29*	3.11 **	-0.21 **	-2.62 **
5	L1xT5	3.15**	-5.83**	0.24	-3.85	-0.53	3.99 **	0.66**	-5.74**	0.30 **	1.45 **
6	L1xT6	-1.83*	6.55**	-2.29**	-19.39 **	-3.09**	1.68 **	0.38 **	6.37 **	-0.11 *	4.16 **
7	L2xT1	3.83**	-4.48**	1.07**	-0.62	-0.37	0.01	0.65**	-1.12	0.04	0.81 **
8	L2xT2	-1.57	4.21**	-1.08**	-1.37	-0.63*	2.45 **	0.67 **	0.29	0.05	9.84 **
9	L2xT3	-2.60**	-2.63**	-0.39*	3.24	-1.18**	-1.12 **	-0.29 *	1.58 *	0.00	0.55 *
10	L2xT4	0.93	4.06**	-0.06	-15.85 *	-1.55 **	3.47 **	-0.34 **	-1.04	-0.26 **	0.37
11	L2xT5	-3.55**	-1.58**	-0.06	9.16	1.41 **	-2.56 **	-0.58 **	-6.20 **	0.06	-4.21 **
12	L2xT6	2.95**	0.41	0.53**	5.43	2.34 **	-2.24 **	-0.10	6.49 **	0.09	-7.36 **
13	L3xT1	5.56**	1.35	0.38*	2.58	0.39	0.31	-0.17	-3.04 **	-0.10 *	-1.67 **
14	L3xT2	-5.04**	-5.11**	-0.49*	-13.67	1.231 **	-0.37	0.01	0.64	-0.16 **	-8.44 **
15	L3xT3	-4.82**	3.86**	-0.24	-7.04	-1.76**	1.02 **	-0.05	0.39	-0.10 *	-0.19
16	L3xT4	2.39**	2.66**	-1.20**	-12.43	-0.45	0.05	-0.80 **	0.78	0.15 **	1.09 **
17	L3xT5	5.84**	0.38	-0.74**	-10.94	-0.71*	1.89 **	0.68 **	4.56 **	0.02	5.46 **
18	L3xT6	-3.94**	-3.15**	2.31**	41.51 **	1.30 **	-2.91 **	0.33 **	-3.34**	0.20 **	3.75 **
19	L4xT1	-6.06**	4.13**	-1.19**	-17.52*	-0.29	0.40	0.37 **	3.39 **	-0.09	3.08 **
20	L4xT2	4.29**	0.40	2.07**	38.89**	-0.23	-0.36	-0.67 **	-4.24**	0.51**	2.35 **
21	L4xT3	6.83**	0.31	-1.47**	-17.23 *	-0.29	0.37	0.22	5.84 **	-0.16**	-3.33 **
22	L4xT4	-2.43**	-8.08**	0.56**	17.76 *	1.54 **	-0.566*	1.44 **	-2.85 **	0.32 **	1.15 **
23	L4xT5	-5.45**	7.03**	0.57**	5.63	-0.16	-3.32**	-0.76 **	7.38 **	-0.39**	-2.70 **
24	L4xT6	2.82**	-3.80**	-0.55**	-27.55**	-0.54	3.47 **	-0.61 **	-9.53**	-0.18 **	-0.55 *
	SE± (sca)	0.85	0.56	0.1	7.02	0.29	0.25	0.11	0.69	0.05	0.23
CD@5%(sca)		1.72	1.12	0.3	14.14	0.6	0.52	0.23	1.39	0.1	0.48
CD@1%(sca)		2.3	1.5	0.4	18.88	0.8	0.69	0.31	1.86	0.13	0.64

*, **denotes significance at 5% and 1% respective

Table 4. Mean performance of hybrids for yield and it contributing traits in brinjal

Sr.no	Genotypes	Days to 50% Flowering	Days to First Picking	Fruit Length (cm)	Average fruit weight (g)	Fruit girth (cm)	No. of fruit per plant	No. of primary branches	Plant height (cm)	Total fruit yield per plant (kg)	Fruit borer infestation (%)
1	L1xT1	37.73	63.47	12.99	88.21	22.06	23.03	6.60	75.99	5.63	14.40
2	L1xT2	44.73	57.67	12.09	68.13	19.42	25.21	7.53	74.82	5.47	16.67
3	L1xT3	47.20	66.07	12.67	93.44	22.85	22.26	7.13	71.81	5.54	12.40
4	L1xT4	32.27	67.40	12.49	97.54	22.25	21.60	8.43	78.45	5.73	16.33
5	L1xT5	40.40	67.07	14.67	72.19	22.95	22.77	7.40	80.20	5.34	15.57
6	L1xT6	36.33	68.47	11.83	90.78	20.67	28.39	7.50	77.93	5.74	28.40
7	L2xT1	33.60	61.71	13.71	100.58	25.20	22.30	7.27	77.18	5.75	8.33
8	L2xT2	39.63	65.77	17.67	177.36	23.83	21.57	7.33	72.50	6.60	18.30
9	L2xT3	40.73	62.00	15.39	98.41	24.15	24.17	7.50	61.42	5.85	19.90
10	L2xT4	37.40	58.60	10.63	76.74	17.70	24.78	6.50	71.56	5.54	16.70
11	L2xT5	35.93	67.67	12.06	88.55	19.79	23.67	7.17	69.27	5.66	14.17
12	L2xT6	44.27	62.67	12.22	102.57	21.35	22.27	8.20	74.93	5.77	10.20
13	L3xT1	40.07	68.03	13.84	107.87	22.51	21.85	7.83	79.30	5.37	14.10
14	L3xT2	41.73	68.43	10.83	77.60	18.48	29.76	7.20	75.87	5.28	16.33
15	L3xT3	43.93	69.60	10.97	103.12	22.25	23.07	7.17	76.60	5.92	15.27
16	L3xT4	35.80	57.40	14.13	157.53	24.33	21.70	10.17	73.17	6.27	14.50
17	L3xT5	50.00	65.87	14.04	87.35	22.03	25.93	8.03	67.49	5.83	14.77
18	L3xT6	43.13	67.80	11.48	96.47	21.97	20.84	6.20	67.75	5.54	8.33
19	L4xT1	53.27	72.33	12.08	98.46	22.51	22.03	7.90	77.43	5.72	16.23
20	L4xT2	38.67	77.53	14.79	139.25	23.14	16.07	7.20	80.45	5.49	7.23
21	L4xT3	39.33	74.23	11.29	79.30	18.87	23.77	7.40	76.63	5.49	22.07
22	L4xT4	43.97	65.77	11.87	100.23	22.31	21.30	6.33	77.49	5.65	9.77
23	L4xT5	37.80	64.77	14.93	158.41	23.93	17.37	7.20	66.55	5.99	19.10
24	L4xT6	41.27	62.67	13.45	113.55	22.17	23.00	7.00	60.57	5.78	13.97
25	Line 1	34.60	79.23	16.45	135.53	27.68	13.23	6.77	81.53	5.67	12.20
26	Line 2	36.07	76.47	14.61	97.47	19.40	23.40	6.73	85.85	5.82	13.97
27	Line 3	33.73	64.03	14.92	127.21	25.35	21.53	8.53	81.26	5.83	13.13
28	Line 4	40.80	70.00	11.73	117.78	23.15	13.70	6.80	77.40	5.73	10.20
29	Tester 1	40.80	70.00	11.73	117.78	23.15	21.67	6.93	75.04	5.94	19.67
30	Tester 2	40.33	76.13	14.76	125.75	25.46	17.43	7.20	82.52	5.72	8.00
31	Tester 3	48.00	71.87	11.11	87.43	18.25	25.07	7.60	74.63	5.62	15.93
32	Tester 4	32.60	69.57	11.88	119.39	25.74	20.17	8.77	74.81	5.76	13.93
33	Tester 5	33.83	64.53	19.97	166.57	26.31	22.83	7.60	78.58	6.93	8.00
34	Tester 6	49.47	63.20	13.07	112.03	25.01	23.07	7.57	75.43	6.04	16.80
35	Check	43.40	73.07	12.57	96.47	20.20	18.80	5.80	67.75	4.83	13.67

eight crosses had considerable positive effects. The cross JBR-20-04 x JBR-21-06 displayed the highest and significantly positive Specific Combining Ability (SCA). Regarding total fruit yield per plant, specific combining ability analysis indicated that 07 cross combinations exhibited significant positive estimates.

The combination JBR-20-04 x JBR-20-05 demonstrated the highest and significant positive SCA, followed by the other crosses. Gangadhara *et al*. (2021) examined 8 parents and 15 hybrids, revealing similar observations concerning fruit yield per plant in F1 hybrids of eggplant *S. melongena* (L). The specific combining ability (SCA) effects on the number of fruits borer infestations showed that ten crosses exhibited a significant positive effect. The cross JBR-20-03 x JBR-20-05 exhibited highly desirable and significant SCA. Solanki *et al*. (2022) similarly reported noteworthy negative SCA effects for the number of fruit borer infestations in brinjal (*S. melongena* (L.)) among a group of 9 parents and 36 hybrids. In brinjal, understanding the interplay between combining ability and gene action is crucial for effective breeding programs. Combining ability assesses the potential of parental lines to contribute desirable traits in hybrids, while gene action elucidates how these traits manifest in offspring. This synergistic approach enhances the precision of breeding strategies, ensuring the development of superior brinjal varieties with desired characteristics.

An analysis of the most potent general combiners and notable special combining effects (Table 3) shows that in most cases, the top general combiners do not consistently provide the most favourable cross combinations for the traits studied. Based on this study, it is advised that prospective transgressive segregants in future generations be investigated for possible inclusion in breeding programmes.

Therefore, emphasizing individual performance, the performance of parents and hybrids in Table 4 was crucial when prioritizing cross combinations. SCA effects predominantly signify deviations in F1 performance, and their magnitude is contingent on the performance of the parent lines. Consequently, a heightened SCA effect does not invariably assure superior hybrid performance. As a result, the utility of estimating SCA effects in the selection process appears to be limited.

Moreover, increased resistance to fruit and shoot borers has been observed to correlate with a natural boost in yield (Praneetha *et al*., 2022). Looking ahead, the exploration of Fruit and Shoot Borer (FSB) resistance, a complex trait influenced by multiple genes, can be elevated by utilising Quantitative Trait Loci (QTL) mapping. This method entails identifying major QTLs associated with broad-spectrum resistance against FSB, offering valuable insights for future breeding strategies (Tiwari *et al*., 2023).

The JBR-20-04 crossed with JBR-20-05 hybrid exhibited larger fruit size and favorable characteristics. Notably, the significant Specific Combining Ability (SCA) for yield per plant, driven by the high individual yields of parent varieties JBR-20-03 and JBR-20-05, along with the hybrid's notable resistance to fruit borer, enhances its economic viability in alignment with consumer preferences. The yield trait, influenced by multiple genes, exhibits a complex expression pattern. Understanding gene actions, including additive, dominance, and epistasis, is crucial for breeders to optimize breeding techniques and enhance crop yield and related characteristics. When additive gene action prevails, crop improvement through selection methods is recommended; however, developing composite varieties or harnessing heterosis can be advantageous in cases involving dominance and epistasis gene actions and associated allelic and non-allelic interactions. Understanding gene action provides valuable guidance to breeders in choosing effective breeding methodologies.

Conclusion

The present study evaluated the combining ability of 10 parents and 24 brinjal hybrids (*Solanum melongena* L.) across 10 traits, revealing notable disparities in genotypes for all traits and indicating significant variation in fruit yield and related characteristics. JBR-20-04 was the most effective general combiner, excelling in average fruit weight, girth, and total fruit yield per plant. Notably, the JBR-20-04 x JBR-20-05 hybrid displayed highly significant SCA effects, particularly for total fruit yield per plant. The resistant JBR-20-07 genotype against fruit and shoot borer infestation held substantial potential for integration into breeding and selection programs to enhance brinjal varieties' resistance. The dominance gene effects, indicated by the prevalence of non-additive genetic variance across all traits, underscore the advantageous prospects of leveraging such effects, especially in heterosis breeding.

Conflict of Interest

The authors declare that they have no conflict of interest.

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