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Combining Ability and Gene Action Studies for Yield and its Attributed Traits Over Different Environment in Brinjal (*Solanum melongena* L.)

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ABSTRACT: The present investigation was carried out by using eight diverse parents for appraisal of combing ability in brinjal. Parents were crossed in half diallel fashion to obtain 28 hybrids. Combining ability is an assessment of genotypes on the basis of their offspring performance in some definite mating design. A parent that performs well by its own performance might not always result in better hybrids when combined with another parent. So, performing combining analysis is necessary to identification of better combination of parents. Analysis of variance for combining ability revealed highly significant differences for mean square of GCA and SCA for all studied characters except days to 50 % flowering indicating that both additive and non additive gene action were important for inheritance of these characters. The ratio of σ^2gca/σ^2sca was lower than unity for all the traits except days to 50 % flowering indicate the pre dominant role of non additive gene action. The GCA effect showed that the parents *viz.*, NB-20-7 and GJB 3 observed as good general combiner for fruit yield per plant while for the SCA effect, hybrids *viz.*, NB-20-3 × NB-20-8 at Navsari (L1), NB-20-3 × GJB 3 at Waghai (L2) and NB-20-4 × NB-20-9 at Bardoli (L3) act as good specific combiner for fruit yield per plant.

Keywords: Combing ability, GCA, SCA, Half diallel, Fruit yield.

INTRODUCTION

Brinjal (*Solanum melongena* L., 2n = 2x = 24) belongs to family solanaceae; prominent and widely known vegetable crop in India. It is an annual herbaceous plant and it is mainly cultivated in tropical and sub-tropical regions of the globe for its immature fruits as vegetable. It is a versatile crop growing into different agro-climatic regions and can be cultivated throughout the year. It is a native to the Indian subcontinent. The name 'eggplant' commonly meant for three species of *Solanum*. Among them, *Solanum melongena* L., is globally cultivated species of Asian origin. There are three main botanical varieties under the species *melongena* (Choudhury, 1976). The common brinjal type which is large, egg shaped and round fruited form comes under var. *esculentum*. The long and slender types are belong to group under var. *serpentinum* and the dwarf plants are included in *var. depressum* (Khobragade *et al.*, 2019).

Combining ability refers to capacity of genotype to transmit superior performance to its offspring. The concept of combining ability was first proposed by Sprague and Tatum (1942). Knowledge of combining ability is essential for selection of desirable parents for hybridization and identification of promising hybrids through general combining ability and specific combining ability studies, respectively. Information regarding combining ability and types of gene action determines the transmission of various economically relevant quantitative traits which helps to operate the breeding techniques for genetic improvement of such traits. Plant breeders can take benefits from such information for developing high yielding lines and hybrids which could helps in evaluation of lines in terms of their genetic value (Patil *et al*., 2018).

The possibility of identifying superior transgressive segregants in the segregating populations of any hybridization programme depends on identifying the best pairing of two or more parental genotypes to maximise variance within related breeding populations. Sprague and Tatum defined GCA as the average performance of a genotype in a series of hybrid combinations. They defined SCA as those cases in which certain hybrid combinations perform better or poorer than would be expected on the basis of the average performance of the parental inbred lines. Higher GCA showing better average combining ability in crosses while if their capacity to combine in particular cross, they are regarded as good SCA. Thus, performing combining analysis is necessary to identification of better combination of parents.

MATERIALS AND METHODS

The experimental materials use for present investigation including 28 hybrids developed by 8×8 half diallel design, 8 parents including check. In present experiment, crossing was carried out in *Rabi* 2020-21 at Vegetable Research Station, RHRS, Navsari and the hybrids as well as parents were evaluated during *Rabi*

2021-22 at three different locations *viz.*, College Farm, N. M. College of Agriculture, NAU, Navsari (L1), Hill Millet Research Station, NAU, Waghai (L2) and Wheat Research Station, NAU, Bardoli (L3) situated in the region of south Gujarat. Eight parents namely, NB-20-1, NB-20-3, NB-20-4, NB-20-5, NB-20-7, NB-20-8, NB-20-9 and GJB 3 were used for crossing. Among them, GJB 3 was used as check for comparison.

The complete set of 36 genotypes comprising of 28 F_1, 8 parents including check were evaluated in a Randomized Block Design (RBD) with three replications over three different locations during late *Rabi* 2021-22. Each entry was sown in a single row having 12 plants keeping row-to-row and plant-to-plant distance of 90 cm and 60 cm, respectively. The recommended package of practices and plant protection measures were followed to raise the healthy crop. Observations *viz.*, plant height (cm), branches per plant, days to 50 % flowering, flowers per plant, fruits per plant, fruit length (cm), fruit weight (g), fruit diameter (cm), fruit yield per plant (kg), total phenol content (mg/100 g), total soluble sugars (%) and ascorbic acid (mg/100 g) were recorded on five randomly selected plants from each entry in each replication over the locations.

RESULTS AND DISCUSSION

The analysis of variance for combining ability, using diallel mating design in respect of eight parents and twenty-eight hybrids for all the twelve characters in individual location and pooled over locations (pooled basis) is presented in Table 1-4.

Analysis of variance for GCA was highly significant for all the characters except days to 50 % flowering at Navsari (L1) and Waghai (L2) studied during the experimental programme at all the three locations as well as pooled over locations. It means that parents have wide variation in their combining ability and hence can be classified into good, average and poor on the basis of their GCA effects.

Mean sum of squares due to specific combining ability were significant for all the characters in all the three locations. Significant SCA effect indicates that the hybrids are somewhere different from the parents involved in every given hybrid. Significant mean sum of squares due GCA and SCA for the concern characters suggested difference among parents for GCA and among hybrids for SCA. Characters with significant mean sum of squares due to GCA of parents and SCA of hybrids are indication that parents and hybrids differed significantly in their combining ability effects and importance of both additive as well as non-additive effects for their inheritance (Patel *et al.*, 2017).

In order to identify predominant gene effect, the ratio σ^2gca/σ^2sca was calculated for the characters where significant GCA and SCA mean sum of squares observed and if the calculated ratio σ^2gca/σ^2sca value is more than unity then it indicates the importance of additive gene action while if it is less than unity then it means preponderance of non-additive gene action in the control of character (Vaddoria and Ramani 2015).

In the present investigation, combining ability revealed that the estimates of SCA variance (σ^2sca) were higher than GCA variance (σ^2gca) for all the characters indicating the predominant of non additive gene action involved in the inheritance of these characters and it is always favourable for heterosis breeding for the improvement of these traits. The predominance of non additive genetic variance suggested that the population comprised of heterozygotes. This type of genetic variation is non fixable so, making hybridization a suitable strategy for crop improvement (Rajan *et al.*, 2022). All the characters showed σ^2gca/σ^2sca ratio less than unity for all three individual locations except fruit length (cm) at Waghai (L2) showing the influence of non additive gene action. Hence, heterosis breeding and recombination breeding with postponement of selection at later generations are ideal for improvement of these characters (Timmareddygari *et al.*, 2021).

Similar outcomes were also reported Chaitanya *et al.* (2018); Chaurasia *et al.* (2018); Patil *et al.* (2018); Pramila *et al.* (2018); Zarna *et al.* (2020); Timmareddygari *et al.* (2021); Mohamed *et al.* (2022); Rajan *et al.* (2022); Raval (2022).

Estimation of general and specific combining ability effect. The estimation and interpretation of GCA effects and SCA effects and the results of GCA

effects (g_i) and the SCA effects (s_{ij}) are presented trait-wise in Table 5-10.

Plant height (cm). Significant and positive GCA effect for plant height (cm) was considered as good general combiner. The GCA effect of parents ranged from -5.56 (NB-20-9) to 6.18 (GJB 3) at Navsari (L1), -4.75 (NB-20-4) to 6.56 (NB-20-8) at Waghai (L2) and -5.96 (NB-20-8) to 4.63 (GJB 3) at Bardoli (L3). Among the parents, NB-20-1 (4.20) and GJB 3 (6.18) at Navsari (L1); NB-20-1 (4.01), NB-20-3 (4.09), NB-20-7 (3.97), NB-20-8 (6.56) and GJB 3 (5.20) at Waghai (L2); NB-20-1 (3.59), NB-20-5 (1.91), NB-20-7 (3.31) and GJB 3 (4.63) at Bardoli (L3) possessed positive and significant GCA effect.

The ranged for SCA effect from -10.93 (NB-20-5 × NB-20-7) to 14.70 (NB-20-4 × NB-20-5) at Navsari (L1); -9.94 (NB-20-8 × GJB 3) to 16.69 (NB-20-3 × NB-20-8) at Waghai (L2) and -10.25 (NB-20-9 × GJB 3) to 11.49 (NB-20-1 × NB-20-7) at Bardoli (L3). The outstanding hybrid with positive and significant SCA effect were NB-20-4 × NB-20-5 (14.70) at Navsari (L1); NB-20-3 × NB-20-8 (16.69) at Waghai (L2) and NB-20-1 × NB-20-7 (11.49) at Bardoli (L3). These finding were in line with the earlier reports of Patil *et al.* (2018); Pramila *et al*. (2020).

Branches per plant. Among 8 parents, the range of GCA effect was varied between -0.30 (NB-20-8) to 0.44 (GJB 3) at Navsari (L1), -0.67 (NB-20-3) to 0.39 (NB-20-7) at Waghai (L2) and -0.50 (NB-20-9) to 0.33 (GJB 3) at Bardoli (L3). For branches per plant, positive and significant effect was desirable. Among the parents, positive and significant GCA effect was observed for NB-20-3 (0.18) and GJB 3 (0.44) at Navsari (L1); NB-20-7 (0.39) and GJB 3 (0.27) at Waghai (L2) and NB-20-1 (0.24), NB-20-5 (0.15) and GJB 3 (0.33) at Bardoli (L3).

The estimates of SCA effects in hybrids varied from -1.55 (NB-20-3 × NB-20-4) to 1.04 (NB-20-5 × NB-20-8) at Navsari (L1); -0.97 (NB-20-3 × NB-20-4) to 1.55 (NB-20-4 × NB-20-9) at Waghai (L2) and -1.12 (NB-20-3 × NB-20-8) to 0.82 (NB-20-8 × NB-20-9) at Bardoli (L3), respectively. Top three hybrids *viz.*,NB-20-5 × NB-20-8 (1.04) followed by NB-20-4 × NB-20-8 (0.92) and NB-20-4 × NB-20-9 (0.89) at Navsari (L1), NB-20-4 × NB-20-9 (1.55) followed by NB-20-3 × GJB 3 (1.13) and NB-20-1 × NB-20-3 (0.93) at Waghai (L2), NB-20-8 × NB-20-9 (0.82) followed by NB-20-3 × GJB 3 (0.74) and NB-20-1 × GJB 3 (0.67) at Bardoli (L3) had found higher significant and positive SCA effect. Conformity results were reported by Pramila *et al.* (2020) for this trait.

Days to 50 % flowering. Early flowering is highly desirable traits. Days to 50 % flowering of a particular parents or hybrid is an indicator of earliness (Timmareddygari *et al.*, 2021). Among the parents, NB-20-4 (-1.25) at Waghai (L2) and NB-20-1 (-1.44), NB-20-4 (-0.14), NB-20-7 (-1.04) at Bardoli registered significant and negative GCA effect. Hence, these parents can be considered as good general combiners for earliness. Range of GCA effect among the parents was varied from -0.67 (NB-20-7) to 1.23 (GJB 3) at Navsari (L1); -1.25 (NB-20-4) to 0.52 (NB-20-9) at Waghai (L2) and -1.44 (NB-20-1) to 1.83 (NB-20-9) at Bardoli (L3).

Range of SCA effect among the hybrids varied from -4.80 (NB-20-3 × NB-20-8) to 6.83 (NB-20-5 × NB-20-8) at Navsari (L1), -4.38 (NB-20-8 × GJB 3) to 6.12 (NB-20-4 × NB-20-9) at Waghai (L2) and -4.90 (NB-20-3 × GJB 3) to 5.67 (NB-20-5 × NB-20-8) at Bardoli (L3). Negative and significant SCA effects were found in hybrids *viz.*, NB-20-1 × NB-20-4 (-4.80), NB-20-1 × NB-20-8 (-3.67), NB-20-3 × NB-20-8 (-4.80) and NB-20-7 × GJB 3 (-3.90) at Navsari (L1); NB-20-1 × NB-20-9 (-3.01), NB-20-3 × GJB 3 (-3.28),NB-20-5 × NB-20-9 (-3.84) and NB-20-8 × GJB 3 (-4.38) at Waghai (L2); NB-20-3 × GJB 3 (-4.90) and NB-20-5 × NB-20-9 (-3.36) at Bardoli (L3) respectively. Chaitanya *et al.* (2018); Chaurasia *et al.* (2018); Timmareddygari *et al.* (2021) also reported similar kind of results for this trait.

Flowers per plant. The parents possessing significant and positive GCA effects were *viz.*, NB-20-4 (2.47), NB-20-7(4.75), NB-20-9 (2.32) and GJB 3 (2.58) at Navsari (L1); NB-20-7 (3.16) and NB-20-9 (2.66) at Waghai (L2); NB-20-4 (2.05) and NB-20-9 (2.78) at Bardoli (L3). This indicated that these respective parents were good general combiners for number of flowers per plant.

Additionally, the estimates of SCA effects in hybrids varied from -12.74 (NB-20-4 × NB-20-7) to 21.92 (NB-20-3 × NB-20-8); -8.68 (NB-20-1 × NB-20-8) to 13.36 (NB-20-3 × NB-20-8) and -6.30 (NB-20-1 × NB-20-7) to 9.67 (NB-20-1 × NB-20-5) at Navsari (L1), Waghai (L2), Bardoli (L3). Top three hybrids *viz.*, NB-20-3 × NB-20-8 (21.92), NB-20-1 × NB-20-9 (13.50) and NB-20-4 × NB-20-8 (11.93) at Navsari (L1), NB-20-3 × NB-20-8 (13.36), NB-20-1 × NB-20-5 (12.41) and NB-20-4 × NB-20-9 (9.31) at Waghai (L2), NB-20-1 × NB-20-5 (9.67), NB-20-1 × NB-20-9 (8.65) and NB-20-3 × NB-20-7 (8.56) at Bardoli (L3), exhibited significant SCA effects in the desired direction for the trait. Similar finding to the one found for above trait have also been reported by Raval (2022).

Fruits per plant. The GCA effects of parents ranged for this trait from -1.62 (NB-20-5) to 1.56 (NB-20-7) at Navsari (L1); -1.80 (NB-20-7) to 1.21 (NB-20-7) at Waghai (L2) and -1.44 (NB-20-8) to 1.10 (NB-20-9) at Bardoli (L3), respectively. GCA effects was significant and positive for NB-20-4 (0.88), NB-20-7 (1.56), NB-20-9 (0.82) and GJB 3 (0.86) at Navsari (L1); NB-20-7 (1.21), NB-20-9 (0.87) and GJB 3 (0.42) at Waghai (L2); NB-20-4 (0.82), NB-20-7 (0.92) and NB-20-9 (1.10) at Bardoli (L3). Hence, they were registered as good general combiners for fruits per plant.

The estimates of SCA effects in hybrids ranged from -4.34 (NB-20-3 × NB-20-9) to 7.38 (NB-20-3 × NB-20-8) at Navsari (L1); -2.04 (NB-20-8 × GJB 3) to 4.54 (NB-20-1 × NB-20-5) at Waghai (L2) and -3.98 (NB-20-1 × NB-20-8) to 3.88 (NB-20-1 × NB-20-9) at Bardoli (L3). The highest positive and significant SCA effect were possessed by hybrids *viz.*, NB-20-3 × NB-20-8 (7.38) at Navsari (L1), NB-20-1 × NB-20-5 (4.54) at Waghai (L2) and NB-20-1 × NB-20-9 (3.88) at Bardoli (L3). The results were corroborative to the reports of Pramila *et al.* (2020); Zarna *et al.* (2020).

Fruit length (cm). Fruit lengthis objective based character and decided by consumer preference (Rani *et al.*, 2018). Among the parents, GCA effect for fruit length (cm) was varied between -0.76 (NB-20-3) to 1.53 (NB-20-1); -0.82 (NB-20-3) to 1.17 (NB-20-1); -0.65 (NB-20-3) to 1.20 (NB-20-1) and -0.74 (NB-20-3) to 1.30 (NB-20-1) at Navsari (L1), Waghai (L2) and Bardoli (L3), respectively.

The estimates of SCA effects in hybrids varied from -2.50 (NB-20-4 × NB-20-5) to 1.98 (NB-20-1 × NB-20-3); -0.78 (NB-20-7 × NB-20-8) to 1.32 (NB-20-1 × NB-20-3) and -2.34 (NB-20-4 × NB-20-5) to 1.70 (NB-20-4 × NB-20-5) at Navsari (L1), Waghai (L2) and Bardoli (L3), respectively. Hybrids *viz.*, NB-20-1 × NB-20-3 (1.98), NB-20-1 × NB-20-4 (1.04), NB-20-4 × NB-20-8 (1.12), NB-20-4 × GJB 3 (1.59) and NB-20-5 × NB-20-7 (1.15) at Navsari (L1) while, NB-20-1 × NB-20-3 (1.32) and NB-20-5 × NB-20-7 (0.94) at Waghai (L2) and NB-20-1 × NB-20-3 (1.00), NB-20-4 × NB-20-9 (1.70), NB-20-4 × GJB 3 (1.62) and NB-20-5 × GJB 3 (1.21) at Bardoli (L3) had positive and significant SCA effects in the desired direction for this trait. These results were in consonance with earlier finding of Chaurasia *et al.* (2018); Pramila *et al.* (2020); Mohamed *et al.* (2022).

Fruit weight (g). The range of GCA effect among 8 parents was found to -5.26 (NB-20-9) to 4.53 (NB-20-3) at Navsari (L1), -7.46 (NB-20-9) to 2.68 (GJB 3) at Waghai (L2) and -6.04 (NB-20-9) to 6.35 (GJB 3) at Bardoli (L3).

Hybrids *viz.*, NB-20-3 × NB-20-9 (16.49), NB-20-4 × NB-20-7 (14.25) and NB-20-1 × NB-20-8 (13.60) at Navsari (L1), NB-20-1 × NB-20-7 (14.82), NB-20-5 × NB-20-8 (14.42) and NB-20-4 × GJB 3 (12.10) at Waghai (L2), NB-20-1 × GJB 3 (16.82), NB-20-1 × NB-20-7 (9.71) and NB-20-5 × NB-20-8 (9.40) at

Bardoli (L3)exhibited significant and desirable SCA effects. Conformity results were reported by Chaurasia *et al.* (2018); Datta *et al.* (2021); Mohamed *et al.* (2022).

Fruit diameter (cm). Among 8 parents, GCA effect were ranged from -0.71 (NB-20-1) to 0.32 (NB-20-3) at Navsari (L1), -0.57 (NB-20-1) to 0.22 (NB-20-9) at Waghai (L2) and -0.47 (NB-20-1) to 0.25 (NB-20-3) at Bardoli (L3). Parents *viz.*, NB-20-3 (0.32), NB-20-4 (0.17), NB-20-9 (0.27) and GJB 3 (0.14) at Navsari (L1); NB-20-4 (0.22) and NB-20-9 (0.22) at Waghai (L2); NB-20-3 (0.25) and NB-20-9 (0.21) at Bardoli (L3) exhibited positive and significant GCA effects which indicated as good general combiners.

The range of hybrid for fruit diameter was -1.06 (NB-20-7 × GJB 3) to 1.14 (NB-20-4 × NB-20-5); -0.83 (NB-20-7 × GJB 3) to 0.81 (NB-20-3 × NB-20-8) and -0.77 (NB-20-7 × GJB 3) to 1.01 (NB-20-4 × NB-20-5) at Navsari (L1), Waghai (L2), Bardoli (L3), respectively. The hybrids *viz.*, NB-20-1 × NB-20-3, NB-20-3 × NB-20-8, NB-20-3 × NB-20-9, NB-20-4 × NB-20-5 and NB-20-8 × GJB 3 exhibited positive and significant SCA effect at all the locations, which showed they were good specific combiner for this trait. The hybrids, NB-20-1 × NB-20-5 and NB-20-7 × GJB 3 had negative and significant SCA effect at all the locations showing poor specific combining ability for this trait. Datta *et al.* (2021) and Mohamed *et al.* (2022) were also observed same results.

Fruit yield per plant (kg). The GCA effects of parents for fruit yield per plant (kg) varied from -0.10 (NB-20-5) to 0.13 (GJB 3) at Navsari (L1); -0.13 (NB-20-5) to 0.13 (GJB 3) at Waghai (L2) and -0.12 (NB-20-8) to 0.09 (GJB 3) at Bardoli (L3). Among the parents, GCA effect was significant and positive for NB-20-7 and GJB 3 at Navsari (L1), Waghai (L2) and Bardoli (L3) with the magnitude of (0.10, 0.13); (0.12, 0.13) and (0.07, 0.08), respectively. Hence, they were registered as good general combiners for fruit yield per plant (kg).

The estimates of SCA effects in hybrids varied from -0.19 (NB-20-4 × NB-20-5) to 0.31 (NB-20-3 × NB-20-8); -0.27 (NB-20-1 × NB-20-8) to 0.35 (NB-20-3 × GJB 3) and -0.23 (NB-20-1 × NB-20-8) to 0.23 (NB-20-4 × NB-20-9) at Navsari (L1), Waghai (L2), Bardoli (L3), respectively. Significant and positive SCA effects for higher fruit yield per plant (kg) were observed for three hybrids *viz.*, NB-20-1 × NB-20-9 (0.17), NB-20-3 × NB-20-8 (0.31) and NB-20-7 × GJB 3 (0.22) at Navsari (L1). In addition to which two hybrids *viz.*, NB-20-1 × NB-20-7 (0.25) and NB-20-3 × GJB 3 (0.35) at Waghai (L2) and NB-20-4 ×NB-20-9 (0.23) at Bardoli (L3) had positive and significant SCA effect.

Similar finding in accordance to the above result has also been reported by Chaurasia *et al.* (2018); Pramila *et al.* (2020); Zarna *et al.* (2020); Datta *et al.* (2021); Mohamed *et al.* (2022).

Total phenol content (mg/100 g). With respect to total phenol content where negative significant GCA and SCA effect are desirable. The range of GCA effect among parents was varied from -5.38 (NB-20-1) to 4.39 (NB-20-5) at Navsari (L1), -8.48 (NB-20-1) to 4.73 (NB-20-5) at Waghai (L2) and -7.44 (NB-20-8) to 4.49 (NB-20-4) at Bardoli (L3). The parents *viz.*, NB-20-1 and NB-20-8 had negative and significant effect at all environments with the magnitude of -5.38 and -5.04 at Navsari (L1); -8.48 and -6.11at Waghai (L2) and -6.38 and -7.44 at Bardoli (L3), respectively.

The magnitude of SCA effects in hybrids varied from -0.17 (NB-20-4 × NB-20-5) to 0.28 (NB-20-7 × NB-20-9); -0.19 (NB-20-4 × NB-20-5) to 0.27 (NB-20-5 × NB-20-7); -0.17 (NB-20-3 × NB-20-7) to 0.23 (NB-20-5 × NB-20-7) at Navsari (L1), Waghai (L2) and Bardoli (L3), respectively. The best performing hybrids were *viz.*, NB-20-3 × NB-20-7 (-0.08), NB-20-3 × GJB 3 (-0.15), NB-20-4 × NB-20-5 (-0.17) NB-20-8 × NB-20-9 (-0.15) and NB-20-8 × GJB 3 (-0.09) at Navsari (L1); NB-20-3 × NB-20-8 (-0.12), NB-20-3 × NB-20-7 (-0.17), NB-20-4 × NB-20-5 (-0.19), NB-20-4 × NB-20-7 (-0.12), NB-20-4 × NB-20-8 (-0.09) and NB-20-8 × NB-20-9 (-0.11) at Waghai (L2); NB-20-1 × NB-20-9 (-0.12), NB-20-4 × NB-20-5 (-0.13), NB-20-4 × NB-20-7 (-0.13) and NB-20-4 × NB-20-8 (-0.10) at Bardoli (L3) exhibited negative and significant SCA effect; considered as good specific combiners for this character.

Conformity results were observed by Datta *et al.* (2021); for this trait.

Total soluble sugars (%). The GCA effects of parents ranged from -0.13 (NB-20-1) to 0.29 (NB-20-3) at Navsari (L1), -0.15 (NB-20-1) to 0.28 (NB-20-3) at Waghai (L2) and -0.12 (NB-20-1) to 0.27 (NB-20-3) at Bardoli (L3). Only a parent, NB-20-3 had positive and significant GCA effect in all three locations with the magnitude of 0.29 at Navsari (L1), 0.28 at Waghai (L2) and 0.27 at Bardoli (L3), respectively. Hence, it registered as good general combiner for total soluble sugars (%). The parents, NB-20-1 had negative and significant GCA effect at all three locations, considered as poor general combiner for total soluble sugars (%).

With regards to hybrid, out of 28 different hybrids evaluated different locations, the range of SCA effect from -0.70 (NB-20-3 × NB-20-5) to 0.72 (NB-20-1 × NB-20-5) at Navsari (L1); -0.64 (NB-20-3 × NB-20-5) to 0.53 (NB-20-3 × NB-20-9) at Waghai (L2) and -0.49 (NB-20-3 × NB-20-5) to 0.63 (NB-20-4 × NB-20-7) at Bardoli (L3).

Top performing hybrids were NB-20-1 × NB-20-5 (0.72), NB-20-5 × NB-20-9 (0.52) and NB-20-9 × GJB 3 (0.48); NB-20-3 × NB-20-9 (0.53), NB-20-5 × NB-20-9 (0.52) and NB-20-1 × NB-20-8 (0.51); NB-20-4 × NB-20-7 (0.63), NB-20-1 × NB-20-9 (0.46) and NB-20-1 × NB-20-5 (0.37) at Navsari (L1), Waghai (L2) and Bardoli(L3), respectively.

Ascorbic acid (mg/100 g). All the parents exhibited significant GCA effect for ascorbic acid (%). However, the desirable positive and significant GCA effects were observed in three parents *viz.*, NB-20-1, NB-20-5 and NB-20-9 at all three locations, indicating good general combiners. While, the parents *viz.*, NB-20-3, NB-20-4, NB-20-7, NB-20-8 and GJB 3 possessed negative and significant GCA effect considered as poor general combiners for this trait. The range of ascorbic acid (%) was from -0.39 (NB-20-3) to 0.68 (NB-20-9) at Navsari (L1), -0.40 (NB-20-3) to 0.65 (NB-20-9) at Waghai

(L2) and -0.38 (NB-20-3) to 0.64 (NB-20-9) at Bardoli (L3).

The spectrum of variation for SCA effects in hybrids ranged from -1.85 (NB-20-4 × NB-20-8) to 1.07 (NB-20-1 × NB-20-5); -1.84 (NB-20-4 × NB-20-8) to 1.16 (NB-20-1 × NB-20-5) and -1.83 (NB-20-4 × NB-20-8) to 1.17 (NB-20-4 × NB-20-8) at Navsari (L1), Waghai (L2) and Bardoli (L3).Hybrid NB-20-1 × NB-20-5 (1.07) at Navsari (L1); NB-20-1 × NB-20-5 (1.16), NB-20-1 × NB-20-7 (0.64) and NB-20-3 × NB-20-5 (0.67) at Waghai (L2); NB-20-1 × NB-20-5 (1.17), NB-20-1 × NB-20-7 (0.58), NB-20-3 × NB-20-5 (0.67), NB-20-3 × NB-20-7 (0.54), NB-20-5 × GJB 3 (0.54) and NB-20-8 × NB-20-9 (0.89) at Bardoli (L3) had positive and significant SCA effect for this character. Similar kinds of results were noticed by Chaitanya *et al.* (2018); Datta *et al.* (2021); Timmareddygari *et al.* (2021).

Table 1: Analysis of variance for combining ability for plant height (cm), branches per plant and days to 50% flowering at individual location and pooled over locations.

Source of variation	df	Plant height (cm)				Branches per plant				Days to 50% flowering			
		L1	L2	L3	Pooled	L1	L2	L3	Pooled	L1	L2	L3	Pooled
		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli	
GCA	7	141.84**	232.07**	167.95**	481.77**	0.53**	1.00**	0.74**	1.13**	4.30	2.99	12.89**	12.25**
SCA	28	62.98**	62.59**	50.62**	122.99**	0.45**	0.42**	0.29**	0.71**	15.06**	11.43**	9.73**	27.65**
Environments (E)	2	-	-	-	155.01**	-	-	-	7.24**	-	-	-	8.72
GCA × Environments	14	-	-	-	30.04**	-	-	-	0.58**	-	-	-	3.96
SCA × Environments	56	-	-	-	26.60**	-	-	-	0.22**	-	-	-	4.29
Error	210	4.23	6.17	2.45	4.29	0.06	0.09	0.04	0.06	4.06	2.59	2.66	3.10
Estimates													
σ^2gca		13.76	22.59	16.55	15.92	0.04	0.09	0.07	0.04	-	-	1.02	0.31
σ^2sca		58.75	56.42	48.16	39.57	0.39	0.32	0.25	0.21	11.00	8.85	7.07	8.18
σ^2gca/ σ^2sca		0.23	0.40	0.34	0.40	0.12	0.28	0.28	0.17	-	-	0.14	0.04

Table 2: Analysis of variance for combining ability for flowers per plant, fruits per plant and fruit length (cm) at individual location and pooled over locations.

Source of variation	df	Flowers per plant				Fruits per plant				Fruit length (cm)			
		L1	L2	L3	Pooled	L1	L2	L3	Pooled	L1	L2	L3	Pooled
		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli	
GCA	7	125.53**	79.02**	39.99**	182.00**	14.29**	10.11**	8.78**	25.01**	5.99**	5.49**	4.43**	15.52**
SCA	28	85.71**	37.99**	30.95**	103.43**	9.67**	4.57**	5.71**	14.13**	1.17**	0.34**	0.75**	1.75**
Environments (E)	2	-	-	-	227.27**	-	-	-	13.77**	-	-	-	0.04
GCA × Environments	14	-	-	-	31.27**	-	-	-	4.08**	-	-	-	0.20
SCA × Environments	56	-	-	-	25.61**	-	-	-	2.90**	-	-	-	0.25
Error	210	9.34	9.13	10.31	9.59	0.71	0.51	0.72	0.65	0.31	0.26	0.19	0.25
Estimates													
σ^2gca		11.62	6.99	2.97	5.75	1.36	0.96	0.81	0.81	0.57	0.52	0.42	0.51
σ^2sca		76.37	28.86	20.63	31.28	8.96	4.06	4.99	4.50	0.86	0.07	0.56	0.50
σ^2gca/ σ^2sca		0.15	0.24	0.14	0.18	0.15	0.24	0.16	0.18	0.66	7.43	0.76	1.02

Table 3: Analysis of variance for combining ability for fruit weight (g), fruit diameter (cm) and fruit yield per plant (kg) at individual location and pooled over locations.

Source of variation	df	Fruit weight (g)				Fruit diameter (cm)				Fruit yield per plant (kg)			
		L1	L2	L3	Pooled	L1	L2	L3	Pooled	L1	L2	L3	Pooled
		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli	
GCA	7	102.21**	110.12**	150.69**	284.95**	1.10**	0.64**	0.47**	2.09**	0.07**	0.09**	0.06**	0.22**
SCA	28	70.21**	73.74**	64.76**	152.43**	0.38**	0.31**	0.26**	0.88**	0.02**	0.02**	0.01**	0.05**
Environments (E)	2	-	-	-	224.13**	-	-	-	0.23**	-	-	-	0.01
GCA × Environments	14	-	-	-	39.04	-	-	-	0.06	-	-	-	0.006
SCA × Environments	56	-	-	-	28.14	-	-	-	0.04	-	-	-	0.006
Error	210	24.26	26.84	18.40	23.16	0.03	0.07	0.04	0.04	0.009	0.01	0.007	0.008
Estimates													
σ^2gca		7.80	8.33	13.23	8.73	0.11	0.06	0.04	0.07	0.006	0.009	0.005	0.006
σ^2sca		45.95	46.91	46.37	43.09	0.35	0.25	0.23	0.28	0.012	0.012	0.007	0.012
σ^2gca/ σ^2sca		0.17	0.18	0.29	0.20	0.31	0.24	0.19	0.24	0.531	0.684	0.700	0.557

Table 4: Analysis of variance for combining ability for total phenol content (mg/100 g), total soluble sugars (%) and ascorbic acid (mg/100 g) at individual location and pooled over locations.

Source of variation	df	Total phenol content (mg/100 g)				Total soluble sugars (%)				Ascorbic acid (mg/100 g)			
		L1	L2	L3	Pooled	L1	L2	L3	Pooled	L1	L2	L3	Pooled
		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli		Navsari	Waghai	Bardoli	
GCA	7	0.01**	0.02**	0.02**	0.05**	0.17**	0.19**	0.14**	0.45**	2.16**	2.14**	2.07**	6.38**
SCA	28	0.01**	0.02**	0.01**	0.05**	0.16**	0.14**	0.11**	0.37**	0.91**	0.86**	0.87**	2.64**
Environments (E)	2	-	-	-	0.01**	-	-	-	0.02	-	-	-	0.003*
GCA × Environments	14	-	-	-	0.003	-	-	-	0.03*	-	-	-	0.001
SCA × Environments	56	-	-	-	0.004*	-	-	-	0.02*	-	-	-	0.002
Error	210	0.002	0.002	0.002	0.002	0.01	0.01	0.01	0.01	0.0002	0.001	0.001	0.000
Estimates													
σ^2gca		9.92	22.82	18.94	0.002	0.02	0.02	0.01	0.01	0.21	0.21	0.21	0.21
σ^2sca		159.78	222.89	142.24	0.017	0.14	0.13	0.09	0.12	0.91	0.86	0.87	0.88
σ^2gca/ σ^2sca		0.06	0.10	0.13	0.099	0.10	0.14	0.13	0.12	0.24	0.25	0.24	0.24

Table 5: Estimation of GCA and SCA effects for plant height (cm) and branches per plant in brinjal at different locations.

Sr. No.	Genotypes	Plant height (cm)			Branches per plant		
		L1	L2	L3	L1	L2	L3
		Navsari	Waghai	Bardoli	Navsari	Waghai	Bardoli
	Parents						
1.	NB-20-1	4.20**	4.01**	3.59 **	0.02	-0.07	0.24**
2.	NB-20-3	-1.10	4.09**	0.39	0.18*	-0.67**	0.04
3.	NB-20-4	-2.37**	-4.75**	-2.95 **	0.04	-0.03	-0.22**
4.	NB-20-5	-0.31	-1.63 *	1.91**	-0.15*	0.15	0.15*
5.	NB-20-7	1.09	3.97**	3.31**	-0.02	0.39**	0.11
6.	NB-20-8	-2.12**	6.56**	-5.96 **	-0.30**	0.01	-0.15*
7.	NB-20-9	-5.56**	-4.33**	-4.93**	-0.20**	-0.06	-0.50**
8.	GJB 3 (Check)	6.18**	5.20**	4.63**	0.44**	0.27**	0.33**
	S.E.g_i ±	**0.61**	**0.74**	**0.46**	**0.07**	**0.09**	**0.06**
	Hybrids						
1.	NB-20-1 × NB-20-3	10.29**	8.39**	6.75**	0.60**	0.93**	0.42*
2.	NB-20-1 × NB-20-4	2.29	-3.37	3.55*	0.68**	0.16	-0.32
3.	NB-20-1 × NB-20-5	-5.10**	5.71*	-4.91**	-1.01**	-0.29	-0.22
4.	NB-20-1 × NB-20-7	11.56**	8.98**	11.49**	-0.20	-0.60*	-0.44*
5.	NB-20-1 × NB-20-8	-4.23*	-8.49**	-2.05	-0.26	-0.15	-0.19
6.	NB-20-1 × NB-20-9	-5.53**	-6.79**	-5.54**	-0.89**	0.12	-0.37*
7.	NB-20-1 × GJB 3	-1.13	4.49*	0.70	0.21	-0.01	0.67**
8.	NB-20-3 × NB-20-4	-4.81**	-4.45*	-4.98**	-1.55**	-0.97**	-0.32
9.	NB-20-3 × NB-20-5	-8.74**	-6.11**	-0.37	0.03	-0.43	-1.09**
10.	NB-20-3 × NB-20-7	-0.74	-2.50	-8.44**	0.50*	0.07	0.16
11.	NB-20-3 × NB-20-8	-9.66**	16.69**	-0.77	-0.48*	-0.89**	-1.12**
12.	NB-20-3 × NB-20-9	0.64	-3.81	-3.33*	-0.05	-0.75**	-0.17
13.	NB-20-3 × GJB 3	9.31**	4.87*	11.11**	0.18	1.13**	0.74**
14.	NB-20-4 × NB-20-5	14.70**	-4.07	10.83**	-0.03	0.87**	0.10
15.	NB-20-4 × NB-20-7	-10.14**	-5.46*	-5.37**	0.11	0.70*	0.02
16.	NB-20-4 × NB-20-8	6.48**	6.27**	-0.44	0.92**	0.21	0.14
17.	NB-20-4 × NB-20-9	-3.16	0.77	-1.33	0.89**	1.55**	0.29
18.	NB-20-4 × GJB 3	9.04**	13.38**	8.37**	0.06	0.03	0.06
19.	NB-20-5 × NB-20-7	-10.93**	8.55**	2.70	0.69**	0.05	0.64**
20.	NB-20-5 × NB-20-8	11.15**	-0.33	-0.63	1.04**	0.36	-0.50**
21.	NB-20-5 × NB-20-9	-2.55	-2.63	-5.93**	0.60**	0.23	0.32
22.	NB-20-5 × GJB 3	-1.08	0.05	3.98**	-0.16	-0.16	-0.58**
23.	NB-20-7 × NB-20-8	4.48*	-6.52**	0.57	-0.02	-0.08	-0.26
24.	NB-20-7 × NB-20-9	-5.15**	-8.69**	-5.79**	-0.86**	0.13	0.16
25.	NB-20-7 × GJB 3	6.78**	11.46**	10.91**	0.24	-0.13	0.07
26.	NB-20-8 × NB-20-9	2.86	2.84	6.47**	0.29	0.24	0.82**
27.	NB-20-8 × GJB 3	2.33	-9.94**	-5.09**	0.39	0.11	-0.21
28.	NB-20-9 × GJB 3	-6.91**	-5.71*	-10.25**	-0.38	-0.55	-0.46*
	S.E.s_{ij} ±	**1.87**	**2.25**	**1.42**	**0.22**	**0.28**	**0.18**

* and ** indicates significance at 5% and 1% level of probability, respectively.

Table 6: Estimation of GCA and SCA effects for days to 50 % flowering and flowers per plant in brinjal at different locations.

Sr. No.	Genotype	Days to 50 % flowering			Flowers per plant		
		L1	L2	L3	L1	L2	L3
		Navsari	Waghai	Bardoli	Navsari	Waghai	Bardoli
	Parents						
1.	NB-20-1	0.33	-0.12	-1.44**	-0.412	0.07	-1.10
2.	NB-20-3	-0.53	0.38	0.23	-3.38**	0.33	-1.66
3.	NB-20-4	-0.53	-1.25*	-1.14*	2.47**	1.17	2.51*
4.	NB-20-5	0.50	0.05	0.49	-4.81**	-5.01**	0.37
5.	NB-20-7	-0.67	-0.02	-1.04*	4.75 **	3.16 **	1.17
6.	NB-20-8	-0.33	0.15	0.13	-3.52**	-3.29 **	-2.39*
7.	NB-20-9	0.00	0.52	1.83**	2.32*	2.66 **	2.78**
8.	GJB 3 (Check)	1.23*	0.28	0.96	2.58**	0.93	-1.67
	S.E.g_i ±	**0.60**	**0.48**	**0.48**	**0.90**	**0.89**	**0.95**
	Hybrids						
1.	NB-20-1 × NB-20-3	1.20	-0.88	-2.50	-4.12	-3.47	-2.30
2.	NB-20-1 × NB-20-4	-4.80**	-0.58	-0.13	7.62**	-0.60	-2.77
3.	NB-20-1 × NB-20-5	1.83	-1.54	0.57	-1.56	12.41**	9.67**
4.	NB-20-1 × NB-20-7	-2.00	1.52	0.44	-0.59	-1.89	-6.30*
5.	NB-20-1 × NB-20-8	-3.67*	3.69*	0.60	-12.25**	-8.68**	-4.74
6.	NB-20-1 × NB-20-9	1.33	-3.01*	1.24	13.50**	-3.49	8.65**
7.	NB-20-1 × GJB 3	2.77	2.22	0.10	-0.55	0.67	-1.87
8.	NB-20-3 × NB-20-4	-1.60	-2.08	1.54	0.86	-1.93	-0.51
9.	NB-20-3 × NB-20-5	3.03	4.96**	3.24*	-0.53	-0.75	2.03
10.	NB-20-3 × NB-20-7	0.87	-1.98	0.44	9.84**	-1.66	8.56**
11.	NB-20-3 × NB-20-8	-4.80**	-0.81	-0.73	21.92**	13.36**	7.35*
12.	NB-20-3 × NB-20-9	0.87	5.49**	3.24*	-12.73**	5.18	-1.19
13.	NB-20-3 × GJB 3	-1.03	-3.28*	-4.90**	-0.92	5.94*	2.89
14.	NB-20-4 × NB-20-5	6.37**	3.59*	3.94**	-12.2**	-3.92	-2.11
15.	NB-20-4 × NB-20-7	-1.13	-0.01	0.47	-12.47**	1.41	-0.81
16.	NB-20-4 × NB-20-8	-3.13	-0.84	-2.70	11.93**	-0.85	-4.42
17.	NB-20-4 × NB-20-9	6.20**	6.12**	4.94**	8.22**	9.31**	8.11**
18.	NB-20-4 × GJB 3	2.63	4.69**	4.14**	1.03	-4.26	-1.31
19.	NB-20-5 × NB-20-7	-0.17	-1.31	-0.50	5.87*	-1.75	-1.87
20.	NB-20-5 × NB-20-8	6.83**	3.52*	5.67**	-8.86**	-4.40	-4.98
21.	NB-20-5 × NB-20-9	-1.50	-3.84**	-3.36*	-1.10	-4.45	-1.22
22.	NB-20-5 × GJB 3	-3.07	0.06	-2.16	11.44**	6.95*	7.70**
23.	NB-20-7 × NB-20-8	4.00*	5.26**	-0.13	-0.15	4.06	6.52*
24.	NB-20-7 × NB-20-9	0.33	-1.11	1.17	10.34**	8.55**	4.95
25.	NB-20-7 × GJB 3	-3.90*	-1.88	0.70	4.55	-2.49	-1.10
26.	NB-20-8 × NB-20-9	2.00	-0.61	2.00	-7.66**	-5.40	1.68
27.	NB-20-8 × GJB 3	-0.57	-4.38**	0.54	-7.18**	-6.51*	-3.78
28.	NB-20-9 × GJB 3	5.43**	2.26	2.17	3.38	4.15	-4.92
	S.E.s_{ij} ±	**1.83**	**1.46**	**1.48**	**2.77**	**2.74**	**2.91**

* and ** indicates significance at 5% and 1% level of probability, respectively

Table 7: Estimation of GCA and SCA effects for fruits per plant and fruit length (cm) in brinjal at different locations.

Sr. No.	Genotype	Fruits per plant			Fruit length (cm)		
		L1	L2	L3	L1	L2	L3
		Navsari	Waghai	Bardoli	Navsari	Waghai	Bardoli
	Parents						
1.	NB-20-1	0.15	0.06	-0.68**	1.53**	1.17**	1.20**
2.	NB-20-3	-1.12**	-0.01	-0.48	-0.76**	-0.82**	-0.65**
3.	NB-20-4	0.88**	0.38	0.82**	0.31	0.56**	0.47**
4.	NB-20-5	-1.62**	-1.80**	0.44	0.55**	0.84**	0.55**
5.	NB-20-7	1.56 **	1.21 **	0.92**	-0.73**	-0.49**	-0.58**
6.	NB-20-8	-1.23**	-1.13**	-1.44**	-0.48**	-0.48**	-0.48**
7.	NB-20-9	0.82**	0.87**	1.10**	-0.16	-0.50**	-0.34**
8.	GJB 3 (Check)	0.86**	0.42*	-0.69*	-0.27	-0.29	-0.17
	S.E.g_i ±	**0.25**	**0.21**	**0.25**	**0.17**	**0.15**	**0.13**
	Hybrids						
1.	NB-20-1 × NB-20-3	-1.30	-1.19	-1.54*	1.98**	1.32**	1.00**
2.	NB-20-1 × NB-20-4	2.50**	-0.25	0.30	1.04*	0.50	-0.18
3.	NB-20-1 × NB-20-5	-0.54	4.54**	3.81**	0.25	-0.28	-0.05
4.	NB-20-1 × NB-20-7	-0.45	-0.68	-1.80*	0.39	0.38	0.62
5.	NB-20-1 × NB-20-8	-4.06**	-3.80**	-3.98**	-0.56	-0.19	0.18
6.	NB-20-1 × NB-20-9	4.76**	-1.20	3.88**	-1.05*	-0.25	-0.07
7.	NB-20-1 × GJB 3	-0.22	-0.09	-2.26**	-0.84	-0.41	-0.04
8.	NB-20-3 × NB-20-4	0.20	-0.58	0.24	-2.30**	-0.29	-1.54**
9.	NB-20-3 × NB-20-5	-0.17	-1.20	0.88	0.80	-0.22	0.56

10.	NB-20-3 × NB-20-7	3.32**	0.19	1.86*	0.58	0.47	0.53
11.	NB-20-3 × NB-20-8	7.38**	4.40**	3.76**	0.29	0.59	0.63
12.	NB-20-3 × NB-20-9	-4.34**	1.60*	-0.92	0.35	0.24	-0.23
13.	NB-20-3 × GJB 3	-0.31	1.71**	1.20	0.09	-0.80	-0.63
14.	NB-20-4 × NB-20-5	-4.24**	-1.52*	0.11	-2.50**	-0.49	-2.34**
15.	NB-20-4 × NB-20-7	-4.14**	0.40	0.37	0.82	-0.51	0.21
16.	NB-20-4 × NB-20-8	3.98**	-0.20	-1.67*	1.12*	0.52	0.68
17.	NB-20-4 × NB-20-9	2.73**	3.00**	3.59**	0.65	0.17	1.70**
18.	NB-20-4 × GJB 3	0.29	-1.42*	-0.29	1.59**	0.80	1.62**
19.	NB-20-5 × NB-20-7	1.95*	-0.48	-0.92	1.15*	0.94*	0.59
20.	NB-20-5 × NB-20-8	-2.86**	-1.54*	-2.83**	0.84	0.71	0.31
21.	NB-20-5 × NB-20-9	-0.58	-1.88**	-1.24	0.14	-0.38	-0.30
22.	NB-20-5 × GJB 3	3.78**	2.50**	3.35**	0.85	0.44	1.21**
23.	NB-20-7 × NB-20-8	-0.04	1.38*	1.96*	-0.79	-0.78	-0.61
24.	NB-20-7 × NB-20-9	3.58**	2.51**	2.68**	0.17	-0.11	0.03
25.	NB-20-7 × GJB 3	1.54*	-0.84	-0.26	0.05	0.42	-0.42
26.	NB-20-8 × NB-20-9	-2.50**	-1.62*	0.84	-0.39	0.15	-0.10
27.	NB-20-8 × GJB 3	-2.33**	-2.04**	-0.57	-0.64	-0.10	-0.46
28.	NB-20-9 × GJB 3	1.02	1.90**	-1.71*	-0.61	-0.32	-0.69
	S.E.s_{ij} ±	**0.76**	**0.65**	**0.77**	**0.51**	**0.46**	**0.40**

* and ** indicates significance at 5% and 1% level of probability, respectively

Table 8: Estimation of GCA and SCA effects for fruit weight (g) and fruit diameter (cm) in brinjal at different locations.

Sr. No.	Genotypes	Fruit weight (g)			Fruit diameter (cm)		
		L1	L2	L3	L1	L2	L3
		Navsari	Waghai	Bardoli	Navsari	Waghai	Bardoli
	Parents						
1.	NB-20-1	1.51	1.91	2.37	-0.71**	-0.57**	-0.47**
2.	NB-20-3	4.53**	1.41	1.32	0.32**	0.11	0.25**
3.	NB-20-4	-2.20	-1.06	-2.81*	0.17**	0.22**	0.03
4.	NB-20-5	1.67	2.63	-3.28*	-0.12*	-0.04	-0.02
5.	NB-20-7	-3.06*	0.45	0.53	0.10	0.05	0.01
6.	NB-20-8	1.22	-0.56	1.54	-0.16**	-0.08	-0.07
7.	NB-20-9	-5.26**	-7.46**	-6.04**	0.27**	0.22**	0.21**
8.	GJB 3 (Check)	1.59	2.68	6.35**	0.14**	0.11	0.07
	S.E.g_i ±	**1.46**	**1.53**	**1.27**	**0.05**	**0.08**	**0.06**
	Hybrids						
1.	NB-20-1 × NB-20-3	3.26	6.35	5.83	0.54**	0.70**	0.69**
2.	NB-20-1 × NB-20-4	-4.92	1.95	1.06	0.25	0.09	-0.09
3.	NB-20-1 × NB-20-5	-1.66	-14.75**	-9.05*	-0.61**	-0.64**	-0.41*
4.	NB-20-1 × NB-20-7	5.68	14.82**	9.71*	0.37*	0.22	0.24
5.	NB-20-1 × NB-20-8	13.60**	2.61	4.70	-0.02	-0.21	0.09
6.	NB-20-1 × NB-20-9	-8.34	5.03	-8.52*	-0.42**	-0.19	-0.22
7.	NB-20-1 × GJB 3	2.24	7.38	16.82**	0.84**	0.55*	0.26
8.	NB-20-3 × NB-20-4	-3.60	1.11	1.49	0.68**	0.75**	0.81**
9.	NB-20-3 × NB-20-5	-1.48	0.92	-4.79	-0.65**	-0.32	-0.69**
10.	NB-20-3 × NB-20-7	-7.84	-3.45	-2.22	-0.12	0.18	-0.26
11.	NB-20-3 × NB-20-8	-14.51**	-11.53*	-8.96*	0.95**	0.81**	0.57**
12.	NB-20-3 × NB-20-9	16.49**	-3.93	6.59	0.51**	0.68**	0.80**
13.	NB-20-3 × GJB 3	5.38	9.81*	1.38	-0.30	-0.49*	-0.35*
14.	NB-20-4 × NB-20-5	10.15*	0.27	-0.87	1.14**	0.89**	1.01**
15.	NB-20-4 × NB-20-7	14.25**	1.30	1.97	0.52**	-0.22	0.02
16.	NB-20-4 × NB-20-8	-10.63*	-1.02	7.36	-0.79**	-0.22	-0.14
17.	NB-20-4 × NB-20-9	-0.38	-3.21	3.02	-0.61**	-0.06	-0.31
18.	NB-20-4 × GJB 3	4.55	12.10**	6.37	0.04	0.09	0.10
19.	NB-20-5 × NB-20-7	-2.84	0.59	4.27	0.07	0.44	0.43*
20.	NB-20-5 × NB-20-8	9.06*	14.42**	9.40*	0.28	0.24	0.22
21.	NB-20-5 × NB-20-9	1.94	11.85*	6.07	0.42**	-0.22	0.05
22.	NB-20-5 × GJB 3	-5.81	-8.71	-10.22**	0.15	0.05	-0.03
23.	NB-20-7 × NB-20-8	0.87	-4.70	-2.46	0.17	0.17	0.14
24.	NB-20-7 × NB-20-9	-4.79	0.15	-4.36	0.35*	0.40	0.20
25.	NB-20-7 × GJB 3	5.93	7.06	7.54	-1.06**	-0.83**	-0.77**
26.	NB-20-8 × NB-20-9	10.29*	9.51*	-1.27	0.08	0.09	0.01
27.	NB-20-8 × GJB 3	6.25	-1.99	3.99	0.72**	0.68**	0.47**
28.	NB-20-9 × GJB 3	-1.67	-1.34	6.01	0.16	0.17	0.33
	S.E.s_{ij} ±	**4.47**	**4.70**	**3.89**	**0.16**	**0.23**	**0.18**

* and ** indicates significance at 5% and 1% level of probability, respectively

Table 9: Estimation of GCA and SCA effects for fruit yield per plant (kg) and total phenol content (mg/100 g) in brinjal at different locations.

Sr. No.	Genotypes	Fruit yield per plant (kg)			Total phenol content (mg/100 g)		
		L1	L2	L3	L1	L2	L3
		Navsari	Waghai	Bardoli	Navsari	Waghai	Bardoli
	Parents						
1.	NB-20-1	-0.02	0.03	-0.02	-5.38**	-8.48 **	-6.38**
2.	NB-20-3	-0.03	0.01	-0.03	1.16	3.69 *	4.43**
3.	NB-20-4	0.05	0.03	0.07**	1.29	4.13 **	4.49**
4.	NB-20-5	-0.10**	-0.13**	-0.06*	4.39**	4.73 **	0.39
5.	NB-20-7	0.10 **	0.12 **	0.08 **	2.33	-2.08	-0.41
6.	NB-20-8	-0.10**	-0.13**	-0.12**	-5.04**	-6.11**	-7.44 **
7.	NB-20-9	-0.05	-0.06	-0.01	1.63	2.79	3.26 *
8.	GJB 3 (Check)	0.13**	0.13**	0.09**	-0.38	1.33	1.66
	S.E.g_i ±	**0.03**	**0.03**	**0.02**	**1.39**	**1.42**	**1.45**
	Hybrids						
1.	NB-20-1 × NB-20-3	-0.01	0.03	-0.01	0.07	0.19**	0.15**
2.	NB-20-1 × NB-20-4	0.08	-0.03	-0.01	-0.05	-0.07	0.08
3.	NB-20-1 × NB-20-5	-0.07	0.11	0.12	-0.01	0.05	-0.03
4.	NB-20-1 × NB-20-7	0.10	0.25**	0.04	0.01	-0.01	0.04
5.	NB-20-1 × NB-20-8	-0.12	-0.27**	-0.23**	0.09*	0.03	0.02
6.	NB-20-1 × NB-20-9	0.17*	-0.01	0.06	-0.07	-0.04	-0.12**
7.	NB-20-1 × GJB 3	0.03	0.12	0.12	0.02	0.00	-0.05
8.	NB-20-3 × NB-20-4	-0.05	-0.03	-0.01	0.13**	0.18**	0.10*
9.	NB-20-3 × NB-20-5	-0.02	-0.08	0.01	-0.01	0.10*	0.09*
10.	NB-20-3 × NB-20-7	0.08	-0.06	0.11	-0.08*	-0.08	-0.17**
11.	NB-20-3 × NB-20-8	0.31**	0.14	0.15	-0.06	-0.12**	-0.05
12.	NB-20-3 × NB-20-9	-0.06	0.03	0.04	0.18**	0.22**	0.01
13.	NB-20-3 × GJB 3	0.08	0.35**	0.13	-0.15**	-0.17**	-0.07
14.	NB-20-4 × NB-20-5	-0.19*	-0.13	-0.07	-0.17**	-0.19**	-0.13**
15.	NB-20-4 × NB-20-7	-0.12	0.03	-0.03	-0.04	-0.12**	-0.13**
16.	NB-20-4 × NB-20-8	0.05	-0.03	-0.04	-0.02	-0.09*	-0.10*
17.	NB-20-4 × NB-20-9	0.16	0.11	0.23**	-0.02	0.04	0.06
18.	NB-20-4 × GJB 3	0.08	0.06	0.00	0.15**	0.17**	0.13**
19.	NB-20-5 × NB-20-7	0.08	-0.04	0.04	0.07	0.27**	0.23**
20.	NB-20-5 × NB-20-8	-0.07	0.10	-0.01	-0.02	-0.06	0.05
21.	NB-20-5 × NB-20-9	0.01	0.07	0.02	0.19**	0.05	0.11**
22.	NB-20-5 × GJB 3	0.17	0.03	0.03	0.15**	0.06	0.09*
23.	NB-20-7 × NB-20-8	-0.02	0.03	0.12	0.08*	0.18**	0.09*
24.	NB-20-7 × NB-20-9	0.12	0.16	0.05	0.28**	0.15**	0.17**
25.	NB-20-7 × GJB 3	0.22*	0.02	0.11	0.01	0.02	0.05
26.	NB-20-8 × NB-20-9	0.04	0.05	0.04	-0.15**	-0.11**	-0.06
27.	NB-20-8 × GJB 3	-0.06	-0.24*	0.01	-0.09*	-0.07	0.08
28.	NB-20-9 × GJB 3	0.02	0.06	-0.07	0.12**	0.20**	0.18**
	S.E.s_{ij} ±	**0.09**	**0.09**	**0.08**	**4.25**	**4.37**	**4.45**

Table 10: Estimation of GCA and SCA effects for total soluble sugars (%) and ascorbic acid (mg/100 g) in brinjal at different locations.

Sr. No.	Genotypes	Total soluble sugars (%)			Ascorbic acid (mg/100 g)		
		L1	L2	L3	L1	L2	L3
		Navsari	Waghai	Bardoli	Navsari	Waghai	Bardoli
	Parents						
1.	NB-20-1	-0.13**	-0.15**	-0.12**	0.50**	0.52**	0.50**
2.	NB-20-3	0.29**	0.28**	0.27**	-0.39**	-0.40**	-0.38**
3.	NB-20-4	-0.08*	0.04	-0.09**	-0.30**	-0.29**	-0.28**
4.	NB-20-5	-0.05	-0.14**	0.02	0.47**	0.48**	0.48**
5.	NB-20-7	0.02	0.002	-0.04	-0.36**	-0.37**	-0.35**
6.	NB-20-8	-0.07	-0.10**	0.006	-0.32**	-0.31**	-0.33**
7.	NB-20-9	-0.03	0.02	-0.004	0.68**	0.65**	0.64**
8.	GJB 3 (Check)	0.06	0.04	-0.03	-0.27**	-0.26**	-0.27**
	S.E.g_i ±	**0.03**	**0.03**	**0.03**	**0.48**	**0.95**	**0.89**
	Hybrids						
1.	NB-20-1 × NB-20-3	-0.22*	-0.14	0.02	0.83	-0.87**	-0.81**
2.	NB-20-1 × NB-20-4	-0.25*	-0.36**	-0.39**	0.50	0.52	0.51
3.	NB-20-1 × NB-20-5	0.72**	0.39**	0.37**	1.07**	1.16*	1.17**
4.	NB-20-1 × NB-20-7	0.35**	0.25*	0.23*	0.70	0.64*	0.58*
5.	NB-20-1 × NB-20-8	0.31**	0.51**	0.35**	-0.48	-0.50	-0.48
6.	NB-20-1 × NB-20-9	0.30**	0.46**	0.46**	-1.49**	-1.41**	-1.48**
7.	NB-20-1 × GJB 3	-0.29**	-0.09	-0.19	-1.71**	-1.70**	-1.66**
8.	NB-20-3 × NB-20-4	0.20	-0.06	0.09	-0.78	-0.74*	-0.74**
9.	NB-20-3 × NB-20-5	-0.70**	-0.64**	-0.49**	0.80	0.67*	0.67*
10.	NB-20-3 × NB-20-7	-0.07	-0.02	0.00	0.47	0.50	0.54*
11.	NB-20-3 × NB-20-8	0.22*	0.11	0.22*	-0.75	-0.71*	-0.71**
12.	NB-20-3 × NB-20-9	0.15	0.53**	0.26**	0.59	0.56	0.52
13.	NB-20-3 × GJB 3	-0.34**	-0.26**	-0.01	0.37	0.39	0.39
14.	NB-20-4 × NB-20-5	0.34**	0.17	0.21*	-1.66**	-1.59**	-1.59**
15.	NB-20-4 × NB-20-7	0.07	0.39**	0.63**	0.37	0.34	0.28

16.	NB-20-4 × NB-20-8	-0.05	-0.28**	-0.15	-1.85**	-1.84**	-1.83**
17.	NB-20-4 × NB-20-9	0.19	0.04	0.09	0.49	0.44	0.43
18.	NB-20-4 × GJB 3	0.30**	0.22*	0.15	0.27	0.27	0.27
19.	NB-20-5 × NB-20-7	-0.03	-0.23*	-0.18	-0.42	-0.37	-0.37
20.	NB-20-5 × NB-20-8	-0.31**	-0.03	-0.19	0.37	0.41	0.43
21.	NB-20-5 × NB-20-9	0.52**	0.52**	0.25*	-0.29	-0.34	-0.33
22.	NB-20-5 × GJB 3	0.04	-0.13	-0.09	0.68	0.60*	0.54*
23.	NB-20-7 × NB-20-8	0.46**	0.26**	0.23*	-0.80	-0.75**	-0.73**
24.	NB-20-7 × NB-20-9	0.19	0.04	0.21*	-0.62	-0.61*	-0.63*
25.	NB-20-7 × GJB 3	0.03	-0.01	-0.20*	0.34	0.25	0.32
26.	NB-20-8 × NB-20-9	-0.16	-0.16	-0.11	0.52	0.40	0.89**
27.	NB-20-8 × GJB 3	-0.08	-0.11	-0.18	0.30	0.30	-0.71**
28.	NB-20-9 × GJB 3	0.48**	0.47**	0.36**	-0.72	-0.61*	0.27
	S.E.s_{ij} ±	**0.11**	**0.10**	**0.10**	**1.48**	**2.92**	**2.73**

* and ** indicates significance at 5% and 1% level of probability, respectively

CONCLUSIONS

Studies on combining ability help to identify the best parents and provide genetic information on the inheritance pattern of characters. Parents *viz.*, NB-20-7 and GJB 3 had good general combining ability for fruit yield per plant at all three locations. Among the hybrids, NB-20-3 × NB-20-8 at Navsari (L1), NB-20-3 × GJB 3 at Waghai (L2) and NB-20-4 × NB-20-9 at Bardoli (L3) had good specific combining ability. An analysis for the specific combining ability effect revealed that none of the hybrid was found positive and significant SCA effect for fruit yield per plant (kg) in all the three locations.

FUTURE SCOPE

Breeders should be familiar with the genetic makeup of the relevant plant species in order to create an effective breeding strategy. GCA effect revealed that the parents, GJB 3 and NB-20-7 were identify as good general combiner at all three locations. Hence, these parents may be used in the crop improvement programmes aimed at improving fruit yield and yield contributing characters. Analysis of variance for combining ability revealed that all characters had non-additive gene action. In this scenario, hybridization followed by recurrent selection seems to be most suitable breeding method for brinjal.

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